TRANSACTIONS

OF THE

Illinois State Academy of Science

SIXTEENTH ANNUAL MEETING

Knox College, Lombard College, Galesburg High School

Galesburg, Illinois

May 3, 4 and 5, 1923

VOLUME XVI

[Printed by authority of the State of Illinois.]

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ACADEMY MEMBERS
Taken at Galesburg Meeting.

TRANSACTIONS OF THE ILLINOIS STATE ACADEMY OF SCIENCE.

A. R. Crook, *Librarian.*

State Museum, Springfield, Ill.

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

The Council.

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Committee on Membership.

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Patsy H. Lupo, Rockford College, Rockford.
W. H. Packard, Bradley Polytechnic Institute, Peoria.
Fred R. Jelliff, President Knox County Academy of Science, Galesburg.
E. E. DeTurk, University of Illinois, Urbana.

Committee on Ecological Survey.

Henry C. Cowles, University of Chicago, Chicago, Chairman.
Geo. D. Fuller, University of Chicago, Chicago.
Ruth Marshall, Rockford College, Rockford.
V. E. Shelford, University of Illinois, Urbana.
W. B. McDougall, University of Illinois, Urbana.
R. B. Miller, State Natural History Survey, Urbana.
A. O. Weese, James Millikin University, Decatur.
James H. Ferriss, Joliet Park District, Joliet.
H. S. Pepoon, Lake View High School, Chicago.
M. M. Leighton, Illinois Geological Survey, Urbana.

Committee on High School Science and Clubs.

J. C. Hessler, Knox College, Galesburg, Chairman.
C. M. Turton, 2055 E. 72nd Place, Chicago.
Frank H. Colyer, State Normal University, Carbondale.
Harriet Strong, Downers Grove.
W. S. Bayley, University of Illinois, Urbana.
F. C. Bohannan, Galesburg High School, Galesburg.
R. G. Buzzard, State Normal University, Normal.
F. D. Townsley, James Millikin University, Decatur.
H. H. Radcliffe, 1346 W. Macon St., Decatur.

Committee on Publications.

The President.
The Secretary.
Mary E. Steagall, State Normal University, Carbondale.

PAST OFFICERS OF ILLINOIS STATE ACADEMY.

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-Presdent, 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.
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 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. Ferris, 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.

ILLINOIS STATE ACADEMY OF SCIENCE

Office of the Secretary
State Teachers College, DeKalb, Illinois

Council Meeting, Urbana, June 3, 1922

President W. S. Bayley presided at the Council meeting. The other officers present were, Past President C. T. Knipp, Treasurer W. F. Schulz, Librarian A. R. Crook, and Secretary C. F. Phipps.

It was voted to accept the invitation from Galesburg to meet there in the spring of 1923 for the annual meeting of the Academy.

With the approval of the Council the President appointed the following chairmen of Sections for the annual meeting in 1923: Chairman of Geology and Geography Section, Professor Robert G. Buzzard, DeKalb. (Address after September, 1922, State Normal Univ., Normal, Ill.); chairman of Chemistry and Physics Section, Professor R. D. Mullinix, Rockford College; and chairman of Psychology and Education Section, Dr. C. R. Griffith, Urbana. The President is to appoint later the chairmen for the Sections in Biology and Agriculture, and Medicine and Public Health.

It was voted that the present committee on High School Science and Clubs be continued in office for another year, that President Bayley be added to this committee, and that Chairman J. C. Hessler be authorized to appoint four additional members to this committee.

By vote the present committee on Ecological Survey was reappointed for another year.

The suggestion was made that it would be advisable for the committee on High School Science and Clubs to ask Academy members in various towns and cities to endeavor to start Science Clubs in their communities, especially in the high schools and colleges.

A report from the State Printer, relative to the cost of printing the last volume of Transactions, was presented by Doctor Crook. The bill amounted to $1,135.19. By vote, Doctor Crook was asked to confer with the proper authorities and endeavor to have the appropriation from the State to the Academy increased sufficiently to cover the printer's bill. If this appropriation cannot be increased, money will have to be drawn from the Academy treasury to pay the difference, namely, $135.19.

By vote, the Secretary was instructed to add 10% to the printer's price for all reprints of papers from the Transactions, to cover Academy overhead charges on same.

Council Meeting, Urbana, November 25, 1922

President W. S. Bayley called the meeting to order. Others present were the Vice-President, Treasurer, Secretary and Chairman of the High School Science and Clubs Committee.

Plans for the annual meeting were discussed. It was decided finally that the dates for the annual meeting to be held at Galesburg, 1923, should be May 3rd, 4th and 5th.

The proposed work of the Committee on High School Science and Clubs was discussed. Among other things an active campaigning for more science clubs in high schools is being planned by the Committee. The Council authorized the Committee to send copies of the Academy Transactions to high school science clubs now affiliated, or to be affiliated, with the Academy.

The Treasurer gave the following report:

Balance on hand April 27, 1922		$ 629.32
Collected since that date		1,169.77
		$1,799.09
Paid to A. A. A. S. dues collected from National Members, $4.00 each	$776.35	
All other expenditures	620.12	1,396.47
Balance on hand		$ 402.62

The Treasurer submitted 14 names for membership. It was voted to approve the list and to present these names at the Galesburg meeting for election.

The Secretary was asked to give, at the annual meeting, a summary of the growth of the Academy for the fifteen years of its existence.

It was the opinion of the Council that the section chairmen should be asked to secure papers for the annual meeting from high school teachers and from those beginning research work, and not so many as in recent years from university research professors.

A communication from the Baird Memorial Committee of Washington, D. C., was read and discussed. The communication stated that the 100th anniversary of the birth of Spencer Fullerton Baird is to be commemorated February 3rd, 1923, and that the committee is being formed in Washington to decide on the most appropriate form for the memorial, and that our Academy, with other organizations, is asked to appoint a delegate to meet with the committee, and to offer suggestions for a fitting memorial.

Dr. Baird was not only Secretary of the Smithsonian Institute, but he was the virtual founder of the U. S. National Museum, the creator and head of the U. S. Fish Commission, and the prime mover in the establishment of the U. S. Geological Survey and the Bureau of American Ethnology.

President Bayley was authorized to write to Dr. H. E. Ewing, one of our members in Washington, and ask him to represent the Academy on the Baird Memorial Committee, and to express the Council's view that a bust statue or bronze tablet would be most appropriate for the memorial.

Reprints

The following new prices on reprints have been obtained recently by the Secretary from the printers of the Transactions:

	100 copies or less	101 to 200 copies
4 printed pages, or less, Bound	$2.75	$3.05
5 to 8 " " Bound	4.10	4.55
9 to 16 " " Bound	4.50	5.40
Covers on 2 to 16 pages, Bound	3.10	3.70

Council Meeting, Galesburg, May 3, 1923

The Council met with the Local Committee of Arrange ments at Custer Hotel, Galesburg, on Friday, May 3 Final arrangements for the Annual Meeting were discussed and all plans completed.

The Treasurer presented 20 new names to be voted on at the Academy business meeting for membership. Favorable action was taken on all the names.

A letter from H. E. Ewing, one of our members in Washington, D. C., and an appointed delegate to the Spencer Fullerton Baird Memorial Committee meeting held in February, was read and approved and placed on file. This report stated that the following three resolutions were adopted, and the Memorial Committee is to carry them out:

First—That the Congress be memorialized to establish in the City of Washington a museum of fisheries and oceanography, a laboratory and a public aquarium as a memorial to Spencer Fullerton Baird.

Second—That there be established a fund for the encouragement of research and exploration in the direction in which Spencer Fullerton Baird was a leader.

Third—That the name of Baird be given to the laboratory of the Bureau of Fisheries at Wood's Hole, Massachusetts.

A letter from the general secretary of the A. A. A. S. was read, outlining their change in policy concerning the collection of dues from members who were also members of affiliated State Academies. The letter was handed to our Treasurer in order that he might cooperate with the Washington office of the A. A. A. S. in the matter of collecting dues from our national members.

Annual Business Meeting, Friday, May 4, 1923
Lombard College, Galesburg

President Bayley presided and called first for reports of officers.

The Treasurer submitted the following written report:

REPORT OF THE TREASURER FOR THE YEAR 1922-1923.

RECEIPTS

Balance on hand May 1, 1922	$ 629.32
Received for dues (Initiation and Annual)	445.10
A. A. A. S. dues collected by the Academy	1,224.85
Received for reprints	368.93
Received for sale of Transactions	34.24
	$ 2,702.44

DISBURSEMENTS

Paid for stationery, postage, and other expenses of officers	$ 403.37
Paid printing bills	449.25
Paid to A. A. A. S. for dues collected	1,224.85
Amount refunded for excess dues, etc.	15.00
Secretary's salary	150.00
	$ 2,242.47

Total Receipts	$ 2,702.44
Total Disbursements	2,242.47
Cash on hand	$ 459.97

The Secretary reported on the growth of the Academy as follows: In 1908, when the Academy was organized, there were 114 charter members. During that year the membership was increased to 246. The membership by years has been as follows: 1909, 283; 1910, 384; 1911, 357; 1912, 362; 1913, 388; 1914, 363; 1915, 363; 1916, 318; 1917, 361; 1918, 298; 1919, 298; 1920, 408; 1921, 590; 1922, 546. Of this membership of 546 in 1922, 329 were also members of the A. A. A. S., 36 were charter members, 49 were life members, and 54 were living outside the state of Illinois.

The Librarian reported that there had been a steady call for copies of the Transactions from all parts of the country, and for those which had been published by the Academy a price of $1.50 had been collected. $34.24 had been turned in to the treasury for such sales. Books published by the state were sent gratis to all applicants.

The above reports of officers were accepted.

Reports of committees called for:

Chairman H. J. VanCleave of the Membership Com mittee presented 36 names for action. They were all elected to membership.

Chairman H. C. Cowles reported progress for the Ecological Committee.

Chairman J. C. Hessler reported progress for the Committee on High School Science and Clubs. He stated also that the committee had worked during the year on plans looking to the formation of High School Clubs and their affiliation with the Academy. The committee had sent out to 621 high schools of the state an 8-page pamphlet outlining the importance of Science Clubs, and suggesting methods of carrying on meetings of such clubs. A further report was promised for the business meeting of May 5.

For the Publication Committee the Secretary reported that the Transactions for the Rockford meeting had been received the middle of April and copies had been mailed to members. Reprints were expected soon for those who had ordered them.

The above committee reports were accepted.

On motion of A. R. Crook it was voted that all papers presented at meetings must be sent to the secretary within 30 days after the adjournment of the annual meeting, or they could not be published.

The President appointed the following committees with instructions to report at the business meeting for May 5: Committee on Nominations, C. T. Knipp, Chairman, Isabel S. Smith, F. C. Baker, and M. M. Leighton. Committee on Resolutions; H. C. Cowles, Chairman, H. J. VanCleave and A. R. Crook. Auditing Committee, A. C. Longden, Chairman, Mary Renich and W. N. Speckman.

Adjourned to meet Saturday morning, May 5.

Business Meeting, May 5, Lombard College

President Bayley called for reports of committees. The written report of the Auditing Committee was as follows:

We, the committee appointed to audit the accounts of W. F. Schulz, the Treasurer, certify that we have examined the accounts and find them correct.

Respectfully submitted,

A. C. Longden,
Mary Renich,
W. N. Speckman.

The Nominating Committee submitted the following report:

Nominations for officers of the Academy for 1923-24

President—W. G. Waterman, Northwestern University, Evanston.

Vice-President—H. J. VanCleave, University of Illinois, Urbana.

Secretary—C. Frank Phipps, State Teachers College, DeKalb.

Treasurer—W. F. Schulz, University of Illinois, Urbana.

Librarian—A. R. Crook, State Museum, Springfield.

Membership Committee for 1923-24

Clarence Bonnell, Township High School, Harrisburg, Chairman.

Patsy H. Lupo, Rockford College, Rockford.

W. H. Packard, Bradley Polytechnic Institute, Peoria.

Fred R. Jelliff, President Knox County Academy of Science, Galesburg.

E. E. DeTurk, University of Illinois, Urbana.

Third member on the Publication Committee for 1923-24

Mary E. Steagall, State Normal University, Carbondale.

By vote the secretary was instructed to cast the ballot of the Academy for the list of nominees for office. The new officers were declared elected. The Membership

Committee and the member of the Publication Committee as presented by the Nominating Committee were elected in the same manner.

W. G. Waterman submitted the following Resolution relative to legislation in favor of state parks:—

"Resolved that the Illinois State Academy of Science heartily favors the bills for state parks and forests now before the legislature, and urges that every effort be put forth to secure their passage."

By vote the Resolution was adopted, and the Secretary was authorized to confer with State Forester R. B. Miller and forward a copy of the Resolution to influential members of the state legislature.

Chairman Hessler, in reporting for the Committee on High School Science and Clubs, stated that the High School Section Meeting held Friday was an enthusiastic one, interesting papers were presented, and the Chairman and President Bayley had presented the matter of Science Clubs to the meeting, and the response was good.

Chairman Hessler moved that the committee on High School Science and Clubs be empowered to carry out details in the formation of a Science Clubs Section for the next Annual Meeting, this Section to include all High School Science Clubs which affiliate with the Academy; also this Committee should meet with any committee which might be appointed by the High Schools.

This motion was carried. Very favorable discussion on the work of Chairman Hessler's Committee followed the vote.

Report of the Resolutions Committee

The Resolutions Committee reported as follows in writing:

It is with regret that the Illinois State Academy of Science notes the passing from its ranks by death during the preceding year of several of its members as follows:

Arseneau, Stanislaus, R., State Teachers College, DeKalb, Ill.

Caldwell, C. B., Lincoln, Ill.

Cook, Mrs. Jane Perry, 5456 Kimbark Ave., Chicago, Ill.

Goodell, William L., Effingham, Ill.

Johnson, Frank S., 925 Oakland Ave., Pasadena, Cal.

Salisbury, Rollin D., University of Chicago, Chicago, Ill.

A loss particularly severe has been occasioned by the death of Professor Salisbury, a charter member and former president of the Academy. His service to the Academy, the state, and the nation has been outstanding, and his place will be impossible to fill.

The Illinois State Academy of Science desires herewith to express its hearty endorsement of the state park and forestry bills that are now up for action before the Illinois legislature, and the hope is hereby expressed that the members of the Academy will individually carry out the spirit of this resolution by endeavoring to secure for these measures the support of the legislators in their respective districts.

The Illinois State Academy of Science views with satisfaction the growing interest in the work of the Academy on the part of the teachers and students in the colleges, normal schools and high schools in the state. In such institutions lies the hope of scientific progress in the future, and on this account the Academy specifically expresses its purpose to continue to cooperate in every possible way with the schools and science clubs.

By common consent the Galesburg meeting of the Academy for 1923 is one of the largest and best meetings in the history of the Illinois State Academy of Science. In large part this success is due to the efficiency of the local organizations, representatives, and committees. Singled out for special appreciative mention are Knox and Lombard Colleges, the Galesburg High School, the Knox County Academy of Science, the Knox College Biology Club, the Lombard College Chemical Fraternity, the High School Science Club, the Galesburg Chamber of Commerce, the Galesburg Press, the Galesburg Street Car Company, and, last but by no means least, the local committee on arrangements of which Mr. Fred R. Jelliff has been the efficient chairman, and Mr. Paul Houdek a most able helper. The Galesburg meeting sets a high standard of efficiency and excellence that is going to be hard to equal.

HENRY C. COWLES, *Chairman;*
H. J. VAN CLEAVE,
A. R. CROOK.

It was voted that the resolutions submitted be adopted and placed on file.

The report of the Committee on Metric System was presented by A. C. Longden, Chairman, Thomas G. Hull not being present.

Report of the Committee on Metric System

This committee was appointed in 1922 to co-operate with other scientific organizations whose purpose it is to promote the Metric System of weights and measures so that the public in general may become familiar with the advantages of the system and proper legislation enacted. The chairman of the committee has been in touch with the "World Metric Standardization" council and the "American Metric Association", offering the services of the committee to those organizations. It would seem that education is necessary before any legislation is enacted, since the majority of individuals do not appreciate the value of the Metric System. This education should be undertaken in the schools. As yet, the committee has not arranged such a program. Possibly the science clubs of the Academy could assist in the movement.

It would seem timely to bring to the attention of the academy a few facts regarding the history of the Metric System and its present status in this country. James Watt, the British inventor, was the originator of the "Dollar—Meter—Liter—Gram" system. Both George Washington and Thomas Jefferson urged very strongly upon the early American Congress the adoption of all four of these items. The decimal dollar system was adopted but the others after prolonged discussion were allowed to be dropped. In 1866 Congress legalized the

Metric System but missed the opportunity for complete simplification by not making it the exclusive standard. Early in the World War, the War Department found it necessary to adopt the Metric System for the Army in France and no other units were used. In 1919 the Brittan-Ladd Bill was introduced in Congress making the Metric System the only legal system of measurements, allowing a transmissional period of 10 years before the bill should be effective. As an indication of some of the organizations in Illinois that have advocated the use of the Metric System, the following list is given:

Illinois State Senate;
Chicago City Council;
South Side Business Men's Association, Chicago;
Chamber of Commerce, Elizabethtown;
Logan County Medical Society;
Chicago Laundry Owners' Association, Chicago;
The 4-Ones, Chicago;
Millinery Jobbers Association, Chicago;
National Association of Box Manufacturers, Chicago;
National Association of Loose Leaf Manufacturers, Chicago;
National Association of Retail Druggists, Chicago;
National Manufacturers of Soda Water Flavors, Chicago;
National Refrigerator Manufacturers Association, Chicago;
Women's Association of Commerce, Chicago;
Chicago Heights Chamber of Commerce, Chicago;
Chamber of Commerce, LaSalle;
Illinois Valley Manufacturers Club, LaSalle;
Commercial Club, Liberty;
Chamber of Commerce, Ottawa;
Illinois Wholesale Grocers Association, Peoria.

This is only a partial list of Illinois organizations recommending and urging the adoption of the Metric System. There are thousands of organizations in other states as well as national organizations in the same work. A concerted effort by all of these organizations, headed by the American Metric Association, would be able in the next few years, in the opinion of the committee, to bring about sufficient education so that no difficulties would be met in obtaining the legislation.

The above report was accepted and placed on file.

President-elect Waterman was called upon for a few remarks. In a brief speech he outlined some policies which he would like the Academy to consider the coming year,—such as popularizing science more, but in the right way; selling science properly to the people; and continuing to select carefully meeting places in cities prepared to cooperate with us in making the meeting a success. He suggested also that a four-page pamphlet, setting forth the aims of the Academy, be used freely with application cards in securing new members.

Treasurer Schulz spoke of the need of securing new members, since we were barely keeping up our membership, and the funds in the treasury were growing smaller in amount each year.

Council Meeting, Urbana, May 19, 1923

President Waterman presided and all six members of the Council were present.

Invitations from Elgin, Decatur, Normal and Bloomington, and Joliet, urging the Academy to hold its next annual meeting in their respective cities, were read, and after thorough discussion it was voted to accept the Elgin invitation. The decision was based on two facts; first, that the Academy has never met in Elgin while it has met in the other cities named; and second, Elgin had extended a cordial invitation a year ago to hold our 1923 meeting there.

The following standing committees were appointed:

Committee on Ecological Survey—H. C. Cowles, Chairman; George D. Fuller, Ruth Marshall, V. E. Shelford, W. B. McDougall, R. B. Miller, A. O. Weese, James H. Ferriss, H. S. Pepoon and M. M. Leighton.

Committee on High School Science and Clubs—John C. Hessler, Chairman; F. H. Colyer, C. M. Turton, Harriet Strong, W. S. Bayley, F. C. Bohannan, R. G. Buzzard, F. D. Townsley and H. H. Radcliffe. Chairman Hessler was authorized to add another member to the committee and to make other changes if desired.

By vote the Committee on High School Science and Clubs was empowered to use funds up to $50 if necessary, to carry on its work.

The President was given authority to have printed a small four page pamphlet, setting forth useful information concerning the Academy and its work, for distribution among members and for use in securing new members; the cost of such a pamphlet not to exceed $30.

The following amendments and additions to the constitution were presented to be acted upon at the next annual meeting:

Article V.—Council. The first sentence to read: The Council shall consist of the President, Vice-President, Secretary, Treasurer, Librarian, and the presidents of the two preceding terms. (This allows for two past-presidents on the Council instead of one).

Addition to Article V.—At the annual meetings the presiding officers of all the affiliated scientific societies of the state shall meet with the Academy Council for the discussion of policies.

Article VI.—Standing Committees. Add to this article a Committee on Affiliation. Also add to this article: The Committee on Affiliation shall consist of five members, chosen annually by the Academy.

By vote the President was empowered to appoint a temporary committee on Affiliation to serve this year and work among the County Academies and other scientific societies of the state, with a view to securing the affiliation of their members with the Academy, so that all may cooperate in the interest of science.

The following Committee on Affiliation was appointed: W. S. Bayley, Chairman; H. J. VanCleave, F. R. Jelliff, Clarence Bonnell and W. G. Waterman.

C. F. Phipps, *Secretary.*

PAPERS PRESENTED AT THE GENERAL SESSIONS OF THE GALESBURG MEETING

STUDYING MINES WITH A MICROSCOPE

W. S. BAYLEY, UNIVERSITY OF ILLINOIS

(Abstract)

The address by President Bayley was on the modern methods of studying mines with the microscope to determine the way in which their ores have been formed, and thereby to learn something as to their expectancy of life. The lantern pictures of extremely thin sections of rocks, disclosing the minerals composing them, were graphic and beautiful.

The speaker introduced his subject by explaining briefly how pieces of rock are ground so thin that they are transparent, and how in these transparent sections the character of the different minerals present and their relations to one another may be discovered by allowing polarized light to pass through them and noting the effects. Photographs of thin sections of granites, hornblende-schists and other rocks were thrown on the screen and the methods by which the minerals in them were recognized were explained briefly. After giving a general view of the differences between some of the commoner rocks and the changes that take place when one type is changed into another, the speaker threw on the screen a number of photographs of the ore and associated rocks from some of the iron mines in North Carolina and showed that the ore was derived from deep-seated sources. It was inferred therefore that the ore body was persistent downward as far as mining is profitable. Incidentally, the minute character of the ore was observed and a method for concentrating it was suggested. It was seen from the photographs that the ore consists of magnetite and hornblende so inextricately mixed that it is hopeless to attempt to separate them. It was seen, however, that these two minerals are also mixed with quartz, which is an objectionable component, but in such a way that it can be separated from the magnetite and hornblende by crushing and treatment with a magnet. The hornblende is not injurious to the ore and consequently its presence in the concentrate does not injure it.

Another kind of iron ore is abundant in the south and elsewhere but it is not mined because it contains titanium. It is of some importance to know the form in which this objectionable constituent occurs in the ore mineral, as the titaniferous ores will probably be needed at some time in the not very distant future and it is desirable to know whether the titanium can be removed from the ore without reducing its iron content. Photographs of sections of some of the ores were thrown on the screen and it was seen readily that the titanium is present as little particles of the mineral rutile imbedded in the magnetite which is the ironbearer. The rutile is not magnetic; consequently if the ore is ground to the fineness of the grains of rutile in it, all the magnetite, which is magnetic, may be withdrawn from the powder by electro-magnets and may be used as an iron ore.

Incidentally a number of veins in the mountains in the vicinity of the mines in North Carolina and Tennessee, and a number of sections of the iron ores of the Lake Superior region were shown on the screen.

THE PRESENT STATUS OF EVOLUTION

(The Botanist's View)

JOHN M. COULTER, UNIVERSITY OF CHICAGO.

In the last few months I have been asked frequently to speak on this subject. My audiences, however, have not been made up of members of an Academy of Science and their friends, but of people who want evolution explained, and to know whether it is as wicked as some claim. The misunderstanding in reference to evolution is very widespread. This has arisen from ignorance of the subject, from misinterpretation of the statements of scientific men, and from what may be called a mediaeval attitude of mind. It has been a shock to educators to realize that there still remains such a mass of untrained minds that can be imposed upon by eloquent ignorance.

As one illustration of the misinterpretation of the attitude of scientific men, I may call attention to the use that has been made of the address given by Bateson at the Toronto meeting of the American Association. He has been quoted extensively as an illustration of a distinguished biologist and student of evolution who has given up his belief in the theory of organic evolution. No statement in his address can justify such a claim. The burden of his argument was that with our increasing knowledge of the complexity of the subject, our present explanations of the origin of species are inadequate. Each discovery opens up a new perspective for exploration. To quote Bateson as denying the fact of evolution is to disregard the following statement which concludes his address:

"Let us proclaim in precise and unmistakable language that our faith in evolution is unshaken. Every available line of argument converges on this inevitable conclusion. The obscurantist has nothing to suggest which is worth a moment's attention. The difficulties which weigh upon the professional biologist need not trouble the layman. Our doubts are not as to the reality or truth of evolution, but as to the origin of species, a technical problem."

To quote Bateson as having given up his belief in evolution, and in doing so to disregard this closing statement of his address, is plain dishonesty. In such ways are the people being imposed upon.

One of the curious facts in reference to the current discussion of evolution, which shows great lack of information, is the confusion of evolution with Darwinism. As you know, Darwin's explanation of the fact of evolution is simply one of a number of explanations, and it belongs to the mediaeval period in the history of evolution, when only the method of observation and inference was used. Of course, Darwin's explanation came at a psychological moment and attracted an attention that was wholly a surprise to him. It is this fact that has made his explanation so famous that many think that Darwinism and evolution are synonymous.

With this preface, dealing with the present commotion concerning evolution, a preface hardly pertinent to this occasion, but perhaps excusable under the circumstances, I shall now address myself to a scientific group, a group which I am assuming is not troubled by doubts as to the *fact* of evolution.

The problem that faces us is the *explanation* of evolution. All of the explanations proposed thus far may prove inadequate and still the fact remain to be explained. In the early history of the subject, simple explanations were offered. As facts multiplied, however, and especially such facts as genetics has been uncovering, it became evident that evolution is not a single problem, but a complex of problems, involving a multitude of factors. It is obvious now that no single explanation can be adequate for all the phenomena of evolution. It may be said that all of the classic explanations explain *some* things, but no one of them can explain *all* things. The present status of evolution will be appreciated more clearly if we evaluate the classic explanations in the light of recent knowledge.

Lamarck's explanation encountered the obstacle of the inheritance of acquired characters. Biologists presently became convinced that acquired characters are not inherited, and therefore Lamark's explanation was thrown out of court. Now, however, we have discovered that the inheritance of acquired characters is possible in many organisms under certain conditions, especially in the simpler organisms. This means that Lamarckism is coming into notice again, and there is a decided revival of interest in a modern modified form of this explanation.

A single simple illustration of the work on the inheritance of acquired characters in plants may be given. A great many plants have been used in experimental work of this kind. In investigating the periodicity of sexual cells in *Dictyota*, a marine alga, Williams has proved the possible inheritance of acquired characters. In a given locality the male and female organs develop simultaneously, and a general liberation of gametes and fertilization take place on a particular day. This date differs in different localities, showing a relation to tides and therefore to the amount of available light. On the other hand, there is no evidence of periodicity in seas where there are no tides. Plants transferred to the laboratory, and thus removed from tides and varying light, continue to show the characteristic periodicity of the locality from which they came. Here is an obvious adjustment of the plant to a varying set of environmental conditions which has become hereditary.

As perhaps many of you know, very recently much more important and convincing testimony as to the inheritance of acquired characters has been secured by Guyer in his experimental work on eye defects in white rabbits. In short, there seems to be no doubt but that acquired characters *may be* inherited.

Darwin's explanation encountered the obstacle of variations of a sort that were claimed to be inadequate to account for the results of evolution. It ought to be kept in mind that this objection does not involve the idea of natural selection. That such selection occurs is obvious, for some forms survive and others perish, but does this result in building up new species with these small variations we call continuous? The question whether Darwin's variations are adequate for his conclusion is being examined critically by geneticists.

DeVries' explanation simply changes the type of variation subjected to selection. Instead of a new species being built up gradually, it is born full fledged, and natural selection merely decides which of the fledglings shall survive. This explanation encountered the objection that the so-called mutating forms are simply hybrids splitting. In fact, the original classic example of mutation, *Oenothera Lamarckiana,* has turned out to be probably a hybrid, and not a genuine case of mutation. The situation was concealed for a time by the fact that the ratio of a splitting hybrid and the ratio shown by these so-called mutants were very far from consistent. This, however, has now been explained by work in genetics, so convincingly, in fact, that DeVries himself has accepted the explanation. His attitude toward his proposed explanation of evolution should be understood. He told me on several occasions that he was not at all sure of this explanation, but that he prided himself not on his theory, but on the fact that he had started a new method of studying evolution, that is the experimental method.

I might also state for your benefit an experience I had showing the same spirit in Darwin with reference to his explanation. As you know, Asa Gray was the champion of Darwinism in this country, writing many notable papers on the subject, which were afterwards collected in a volume entitled *Darwiniana.* On one occasion Dr. Gray showed to me a letter he had received from Darwin after the latter had read one of these papers. In the letter Darwin said: "You have stated the case so clearly and convincingly that I am almost persuaded to believe it myself." In other words, these pioneers in evolutionary theory realized better than their followers that their explanations were only tentative, to be tested by subsequent investigation. They were *suggestions* rather than *conclusions,* to be thought about rather than believed.

Weismann's explanation, revived by Lotsy, that hybridization is responsible for evolution, encountered the obstacle that although hybridizing multiplies variations, it can never account for original differences. It results in mixtures of various kinds, but introduces nothing new. It is the appearance of new things that leads from one great group to another.

Another subsidiary explanation is called "isolation," which certainly accounts for the survival of variations that might otherwise have been swamped out by crossing and competition. After all it is a method of natural selection; that is, selection is usually made by competition, but sometimes by isolation.

Now, however, we are in the modern period in the history of evolution. Darwin carried the method of observation and inference to its limit in space and time, but inference is not demonstration. At present we are developing the technique of demonstration, by opening up the great field of heredity, which is not only vast in extent, but also extremely complex. When a species ordinarily begets its own kind, according to well defined laws of inheritance, what are the very occasional conditions that make it beget or at least start another species? At the present time, therefore, attention is being focused upon the experimental study of inheritance, the field of genetics, which may be rightly called also the experimental study of evolution. This newly developed field of genetics, with its increasing complexities, has taught us that evolution is a very intricate process, and that some of the earlier explanations, like that of Darwin for example, deal only with the more superficial phenomena. They are true as far as they go, but they do not get at the fundamentals. To say that evolution is discredited because Darwin's explanation does not explain the whole situation would be like discrediting the rotation of the earth because some one explanation is not satisfactory. It was in recognition of this modern genetical attack upon the problems of evolution, with its multiplying complications, that Bateson spoke of evolution as he did, as a problem not yet solved. Of course, any explanation of evolution must take into account the machinery of heredity, and we are finding that machinery not only complicated, but now and then producing unexpected results, which the geneticist must explain.

Naturally, this intensive study of evolution through experimental work in inheritance has somewhat restricted the presentation of evolution. When the only method was inference from observed facts, there was no limit to inference, and it could be made to include the whole plant and animal kingdoms. Now, however, the experimental method limits us to a few generations, and the wide-ranging inferences are left to the unscientific who are not particular about the facts.

In considering the relative merits of these explanations, it is not necessary to subscribe to a belief in any one of them, to the exclusion of the others. All of them may be factors in evolution, and it is altogether probable that no one of them is adequate to explain all evolutionary changes. We need them all, and more besides.

A good method of evaluating these explanations and any others that may be offered is to realize the questions any explanation of evolution must answer. There are at least four conspicuous questions: (1) What is the cause of variation? (2) What is the nature of the variations that are important in evolution? (3) How may variations be perpetuated and mutiplied? (4) How are the variations manipulated to effect progressive evolution?

Lamarck's explanation goes farther than any other in answering the first question, the cause of variation, and also in suggesting a basis for progressive evolution. Darwin and DeVries accept the variations without attempting to explain the cause, differ as to the kind of variations used, and agree as to the method of manipulating them. The hybridization explanation answers the third question, how variations are perpetuated and multiplied. It will be noted that no one of them answers all these questions.

Such an estimate of the proposed explanations emphasizes the fact that there must be more exact experimental evidence before much further progress can be made in solving the problems of evolution. It was in realization of this that at the beginning of the present century the study of evolution culminated in, and became diverted into, genetics, the experimental study of inheritance, which has already suggested many things, and promises to be still more suggestive in the future.

As an illustration of this, reference may be made to the results of this work as bearing on the mutation explanation. Until genetics began to uncover the machinery of inheritance, which of course is fundamental in producing variations, the general belief in evolution included the following ideas: Inheritance of acquired characters is exploded; Darwinian variations are dubious as a basis for explaining evolution; but mutation, with natural selection among the mutants, doubtless accounts for the facts. Now what does genetics tell us? The majority of mutants may be called degenerates, the new characteristics shown serving to adapt the mutant more poorly to the environment than the parent was adapted. In fact, the general statement is that the majority of mutants are much worse than their parents, and none of them are better. If only a few were better equipped, they would furnish sufficient material for evolution; but with none better equipped, evolution is blocked.

Such considerations have made many biologists feel less certain in explaining evolution than they were a few years ago. This loss of faith in mutation, added to recent discoveries on inheritance of acquired characters, has caused many to seek an explanation of progressive evolution in Lamarckian terms.

The great problem we are facing is progressive evolution, commonly called "orthogenesis", which history has made so evident. Continuous variations, discontinuous variations (so-called "mutations"), and hybrid variations may all be explained as due to a complex of factors. Such variations, however, are like the waves on the surface of a choppy sea, running in every direction, and getting nowhere. Progressive evolution, however, may be likened to a deep-seated oceanic current which moves steadily in one direction without any reference to the choppy surface. How can we explain this oceanic current? In my own field, I have been impressed by the progressive evolution of the gymnosperms, of which we have continuous records from the Paleozoic to the present time. Throughout that tremendous stretch of time, in spite of all imaginable changes in external conditions, certain structures have changed steadily in one direction, and these changes have resulted in the origin and development of the various great groups. What kind of variation furnishes the material for such evolution, and what are the conditions that produce such variations? These questions have not been answered, except in such a vitalistic way that the appeal is to faith rather than to knowledge.

In reviewing the status of the subject of evolution today, it seems fair to conclude that competent opinion is in a condition of flux, inclining now in this direction and now in that as the results of experimental work are reported. It is time for the open mind, for no one can foretell what a day may bring forth. With Lamarck's view once abandoned and now revived, Darwin's view once accepted and now doubted, DeVries' view once hopeful and now questionable, and all the other views fluctuating in apparent importance, no person is in a position to pass judgment. My feeling is that we have been simply playing with the surface, discovering minor factors, drawing general inferences from special cases. This was a necessary introduction to the subject. We begin by wading in shallow water, and as we advance the water gets deeper, until now we must realize that it is over all our heads.

THE ZOOLOGIST'S VIEW OF EVOLUTION

(Abstract.)

Charles Zeleny, University of Illinois

As time goes on it becomes more and more certain that plants and animals have come to their present condition by a long series of changes. Recent advances along many biological lines have furnished what are perhaps the most striking of all the confirmations. There is now no biologist who is not firmly convinced that the only explanation of the present day similarity with diversity among organisms is to be found in the view of blood relationship. And the evidence that man must be included in this statement is equally strong. Any one who is willing to subject this evidence to careful examination will be convinced of its soundness.

When biologists became certain of the fact of evolution they centered their attack on the determination of the way in which evolution acts, upon the conditions or factors of the process. These investigations have gone on step by step, demonstration of each step being gained by accurate observation and experiment with critical discussions. These discussions of the problems at the frontier of investigation have been taken by superficial observers to indicate difference of opinion among biologists as to the fact of evolution itself. The real situation is that as our knowledge of the method of evolution increases there is always a border zone of new problems under active investigation and discussion. In such a zone there will always be differences of opinion. It should not be necessary to state that such differences do not affect belief in evolution itself.

In the time at my disposal I shall pick out a few of the zoological facts upon which our belief in evolution is based, laying special emphasis upon the more recent work:

1. Evidence from comparative anatomy.
2. Evidence from embryology.
3. Evidence from classification.
4. Evidence from geographical distribution.

5. Evidence from physiology.
6. Evidence from direct experimental studies of evolution.

In conclusion, a few words may be said concerning man's relation to the rest of the universe. Scientific investigations have demonstrated that the universe is not a fixed, rigid system but a changing one. The earth is a part of this changing universe and as such has gone through a series of orderly processes, finally reaching a stage in which life became possible. When living things came they in turn did not remain unchanged. They progressed from one condition to another until man himself appeared.

There is grandeur in this view of man as an integral part of the universe. He fits into a large scheme of things, not as a disturbing element but as a fulfillment of the plan. The fertility of this dynamic conception has been demonstrated in all fields of human thought and action. The knowledge of a long course of past improvement leads to a belief in the probability of further advance. It is highly improbable that man is at the apex of a long series of upward change. Instead, there is every reason why we should prepare for boundless further advance. If we will but accept the obvious facts and apply their lessons to human improvement, we can accelerate the onward progress not only to a goal fixed by present aspirations but past it to conditions beyond our dreams.

THE PALEONTOLOGIST'S VIEW OF EVOLUTION

T. E. Savage, University of Illinois.

To the paleontologist, evolution means the progressive change in the life of the earth from age to age, as a result of natural causes. Just as the life of today developed out of the life of yesterday, the life of the present year was derived in a natural way from that of last year; so the life of the present age evolved in a natural way by slow progressive changes out of the age that preceded, and so on back to the earliest appearance of life on the earth, several hundred million years ago. The causes of these changes were partly inherent in the organisms, but were largely a result of responses to changes in the external environment. There are three main lines of evidence which practically compel the student of fossils to believe in the doctrine of evolution. These are (1) the geologic succession of life on the earth, (2) the numerous transitional or connecting forms and (3) the law of recapitulation in the life history of the individual.

1. The fossils preserved in the rocks show us the actual types of life that existed during the time the successive rock formations were deposited. It is significant that these fossils show a constant advance in the life as we pass from lower to higher, i. e. from older to younger rock strata. For example, the earliest known plants are found in rocks of pre-Cambrian age, and are algae and related forms, representatives of the lowest Phylum or group of plants. The higher, fern-like plants did not appear until much later (Silurian) time; and the highest group, the seed bearing plants, were not developed for a long time later than the ferns.

Likewise, the earliest animal fossils preserved in the rocks are the lower invertebrate types, which preceded the vertebrate forms by several million years. Of still greater significance is the fact that within any Phylum or group of animals or plants, it is the lowest members of the group that appear earliest, successively higher types being developed later in time, just as among the Vertebrata the fishes appeared before the Amphibia, the Amphibia before the reptiles, and the reptiles before the birds or mammals; and among seed plants the Gymnosperms appeared before the higher Angiosperms.

2. The connecting or transitional characters possessed by the earliest representatives of any class of plants or animals present still more definite evidence of evolution. For example, the earliest birds are found in rocks of Jurassic age. These first bird forms had teeth in both lower and upper jaws, like reptiles, a long vertebrated tail, like reptiles, and, like reptiles had separate toes, ending in claws, on their front limbs or wings. In fact they show so clearly their reptilian relationship that if it were not for the feathers with which these birds were scantily clothed, there would be no hesitation in calling them reptiles.

A somewhat different kind of connecting or transitional forms is shown in the classic example of the evolution of the horse, of which a most complete series of skeletons has been found in rocks ranging from Eocene to Pliocene in age. These show every step in the change from the small Eocene horse, about as large as a fox terrier, and having four toes and a rudiment of another toe on each front foot, and three toes and a splint on each hind foot, to the full size modern horse found in late Pliocene rocks, having one functional toe and two splints or rudiments of other toes on each foot. The evolution of the elephant and camels is known by series of skeletons almost as complete as that of the horse.

3. The evidence of evolution shown by the law of recapitulation is possibly even more conclusive than that already cited. This law states that the life history of each individual recapitulates, or repeats in a shortened way, the evolutionary history of the race to which it belongs. A clear illustration of this law is shown in the life history of the frog, the young stage of which is a tadpole having no lungs or legs, but breathes by means of gills, swims by movements of its tail, and is a fish in all its main characteristics and habits. Later it develops legs and lungs; absorbs its gills and tail; leaves the water, and is adapted to life on land. According to the law of recapitulation, the fish stage in the early life of the frog indicates a fish ancestry for the class Am-

phibia to which the frogs belong. This law was first discovered by students of embryology, but the paleontologist has in some ways a better opportunity to test its validity than the embryologist, especially as regards stages in the life history somewhat later than the truly embryonic. This is because, according to this law, the mature shells of any age should be found to correspond with immature growth stages of shells of their descendants occurring in rocks of later age, and this has proven true in a wonderful variety of fossil forms. An example will suffice from the Cephalopoda, or animals which have their shells separated into a number of chambers by partitions like the chambered nautilus. The earliest forms with chambered shells were straight. Later, some of these developed curved shells, and later still the loosely coiled, and finally shells closely coiled in one plane, like the Nautilus, were evolved. Now the remarkable thing is that when this closely coiled Nautilus shell is carefully sawed lengthwise through the middle, it is seen that the curvature in the oldest part or apical end of the shell is not symmetrical. The shell begins to grow straight at the tip, later becoming only slightly curved till the first three septa are formed, then becomes loosely coiled, but does not become closely coiled until the end of the first volution. This remarkable manner of growth results in leaving an empty space between the two halves of the first volution, and repeats perfectly the order in which the various degrees of curving and coiling of the Nautilus type were developed successively in time.

Now as if Nature was afraid this record was not sufficiently clear, she has made the evidence of evolution still more definite. In all of the closely coiled chambered shells, like Nautilus, the septa or partitions were evenly curved plates which joined the inner side of the shell along straight regular lines called sutures. In Devonian time there began to be developed in some of these shells irregular wrinkling of the septa, causing the bending backward and forward of the suture lines as in the Goniatites. As time progressed the lobing of the suture lines became more and more complex, as in the Ceratites, and reached its culmination in the later Ammonites. During the Triassic and Jurassic periods the Ammonites with very complex suture lines reached the climax of their careers. Now at the apex of each of these Ammonite shells the first sutures were simple, like those of the adult Nautilus. These were followed in the first half of the coil by sutures with simple lobes, as in Goniatites; and farther forward the lobes of the later sutures became more complex, until the true Ammonite type of suture is attained about the time the first whorl is completed. Thus, each individual Nautilus shell repeats in its growth the successive stages of curvature and coiling that the Nautilus group passed through in its development from straight-shelled ancestral forms; and in a similar way each individual Ammonite shell repeats in its growth the successive stages of complexity of suture line that the Ammonite group passed through in its development from the simple-sutured Nautiloid ancestors.

In their growth the shells in many of the classes of fossils repeat in their young stages adult characters of their earlier ancestors so that the paleontologist does not doubt the general validity of the evidence of the law of recapitulation with regard to evolution.

A NOVEL AND ECONOMIC METHOD OF MAKING CHARTS FOR SCIENCE INSTRUCTION

WILLIAM M. WESLEY, ST. PROCOPIUS COLLEGE, LISLE.

Are charts of any value?

Many of you who are engaged in teaching the sciences, but especially those in connection with botany, zoology or psychology, have, no doubt, realized the importance of charts in the class room. If a particular phase or stage is visualized, it is impressed more forcibly upon the mind of the student; hence it is more readily retained in his memory.

The market is indeed flooded with charts, but seldom is a person able to procure just what he would want. Hence you are confronted with this problem: Are you to adopt a course of instruction to fit the charts available; are you to omit the use of charts altogether, or are you to make your own charts?

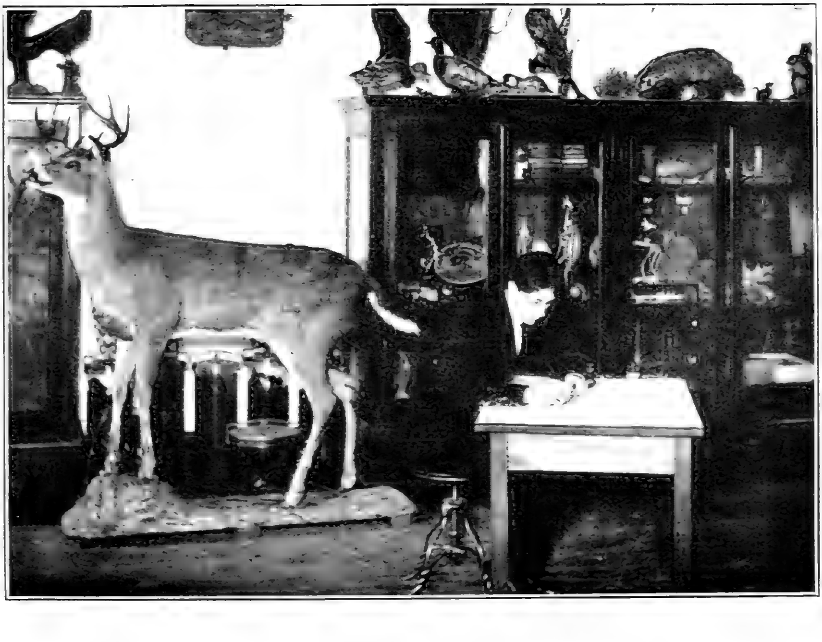
It was the last named course that was adopted at our college at Lisle, for the faculty refused to be satisfied with what the market had to offer. At first Dr. Jurica set a few students to work at making charts free-hand, but soon realized that this was tedious and quite expensive. After negotiating with a number of optical companies, he finally induced the Spencer Lens to modify their Model 3 Delineoscope so that it could be used for projecting opaque illustrations at any distance. Ordinarily the delineoscope is equipped with but a short plunger which does not permit a short working distance. This means that one would have a limit to the size of any particular illustration on the chart. But an 18 inch plunger allows one to come as near the cloth as is desired and correspondingly reduces the size of the picture.

The procedure is quite simple. Having made the proper connection, and having set the delineoscope in place, all one needs to do is to tack the cloth intended for the chart to a wall or beaver board. Then project the selected illustration, from a book, a reprint or a drawing, regulating the size by moving the table backward or forward as is necessary and focusing by means of the elongated plunger. With this all set, one is free to trace the chart in outline with pencil, and later it can be finished with indelible inks or paints. The advantage afforded by this procedure is that one can easily and at a very small cost make whatever charts he desires; that is, a person can include in a series just exactly what he thinks will illustrate the subject best.

The practice at our institution at Lisle is as follows: Dr. Jurica makes the selection, and he, himself, traces it in outline with pencil and leaves the rest to be finished by the students with colored waterproof ink, directing, of course, the choice of colors and all detail work. The cloth used, which has been found to be very satisfactory, is known as "binders", Velum de Lux, and can be purchased in rolls of 40 yards, ranging in price from 17 to 35 cents per yard, depending upon market conditions. It is cut easily into sheets of any size with a knife or razor blade. Our practice is to tack the roll to a kitchen table and to cut along the edge, cutting up the whole roll at one time into sheets of uniform size. After finishing the chart in detail, it is then lettered and bound in loose-leaf form in strong covers made of beaver board and mounted on a tripod. If one desires, the chart could also be put on rollers, but as a rule this does not keep so well. Moreover, where a quantity is made, the book form on a tripod has a decided advantage, for the lecturer can turn readily from chart to chart as necessity demands.

A probable objection may be that it is difficult to find students capable and willing to finish charts. This, however, presents no difficulty; for if the teacher is able, there is no class, not even on the high school level, in which a number of students could not be trained, and who would not be willing to earn some pocket-money. Besides, the students as a rule take pride in their finished products, especially if the proper credit for whatever they do is given them.

The delineoscope in itself is not very expensive, if one considers the time it saves in outlining or merely measuring off the illustrations according to the rules of proportions. With this machine charts have been outlined, ranging in time from 17 minutes to an hour and a half,



depending upon their complexity. It is both a time and a money saver. Moreover, a simple turn of the globe enables one to use the delineoscope for lantern slide projections.

The accompanying illustrations show some of the students at work making charts.

Turning the globe back again and inserting a sliding feeder, postal cards may be projected.

A STATE FOREST PRESERVE.

James H. Ferriss, Joliet Park District

As reported by a national senate committee, the consumption of American timber is now four times greater than production. Many deserts and waste places of the earth were formerly timbered and fertile, densely populated by leading nations of their time. Man with all of his industry, commerce, science, apparently is the great destroyer. His ambitions and enterprise fill the river beds, destroy the forest, and lay waste the fertile plain. Endowed with intelligence, education, incomparable to all the inhabitants of the land and sea, he is the most wasteful, the one great embarrassment of creation.

This is not a sermon, however; neither a thing highly scientific. Merely I have dropped in here neighborly, informally, for ten minutes, to inquire if there is not some pleasing method or plan, whereby we scientifics might add considerably to the park and forest conservation movement. The awaking people are enthusiastic; enterprise runs wide and deep. The state highway project, a forerunner, has been an unexpected and a pleasing success. Electricity and gasoline quicken the pace. The people are doing more and quicker thinking. Perhaps without our help much of the forest lands would be saved and nature's balance in a large measure preserved. As with the older states, the land may not be stripped altogether of its verdure and fertility; however, with our help the saving movements can be started much quicker and more usefully, beautifully, certainly.

It is not needful at this time, in this audience, to discuss the merits of forest preservation, values in public health, protection of navigable streams, effects upon water levels and atmosphere, or the moral effects and educational features as applied to ourselves. If you do not know more of this entire subject than I do, I am sorry. The newspapers and libraries are full of this. The editors, disinterested as they are, have caught on. They find that a truthful story of the hop-toad, an ode to a spray of the Golden Bell, or the portrait of a tumbleweed holds the subscribers better than a whole page of colored screams and rough stuff. Doc Calomel is losing his best customers. The old folks are camping in the woods, also the young ones and their school master.

We scientifics have a large influence with that virile group who make the laws, levy the appropriations and shape the policies of the state. Perhaps you have noticed yourselves that a botanist or a geologist is viewed with a peculiar awe or reverence by legislators and aldermen. A scientific gent, to these law and constitution builders, seems something above and beyond a common creature—something ordained, a super thing, loaded for bear. With busy people, also, toiling eight hours daily at a dollar and a quarter per hour, or sweating around the bulletins of a stock exchange two hours at a time, Coulter, Trelease, a Chamberlin, Ridgeway, Doctor Evans and each of a lot more of us is a larger man than some governors of the state. Any old timer who can chop a log between his feet with these hustling moderns is an architect, a landscape authority or a wizard equipped to build a navy or fix a clock.

There is reason for much encouragement in Joliet playgrounds, parks and an arboretum of 836 acres publicly owned and the 70 acres in parks and forests owned by the Street Railway, all free to everybody. About 330 acres of the arboretum is a matured forest of native trees. Privately owned until recently, it had received five years or more of excellent care and planting before given to the public, and the planting and forest conditions will now be continued.

The Cook County Forest Preserve, within four miles of the Joliet arboretum, is one of the very best enterprises of this character, a splendid testimonial to the industry and the courage of its promoters. Over thirty thousand acres of the Cook County forest land has been purchased, and the purpose is to secure at least forty thousand. To preserve the native forests in their regular, natural order, to build trails and roads in and between, to provide shelters and picnicing conveniences, in short, to develop an outer park belt of wild woods accessible to the people of a greater Chicago is the object of the Park Commission. The Joliet Park District intends to connect its arboretum with the Cook County Preserve along a small river with wooded hills and banks, thus becoming a part of this greatness and beauty.

Winnebago County followed Cook with a county preserve, and already has saved a forest selected for destruction. Peoria, East St. Louis and other cities of the state have their ambitions, and with the Chicago-Joliet link as a commencement, this Queen of the States may do something worth while, namely, save the forest before it is cut over, the soil before it is washed away.

Some of us can remember when Central Park, N. Y., and the Commons of Boston, parkwise, stood alone in the nation. The Arnold Arboretum is just fifty years of age this year. White pine lumber in our time sold in Chicago for sixteen dollars per thousand, firsts, and eight for fencing. Some of us cut down the trees for the nuts, the honey, or the coons, and set the woods on fire to warm our hands.

Now the national government is buying back the mountain ranges of the Atlantic and Pacific slopes and the water sheds of the navigable streams in between, and sixteen states have adopted various forms of parks or forest protection. Thus there is much encouragement, the going is good, and why not continue to preserve all the land in and about the forests not suitable for agricultural purposes?

To do it largest, to do it first, pleases the taxpayers. The best state in the Union should lead the way. Why wait for New York, Pennsylvania, Massachusetts or boastful California?

The deep water route from the Lakes to the Gulf is now well under way, and the suggestion of forest saving along the scenic banks from the Lake to Cairo is receiving some attention from the press and Chambers of Commerce. Here would be greatness—probably the longest enterprise of the character nation wide, the most used and useable in the state. The Illinois counties on the banks of this canal have a population twice as large as all the other counties of the state, with four more counties in Missouri to be heard from. The last census, 1920, gave the waterway counties of Illinois a population of

4,129,859; the whole state, 6,485,280. The scenery itself is fitted exactly for our purpose, parks already made, with wide stretches of water, deep forests, high bluffs, lakes, lily ponds, the greatest of Indian mounds, ever changing scenes, and all delightful.

The makings, the formulas, are before us. The O'Neil bills now at Springfield, house numbers 181, 182, and 183, cover the situation. The first named provides that the state department of public works, now in charge of the state highways and numerous activities of the kind, may acquire tracts of lands of natural scenic beauty, embodying cliffs, forest covered bluffs and forested or woodland areas, of which the chief values are best adapted for natural park areas, reservations and preserves; also to maintain, improve and establish public parks and fish and game preserves in their natural state of beauty. Bill number 182 provides $100,000 to be divided between the two coming years in the acquisition of land. Bill number 183 provides for a board of agricultural advisers of fifteen persons.

The friends of Our Native Landscape, an organization of real workers, containing some of the best authorities of the state in these matters,—Jens Jensen, Stephen A. Forbes, Dr. Cowles and others of their stature—have made an extensive survey of the state, although they contend there is much more to be done. This authority is back of the O'Neil bills. Their survey is mapped and illustrated artistically and to the purpose. Leaving out the Chicago-Joliet corner of the state, this survey suggests twenty locations fairly located, the state over, from the pineries of the northwest down the Mississippi, Savannah, Lima Lake, Piasa Bluff, Ft. Gage, Fountain Bluff, and then through the Ozark Hills to the Ohio, Pomona Natural-Bridge, Giant City, Bald Knob, Wolf Lake, Fern Cliff, Parker, Jackson Hollow, Dixon Springs, and Cave Hill, one near Effingham and three on the Illinois, Greater Starved Rock, Lake Senachwine and Havana, and another in the Rockford pines and hills.

Though the appropriation per the O'Neil bills is small, it is a beginning, and in view of the highway triumph there is a reason for activity upon our part. The Cook

County plan is the result of much study, good talent and time. The method of selecting the governing body is one promising the best talent and is working well. They have made the forest preserve method one of the great achievements of the nation. Their legislative work gives any county in the state the same advantages taken by Cook. Any 500 voters in a county may now call an election for the purpose of adopting this law. Cities have the most votes and the doing is easy. Only one mill upon the dollar of assessed valuation is permitted, but it brings in a large annual revenue. One per cent upon the same valuation is the limit of indebtedness. In my county, with an assessed valuation of fifty-five millions, we can raise $55,000 annually by direct taxation without the taxpayers noticing it, and run in debt for ten times as much for investments to their great profit and pleasure.

There is much encouragement for the preservation of this beloved state, and while things are going our way may we scientifics do our full duty and a little more, and stick.

A COLLECTING TRIP TO ALASKA AND THE CANADIAN NORTHWEST.

RUTH MARSHALL, ROCKFORD COLLEGE.

Alaska has many attractions for the traveler. Historically, it is one of the oldest parts of our country; its people and their needs are almost unknown to the citizens of the States; it has great natural wealth in its minerals, its forests and its fisheries; it is a land of surpassing beauty, with its great glaciers, snow-capped mountains, fiords, and vast meadows of brilliant wild flowers. This great territory, in area one-fifth of the size of the States, is a rich and little explored country for the naturalist. From big game to the tiny beasts in the mountain pools, in the dense forests of the mild and moist coast region to the frozen treeless tundras of the north, there is a great field for the collector.

In the summer of 1922, I spent two months in an extended trip along the coast from Seattle to Kodiak Island, a journey by boat of about two thousand miles. All of the larger coast towns, and many of the cannery settlements were visited. Stops were made in several places, varying from one day to two weeks, and there were short journeys inland on the three Alaskan railways. My scientific interests lay chiefly in the life of the ponds and lakes, especially those at high altitudes, where I hoped to find water mites. In this quest I was reasonably successful, considering the size of the territory and the difficulties of transportation. Altho the material obtained was not great in amount, the stations visited were many and of a varied character. This part of Alaska is rich in lakes. The coast towns, built very picturesquely on the mountain sides, draw their water supply from snow-fed lakes which form natural reservoirs. There are usually trails or roads to some bodies of water at every stopping place. And so, provided with a Birge collecting net, a knapsack and a camera, it was possible to reach and study a goodly number of places.

Five days by boat from Seattle lies Skagway, at the end of the famous Inside Passage. Here I left the boat for the train on the White Pass and Yukon Railway over the mountains and north to White Horse, in Yukon Territory, a hundred miles into the Canadian Northwest. This great scenic route follows the trail of the Klondikers of '98. Along the way are several lakes. Stops were made for collecting at Carcross and at Bennett; at the latter place the ponds are at an elevation of over two thousand feet. To the east lies the beautiful Atlin Lake region, and a few days were spent in collecting material in small pools there.

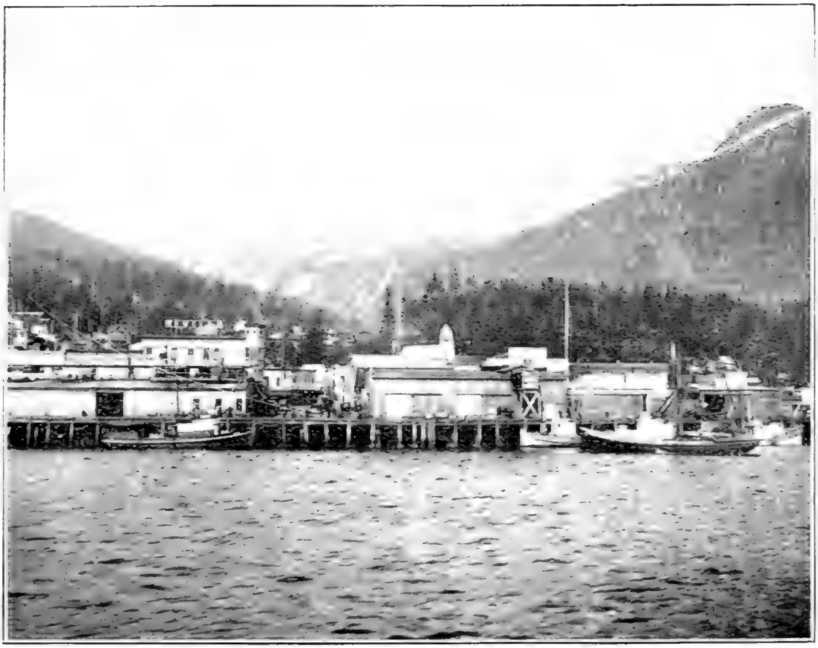
The first material from Alaskan waters was secured at Skagway, at two stations; one was a small pool in the town and the other was the lake reservoir, 1500 feet above the town. In Lake Dewey, adjacent to this, no water mites were found. At Juneau, the territorial capitol, the ponds and pools visited yielded nothing. But in Sitka, the old Russian town and former capitol, I was directed to a pond in a sphagnum bed, choked with yellow water lilies, which gave several interesting forms.

The most intensive collecting was done during a two weeks' stay in Cordova, the port of the Copper River country, famous for its copper and its salmon. Here is a large and beautiful body of water, Lake Eyak, at sea level, and a number of mountain pools, with clay bottoms, in beds of sphagnum, at elevations of a few hundred feet. From Cordova I made the trip on the Copper River and Northwestern Railway, "the Iron Trail" of Rex Beach fame, past Miles and Childs Glaciers, another wonderful scenic route, to the little town of Chitna, one hundred and thirty miles inland. Here among the mountains are several small lakes near the town, one of them at an elevation of 750 feet.

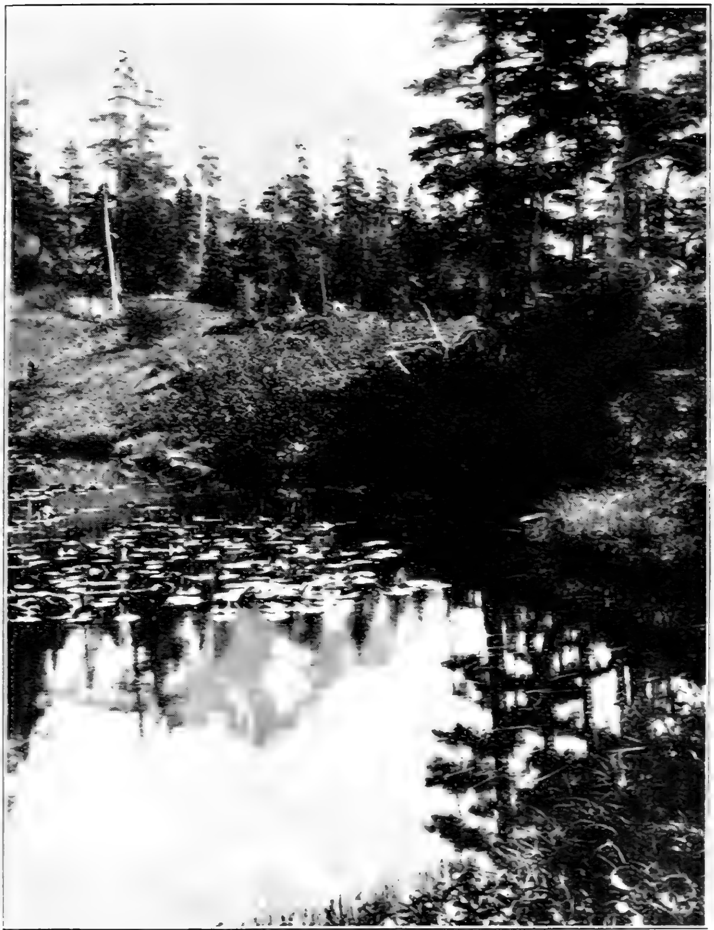
At Seward, on farther to the westward, we again left the steamer, this time to board a train on the Government Railway, for the trip across the Kenai Penninsula to the new town of Anchorage, over a hundred miles north. Again our route took us over a great pass and between living glaciers, with beautiful mountain scenery at every turn. A day's stop in Anchorage afforded a chance to do a little collecting in some small pools.

I was fortunate in being able to make two stops on Kodiak Island. The town of Kodiak, at the northern

Alitak, Kodiak Island, Alaska.

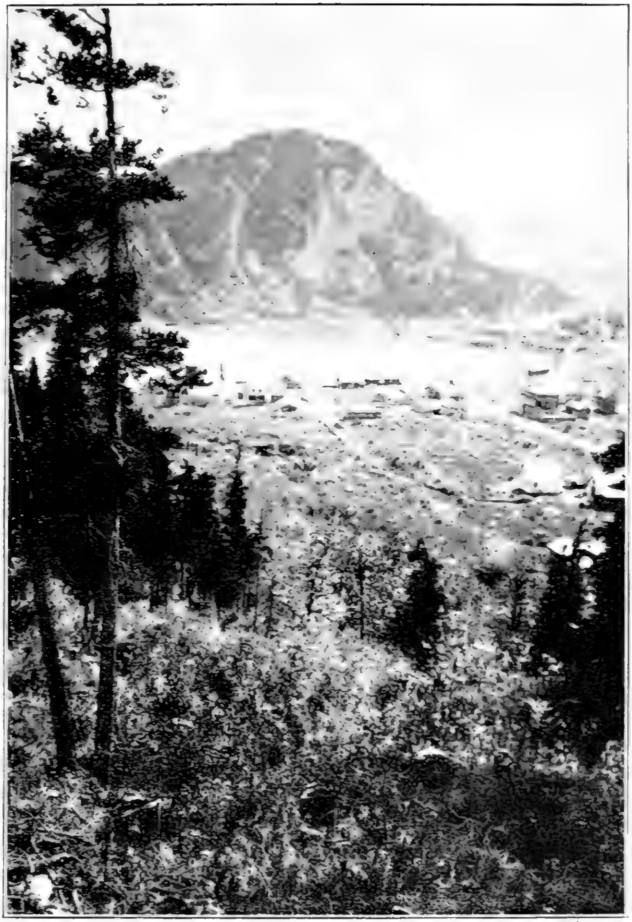


Ketdukan, Alaska. Leaving the harbor from S. S. Queen.



Cordova, Alaska.

Largest of small pools on mountain near reservoir. (Water mites here.) Pond lilies (yellow). Brown salt bottom. About 500 ft. elevation.


Celutina. Alaska. From the mountain side.

end of this beautiful island, is the outfitting station for expeditions to the Valley of Ten Thousand Smokes. Ash from the Katmai eruption of 1912 is still seen blowing about on the mountain tops. A small pond in the town has a bottom of volcanic ash; no life was found in this in the hasty examination made in the evening. But a large shallow pond near the Agricultural Experiment Station, supporting a rank growth of water plants, yielded several mites and crustacea. Alitak is a cannery settlement at the southern end of Kodiak Island, one of the many places where our boat stopped for more than a day to load cases of salmon. On the mountain side, brilliant with the flowers and fruits of late summer, I found several shallow pools of clear water in sphagnum beds, and here there was fair collecting.

Ketchikan, the southernmost town of Alaska, was visited on the return trip, in the first days of September. There is a mountain reservoir here, some three miles along a tram-way up the slope. In a bay of this lake a little material was found.

Besides the stations enumerated, two ponds, one at Seattle and one at Tacoma, were visited on the trip, and interesting material found. On the way out to the coast, a few days were spent in Glacier National Park; but no mites were found in any of the bodies of water tested. But at Banff, on the return trip over the Canadian Pacific Railway, a few mites were found in a marshy pool.

In all, nearly forty stations were visited and between five and six hundred individual water mites were found. Only ten genera were represented, and of these, the genus Hygrobates claimed over half of the specimens. Work on one genus, the Arrhenuri, has been completed, and the paper is now in press. Work on the other genera will be completed as soon as time will allow. Material in other groups collected at the same time has been turned over to other workers for study.

A TUNDRA TRIP IN ALASKA.

PATSY HUGHES LUPO, ROCKFORD COLLEGE.

Since the early gold rush to Alaska, the first boat of the season to venture into the Northwest Seas has left amid the cheers of crowds of people who thrilled at the thought of her adventures and came to wish her well; for something about travel in ice-laden seas appeals to the romantic spirit of even the most stolid. So it is that even today hundreds of people who are strangers to the country and to all the passengers still come to wave good-bye and good luck to the "Old Vict" when she leaves the dock. And well it is that they do, for I doubt if even the oldest of the old-timers go without some little twinge of wonder whether thru storms and ice she will reach Nome in safety. The *Victoria* steers a course almost due west to longitude of about 162°, and then turns north thru Unimak Pass into Bering Sea. This is the "outside" passage, in contrast to the line of travel which leads close to the coast and to the Southern part of Alaska. It is the course which the Oriental boats to Japan take; and few people realize that one is halfway to Japan before he turns north toward Arctic Alaska, and that possessions of the United States and of Russia are in one place only half a mile apart! It is in Bering Sea that the day lengthens until there is no night, and the watch for ice becomes vigilant. Since the days of wireless the danger from being caught in the ice is less, for word comes from the Yukon when the last ice goes, and from Nome as to the condition of her coast. But sometimes the ice is caught in drifts and is brought back again when unexpected; and so it was on our trip in 1922 when on June eleventh the first mate announced, "Ice ahead, sir." But the floe was well broken up and caused no delay, so that we landed at Nome within two days.

Nome is a city of renowned past, made famous by Rex Beach's *Spoilers* and by Sweepstake races on which bets were made around the world. She is now, tho, a city of dwindled population, of unpainted houses, of plank streets in need of repair, and of empty homes where the

Fig. 1. A kyack race of the Eskimos.

Fig. 2. Seward Peninsula railroad—called the "dogomobile."

destruction of a wall exposes furniture deserted in place. The population of the city varies, for the people are transient; they go into the hills to work their claims in summer, and by far the greatest number go "outside" on the last boat that returns to the States. Nome is a drab little mining town, straggling along a narrow coastal plain that borders the hill regions. Its people are occupied mostly in gold mining, and fishing for salmon and whales, and a few little shops supply the necessities of life. This is the town where women once wore Parisian gowns, and imported Corsican dancers were paid in showers of gold!

The Fourth of July in Nome is, even yet, a day of great celebration for both white people and Eskimos. It is a holiday of games, and the Eskimos particularly were very interesting in the originality and execution of their contests. Their walrus skin throwing is similar to blanket throwing of this country, except that the tautness of the skin makes it a more difficult accomplishment; but altho some who attempted it made funny spectacles of themselves, many of them succeeded in landing and rebounding with beautiful poise. A standing kick to touch with both feet a ball suspended about six feet three inches high was one of the novel feats; and a kyack race was an example of a very typical Eskimo sport. The "modern" Eskimo who took part in these sports is little different from the Eskimo of Steffanson's books so far as one can see. They are modern only in the substitution of calico trimmed in fur for the all-fur parka, and in the use of all kinds of expensive American perfumes to add to the odor of seal oil and blubber! Their women are very pretty when young, but age most rapidly, and the most lasting and appealing picture of Eskimo people is the sweet madonna face of the parka-dressed young Eskimo mother with one baby on her back and several holding her by hand. During the influenza epidemic, these people died by hundreds, so that in places their communities are almost depopulated, and the orphanages are crowded with children.

Travel in Alaska may be accomplished with ease only in winter, with dog team over packed ice. A summer journey entails innumerable hardships, and especially in 1922 the late thaw and continued cold made it difficult to get into the hills. There are no trails, and one must go on foot or with team across unbroken, swampy country. We left Nome about the twenty-third of June to go to Teller on the *Sea Wolf,* but ice floes filled Port Clarence Bay and a storm made us anchor for protection behind a big iceberg; and in three days we had to return to Nome. After a month's delay there we set out again for Teller on the *Sea Wolf.* Truly, Alaska is the land of waiting, for there are no schedules for anything and the weather rules supreme. This delay in Nome and another in Teller when the storms racked the house over our heads made us almost despair of finishing our journey to the Kougarok. In Teller is the farthest north newspaper in the world, published every week or so (whenever there is any news!) by a boy of twelve years, who also builds his boats, fishes for the winter supply of dog feed, and helps his father with the reindeer herd.

We left Teller in the twilight of midnight and lull of the storm to cross the bay with the team which carried all our provisions for the distance of fifty miles. We ourselves walked, for the reason that horse feed is scarce in this country, and the horses were ill-fitted even for the load of necessities which they hauled. On our journey we made three stops, one when we were halted by a flood and camped on a gravel bar in the Agiapuk River, one at a tent of a miner, and one at a shack of an English prospector who was making his fire in a pan and letting the smoke out by a hole in his window! In fifty miles we saw one man, and there are many places on Seward Peninsula where one might travel and see none. It was the same story on our outward journey, too,—a claim with one miner, or a dredging camp with five or six men. An empty house, or an empty town were the signs of habitation that we passed. My aunt and I felt ourselves to be objects of curiosity when we came to camps because there are no women in this part of the hill country. One man we passed had not seen a woman for two years, and later I met a Scotchman who said he had lived for seventeen years without seeing a woman! Hospitality, naturally, is the law of the land, and even in a house where the owner is away, a traveler may take what he wants, with the only obligation to leave the place in good condition with some food for the next fellow traveler. Deserted towns as well as houses are not rare. Shelton was a town on our home journey, and from the hill it looked to be quite populous with some dozen fine frame houses, and even two-story homes. But on our arrival we found it occupied by only two men, and both of them were transients!

Our journey of two months ended on July 30th when we crossed the Arctic Divide and saw the red mud roof of our cabin shining in the sunlight on a limestone hill that was part of Kougarok Mountain. It is a simple little cabin built of planks and made secure by bricks of peat. Within, its walls are made picturesque by papering of old magazine covers and pages of ancient date, so that one can read the early *Saturday Evening Post* stories of Mary Roberts Rhinehart as one eats. The furnishings are home-made things of board, with typical cabin "bunks" for beds and only benches to sit on. But there is the real luxury of a good stove with an oven that bakes bread exactly right if you watch it carefully. At first our cabin was damp and dismal with green mold covering wood and paper and fur robes; but fires and air cleared it out; fresh new curtains at the deepset square windows, and the few deft touches of my Aunt very soon made of our shack a cabin home.

Life is busy in house-keeping under primitive conditions. Fires made with willow twigs soon go out, and three substantial meals a day are necessities for vigorous, pioneer life. Nor are there stores nearby! The dried stuff and canned goods brought in must furnish all the food requirements, and bread must be made, and fresh meat killed. For our meat we lived on ptarmigan, with one delicious sandhill crane, and some reindeer that was given to us for variety. And in addition to the necessities of life, for a Botanist the identification of the countless new species of plants on the tundra is a lure which urges him to work with all the haste of civilization, even in this remote corner of the globe.

It is a country wholly different. It is a hill-country prairie, for it is treeless and lies in a region known as the "barren lands." These barrens extend from the Aleutian Peninsula to the region of the McKenzie River delta, the only point where trees border the Arctic Ocean. In truth it is not a barren territory, but is, instead, covered by a most diverse and abundant flora with a hundred or more species in a small area. In Seward Peninsula the area is one of interminable hills gloriously colored and rolling to infinite distances; and often, as one watches them, rainbows arch them over and touch the ground at each end where pots of gold may lie in truth. More than on the prairies does one have a feeling of immense spaciousness and vision to remote places. It is said that on a very clear day one may see from Kougarok Mountain into Siberia, over a hundred miles away. And the ability to see so far, yet the absence of any object of known size in that view by which one may estimate distances, leads the observer, as Steffanson explains, to make strange errors in judgments. Captain MacIntyre of the *Teddy Bear* told a story of mistaking an Arctic mouse for a polar bear, and certainly one of our party mistook a claim stake for our cabin, and was lost thereby. It is a curious country of misleading seeming-familiarity, a fascinating country which, in spite of all its dangers, compels love even from those who most loudly condemn the vagaries of climate and place.

The tundra, as stated before, is not barren but is covered by a carpet of hummocking plants overlying in most places centuries' accumulation of raw humus. Rock surfaces are exposed only on the highest mountains and comparatively recent faults, and in the creek beds of cutting streams. For the most part, it is a country of swampy conditions everywhere, so that to the newcomer "mush," used as it is in Alaska to mean "move on," "travel," would seem to have come into use from the suggestive character of the country rather than from its authentic derivation as a corruption of "marchon." The accumulation of humus which freezes and thus prevents drainage causes the hydrophytic conditions which, together with the cold, are responsible for the universal

Fig. 3. Reindeer lichen and the opposite-leaved Saxifrage of the "fell fields."

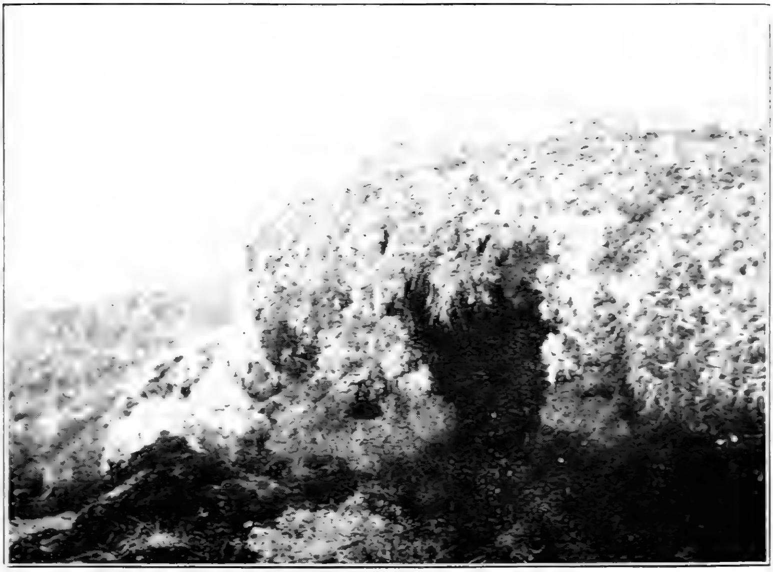


Fig. 4. Tundra of Sphagnum and heath collapsing because of thawing of the substratum by running water.

presence of sphagnum and plants of xeromorphic character. As is well known, the plants are all of the low-growing, dwarf habit, with many of them of cushion forms which retain their dead leaves and structures for some time. The flowers, tho small, are exquisitely vivid, even more beautiful than members of the same genera which are familiar in this region, such as Dodecatheon, Myosotis, and so forth.

Warming, in his *Oecology,* describes the fell fields, the moss tundra, the lichen tundra, and the dwarf shrub heath of Arctic regions; and he indicates the water relationships of these by putting the moss association as following the fell fields when the mosses gain the ascendency, and the lichens as inhabiting the drier portions of any of these associations. Since then no work has been done to determine any further ecological relationships between these associations, tho a great deal has been done toward collection and identification of Arctic species. In the time that was possible the attention of the writer was directed toward the relationships and location of different type associations. But these observations can be regarded only as preliminary, almost as merely casual, for they were made over a very limited area, and also under atypical weather conditions. They make no claim other than to be just suggestive.

The types of tundra observed by the writer were (1) pioneer lichen associations, (2) open dwarf shrub associations, (3) closed dwarf shrub associations, (4) Carex-Eriophorum associations, (5) Spagnum-willow associations, and (6) the grass associations of the flood plains. The most important factor in influencing the rate of succession between these associations is apparently the wind, as the climate is apparently humid enough for the support of mesophytic forms. After the accumulation of humus by the early stages the water relations are affected by drainage, for the freezing of the peat deposits below prevents drainage and creates conditions productive of zeromorphic plant forms; but seepage of water from higher land above the peat tends to keep the substratum thawed and gives rise to swampy conditions described below in the Sphagnum-willow association.

The descriptions of these formations given below are very brief and no species except type species are named. More detail concerning these will be given in a paper that is to be published.

On the rock uplands, the lichens are pioneers as they are elsewhere, but they are of shorter duration except on the perpendicular surfaces, for crevices and slopes are soon taken up with shrubs such as Diapensia lapponica, Salix uva-ursa (?), and Dryas octopetala; and these form the thin scattered cushions of vegetation called "fell fields" above. Their growth continues until they cover the ground with a thick carpet in which other plants intermingle. Potentilla uniflora, P. biflora are prominent in this situation, as are also Arctostaphylos alpina, Andromeda polifolia, Cassiope tetragona, Rhododendron lapponica. One or another of these may be dominant in any particular location, depending perhaps on priority of occupancy; and hence arise the names of Dryas tundra, etc., used by Warming. These shrubs may become so thickly intergrown in later stages with sedges and grasses and herbaceous plants that the shrubby character may be lost entirely, and in this situation the Potentilla and bearberry, perhaps, are the best survivals of the shrubs. This stage is regarded by the writer as a probable transition stage between the dwarf shrub and the Sphagnum-Ericad tundra mentioned below. The rapidity with which dwarf shrubs cover the ground and develop the thick carpet just described depends upon the protection from wind, as stated before. The windward and lee slopes of a hill offer strong contrasts to each other, and even on one boulder, the protected and exposed sides may show, in one case, a solid covering, and in the second, a perfectly bare surface except for a few lichens.

Succeeding the more open stages of the dwarf shrub associations there may be the cotton grass-sedge association, developed in situations made hydrophytic by configuration of the land and drainage influenced thus. These places show accumulations of rock soil and reveal on digging the frozen condition of this soil. Dryas may remain with the sedges, but it is infrequent, and the other shrubs are even still rarer, but mosses and herbaceous plants are plentiful. The clump habit of these plants causes hummocks (what Alaskans call "nigger-heads") and reticulate ridges with puddles between where water often remains and Nostoc sp. and hydrophytic mosses are found.

The question of a climax is a difficult one. In the opinion of the writer it seems probable that the climax is the Sphagnum-Ericad tundra, (1) because it seems from the observations to be most extensive in conditions not made unusual by peculiar drainage conditions, and (2) because it was an association found in areas of greatest age, for example on the Arctic Divide. This association has Sphagnum abundant but not very conspicuous because of the larger size of the shrubs, the most important of which are Ledum palustris, Vaccinium ulignosum, V. Vitis-idaea, Betula glandulosa, and especially Rubus Chamaemorus. On the drier hummocks, which are still characteristic, are sedges and Polytrichum. Deep layers of peat are usually found beneath this association, and are frequently exposed by erosion of streams which cut thru it and expose the frozen, rock-like layers below.

So far as the writer observed the grasses have place only on flood plains of alluvial character, or of peat character, if the former tundra vegetation of the peat has not survived transplantation. It is a brief stage and apparently gives way to either the willows or to the sphagnum and heaths. The willows are particularly interesting in that they are distributed in regions where the ground is thawed and wet. This condition is brought about usually by seepage thru the peat of water draining from higher levels. The drainage lines are usually very conspicuous, and the line of extent of the willows coincides with these drainage lines. These shrubs are of the espalier habit described by Warming; they grow about five to six feet high and attain an inch or so in diamter in fifty to sixty years of growth. Growing beneath the willows are mesophytic mosses, sphagnum, and many herbaceous plants.

It is evident from this brief discussion that any change causing new drainage lines will cause changes in the plant associations; and because the peat is eroded easily this frequently occurs. A gully developed by the spring freshets of one year is shown in the accompanying pictures. The down-cutting was creating market changes in the topography. The lumps of peat dislodged frequently were deposited in short distances with their plants undisturbed, and these then continued their growth in their new situation. Retrogression due to drainage of a previously undrained area would naturally give rise to more xerophytic conditions. In locations where this had happened, a lichen association was found over-growing the former plant association. The plants of this former association did not die completely, but continued to live in less vigorous condition and send occasional shoots above the over-growing lichens.

These observations were made in the month of our stay in the Kougarok. We left there on the third of September and traveled overland to Nome, a "mush" of about one hundred fifty miles, with an Alaskan pack saddle carrying all our luggage. The weight was easy to carry because of the comfort of the pack in spite of the difficult walk; and the weather was the most beautiful of the whole summer. At Shelton we took the Seward Peninsula Railroad, an old track laid for use with gasoline engines in the days when Shelton hummed with gold prospects. Since then no one is left living in Shelton, and the railroad is unrepaired. Its rails are frequently missing, and sometimes the tundra beneath the track has sunk out of sight; yet in spite of danger, it is easier travel than walking, and it is used by individuals who hitch their dogs to small hand cars and enjoy traveling at the greatest speed of five to six miles an hour on the upgrades and twenty miles an hour or more on the down grades. For excitement and adventure, there can be no rival for the Seward Peninsula Railroad!

The journey of nearly four months resulted in only meager results. It was not primarily a Botanical expedition, altho that was the main interest of the writer. But it served as an introduction to a novel land of delight for all those who love adventuring in the open and a land of possibility for Botanists who wish an unexplored field. *The Northward Course of Empire* by Steffanson can help one to a realization of the economic possibilities and a truer appreciation of the pleasures of this country. But no words of any pen can describe adequately the joys of the open hill-country to anyone who has been there and forever longs to go back.

PAPERS ON BIOLOGY AND AGRICULTURE

PRACTICAL PLANT PROTECTION.

WILLARD N. CLUTE, EDITOR, AMERICAN BOTANIST, JOLIET.

In the early days the wildflowers were so abundant and widespread that the destruction of immense numbers was of no consequence, but with the growth of our country, many of the more showy and attractive specimens have been brought to the verge of extinction. A few species have disappeared or are disappearing from purely natural causes, such as the chestnut blight and the pine blister rust, but the greatest enemy of the plants is man. For every flower picked for a bouquet, he destroys thousands by felling the forest, flooding the valleys, draining the swamps, burning the thickets and tearing up the prairie sod to set a whole new race of plants in the place of violet and shooting-star, puccoon and camassia, phlox and gentian, sunflower and goldenrod. His cattle trample them, all sorts of animals feed on them, the mower lays countless thousands low, and yet in some way little short of a miracle another year finds them smiling from fence-row and thicket with the same trustful innocence as of yore. Only when he finally stakes out a factory village in the midst of all this loveliness do the native plants give up the struggle.

Such things have to be if our own race is to survive, but we may well object to all unnecessary destruction of our wild plants. The roadmaker has no sooner torn his way through the wilderness than nature sets to work to repair the damage with a cloud of wildflowers. The ugly wounds of plow and scraper are healed with boneset, Joe-Pye-weed, clematis, bittersweet, asters, goldenrod and a host of others. And then back comes the roadmaker to "improve" his work by removing all this loveliness. To him the birds, the wildflowers, the sheltering trees and the wild things that scurry from one thicket to another are not to be compared with a carefully barbered roadside bordered by a neat barbed wire fence. Lawmaking bodies often encourage him in his efforts to lay waste the countryside by requiring this annual slaughter of wildflowers. Beauty is no excuse for being in the eyes of one who considers himself a practical man. In my own town some time ago, the question arose as to whether a certain nook about one of the public buildings should be covered with concrete or set with plants, and the care-taker was ordered to do whichever was cheapest!

Of all offenders against good taste in such matters, the railroads are the worst. Though quick to see the advantage of planting the station grounds with beautiful flowers, they are blind to the fact that the selfsame species are doing their best to ornament the whole right of way, and they send out laborers to cut them down. Great clumps of lilies, acres of painted-cups, banks of anemones, swamps of wild hyacinth, clouds of phlox, thickets of laurel, sandy wastes blue with lupine and whole galaxies of sunflowers fall before this untutored savage with a scythe. In late August last year, I travelled more than a thousand miles on our mid-west railroads without seeing a single conspicuous patch of wildflowers on the right of way. The mower had done his worst. The poorer railroads through lack of funds may still allow some of these wildlings to grow, but the better roads mow them down and then dilate on the scenery through which their lines run.

Added to the other destructive agencies must be the vandal out for a day's holiday. He not only devastates the roadsides but invades private property as well. Much of his transgressions must be ascribed to ignorance, for the general public seldom considers flowers of any special value and, indeed, supposes them to grow out of the ground much as wool grows on a sheep and therefore to be picked without compunction. It is to this individual that the increasing rarity of the wildflowers in the vicinity of cities and large towns is mostly due and now that the automobile has widened the range of his activities, no part of the country is safe.

It has often been assumed hastily that the methods of protection applied to birds so successfully need only be extended to the wildflowers to have equally happy results, but a moments reflection will serve to show that the cases are far from identical. Birds, being able to move about from place to place, are rarely if ever in the way. They are peculiarly the property of the whole public and their collection may well be prohibited entirely. Unlike the flowers, their attractiveness departs with their collection. Moreover, gifted with movement, they can move out of harm's way and are less easily exterminated. Every person induced to cease hunting them gives them that much more chance of surviving, but with plants, so long as there is a single person collecting, all are in danger. It is also easier to make sentiment in favor of bird protection because birds are known to be helpful as well as attractive in other ways. Birds may even be tolerated among our crops and attracted in various ways to frequent and nest in our grounds.

It may be doubted whether it is wise to prevent or even to discourage all picking of flowers. They appeal to the better natures of everybody, and children especially are not content to admire but must acquire as well. Childhood forbidden to gather flowers would be a sorry spectacle. All our traditions are in favor of making use of the flowers. Man wore flowers long before he wore clothes, and he still takes pleasure in decorating his grounds, his residence and himself with them. The use of plants in garlands and coronels has been a custom for so long that this is embodied in the common names that were in existence long before scientific names were thought of. We still make use of a wealth of flowers on all festive occasions, and with them we also attempt to cheer the sick or soften the grief of those whose friends have passed on to more flowery fields. Every city and hamlet has one or more shops wherein are sold flowers only. In view of all this we cannot reasonably ask the lover of flowers to cease picking them entirely. There is a pleasure in the pursuit of any thing that comes only with possession. Does anybody imagine that the hunting and fishing that still go on in settled communities is inspired by the need of food? Far from it. The spoils brought home by the hunter or fisher are simply the trophies that speak of his success. They are concrete evidences of his prowess. And shall we deny the child, the poet and other flower-lovers their evidences of success? Why, even the birds gather flowers! The martins delight to deck their nesting sites with peach-blossoms, crows are well known to be attracted by bright blossoms, and even the blood-thirsty hawk has been known to ornament his nest with violets.

Fortunately for us, all flowering plants do not need protection. The rough and ugly weeds need not be included in our list since nobody cares to collect them, but there are many fair flowers as well as weeds on the farmer's list of enemies, and many others whose room is regarded as much better than their company. A large number must be exterminated if we and our crops are to live. One may gather as much as he will of buttercups, daisies, toad-flax, evening primroses, bouncing Bet, rudbeckias, goldenrod, wild morning glories and the like without fear of reducing the supply. And there are many others so rampant as to growth, so ubiquitous and persistent, that an annual picking seems almost necessary to keep them within bounds. Of this nature are dandelions, bouncing Bet, the elder and in some localities the wild crab. We may be thankful, also, that there are a few others that are protected by their habitat: species of inaccessible cliffs, remote mountain summits, desert fastnesses and extensive barrens. These are natural sanctuaries in which the embattled plants may persist long after their kind, elsewhere, have given up the contest. No thoughtless band of picknickers are likely to devastate such a region or destroy a whole race at one sweep.

The plants that are in need of special protection are a comparatively small number that have been brought to the attention of the public through some special attractiveness they possess. All the early flowering species are in danger because, coming so close on the heels of winter, they are typical harbingers of the milder season to which we always look forward. The flowers of midsummer rarely receive like attention. Then there is another class made conspicuous by history, tradition or use, such as the fringed gentian, ginseng, golden seal, pitcher plant, lotus, arbutus, the orchids and the like. Plants which are shallow rooted and easily pulled up, like the phlox, hairbell and the cardinal flower, or those in which the leaves are collected with the flowers, such as trillium, jack-in-the-pulpit, rue anemone, are especially in need of protection. Unusually fragile species must be considered also, such as the Dutchman's breeches, bloodroot, celandine, and Indian pipe. To these must be added those species whose leaves are the objects sought, among them the laurel, galax, many ferns, and ground pine. Last are those plants whose beauty is so conspicuous as to attract even the matter-of-fact business man—the azalia, the mountain laurel, water lilies, flowering dogwood, redbud and others. All these must be protected or they will disappear speedily.

All right-thinking people are agreed that our wildflowers should be protected, but they are not of one mind as to the best way to accomplish it. The sentimentalist speaks of "the sanctity of plant life" and adjures us to "love the lily and leave it on its stalk" or perchance to "leave the dainty little recluse to fulfill the law of its being." If he (or is it she?) is speaking of properly protected areas, we may not object, but of what advantage is it to leave a much desired specimen to the tender mercies of the marauding urchin or some wandering cow? I still remember with some chagrin inducing a class on a field trip to refrain from gathering a thousand or more pogonia orchids, and later while lunching in a shady spot, seeing the entire thousand go by—a solid mass of wilting blossoms in the clutches of a couple of small boys. So long as there is one individual interested in picking, no plant in unprotected areas is safe.

If we divest the whole question of sentiment and get down to the business methods of protecting plants, we shall discover that adequate laws, justly enforced, is the only solution of the matter. We should bend our energies toward securing a law in every state which will back up the land-owner in protecting his own. And after such a law is secured, we should see that it is enforced. The sale of wildflowers should be forbidden absolutely except by legal permit, and the dealers in such things should be obliged to breed their stock and not dig it up from the wilds. With proper laws, sanctuaries for plants could be established and maintained. Every park, every large estate, the railroad rights of way, the lake shores, the river banks and many roadsides ought to be made sanctuaries of this kind. The railroads maintain with some truth that the undergrowth must be kept down to prevent disastrous fires, but it is quite possible to indicate the decorative plants and except them from the annual mowing. A number of interesting plants, owing to the special conditions under which they grow, probably must be protected in their present habitats, but this in a majority of cases is entirely feasible. In other cases, rare plants may be removed to protected areas.

Even with adequate laws there is still needed an effort to interest land-owners in protection. Every farm woodlot should become a protected area until the land is needed for something else. It should be fairly easy to induce the farmer to post his entire farm and perhaps to design a special notice for the purpose. When his attention is drawn to the interest the botanist has in some rarity on his lands, he is generally as much in favor of protecting it as anybody.

It is probable that there will always be numerous areas in which flower picking may go on, but even here there is need for education in the selection of the flowers and in the proper manner of gathering. Emphasis should be laid on the fact that a few well-chosen blossoms are far superior to a larger number gathered with less discrimination. The ignorant and unthinking are ever impressed by mere size and reason that if a dozen are good, a hundred are better. It is a failing that all are prone to. Do we not always mention the size of our home town before mentioning its intellectual citizens? Children and adults, too, for that matter, should be taught to select only the fresh and newly-opened specimens, leaving those that are past their prime to reproduce the plants. Merely to instruct the public in the proper way to gather flowers will go a long way toward protecting the landscape from devastation. The true lover of flowers rarely returns from an excursion laden with specimens. The planting of memorial trees and the decorating of our great transcontinental highways with flowering plants should do much to direct the attention of the public toward a right attitude regarding the wild flora.

But in the end we come back to our original thesis; the best and most practical way of protecting the plants is by adequate laws properly enforced. Let us do what we can to hasten the day when this condition shall prevail throughout the land.

MYTILASPIS CITRICOLA AND OTHER SCALE INSECTS

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Scale insects belong to the family Coccidae, which includes three sub-families: Dactylopinae or Mealy Bugs, Coccinae or Soft Scales, and Diaspinae or Armored Scales. Parthenogenesis occurs in many species of Coccidae to a certain extent but it is not so general as among Aphididae. The males, which are smaller than the females, are difficult to secure as they have no mouths and are short-lived. They differ from the females also in having wings with which they move about freely. The female is wingless and, attaching herself to a plant or fruit, secretes a scalelike shield as a refuge for herself and her young, losing in time her external organs and becoming little more than a protecting shell.

Coccidae are destructive to fruit trees and fruits, yet they do not multiply as rapidly as aphids do. The female fastens her beak in a leaf or fruit and remains in one place. After secreting a scale which envelopes her, she lays her eggs beneath the scale, where they hatch. The young females settle down near the mother. Some Coccidae give birth to living young which are visible in the body of the mother, as may be seen in the microscope slides which I made two years ago.

In the Mealy Bug, Dactylopinae, no scales are formed, but usually there is a cottony sac. In the common species of the greenhouses *(Pseudococcus citri)* Lutz* says: "The eggs are laid under the female in a loose nest of sticky, white fibers in such quantities that she is forced to stand on her head in order to feed."

Soft Scales are characterized by the Cottony Scale of Maple and some other plants. These scales, if such they may be called, are the thickened surface of the insect rather than a true scale. This mass of cottony material is secreted by the female of *Pulvinaria innumerabilis* in which to place her eggs. The sticky substance found under the trees is honey-dew secreted by these insects.

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* Frank E. Lutz, Field Book of Insects.

Of the true Scale insects, Diaspinae, the best known, is probably the *Aspidiotus perniciosus* or San José Scale, which is only about .06 inch long, and was introduced originally into California (where it got its name), but is now found in most parts of the United States. This Scale is so well-known that a description of it is superfluous. Kellogg, in "American Insects," says: "Early in the spring, females which have hibernated under their protecting armor begin giving birth to living young, and continue doing this actively for about six weeks, when they die exhausted."

Aspidiotus ficus, Ashmead, is the Red Scale of Florida that affects oranges, especially on the trees grown in conservatories. The color is rich reddish brown, almost black, with the central portion much lighter. It is nearly circular in outline, with the molted skins in the center of the scale.

Aspidiotus aurantii, Maskell, is the name of the Red Scale of California, which differs from the preceding, as Marlatt** says, "in the fact that the body of the female turns a reddish brown and shows through the thin transparent waxy scale. * * * * * It is controlled by oily washes, and also by the gas treatment. The young are born free, or in other words, the insect is semi-oviparous, and therefore any wash which will kill the old scale will destroy the young also."

Mytilaspis citricola, Packard, or the Purple Scale, is one of the most plentiful scales affecting both orange and lemon. It is found in Florida as well as in California. In shape it resembles the Oyster-shell scale of the apple, which is round and flat at one end and gradually narrows to a blunt point at the other. It has a bent or twisted appearance. The color is brownish purple.

** C. L. Marlatt. Scale Insects and Mites on Citrus Trees.

OPPORTUNITIES FOR BOTANICAL RESEARCH IN CENTRAL AMERICA

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It was my good fortune during the winter of 1922 to make a botanical expedition through Central America. I have no intention now of giving an account or travelogue of that expedition, yet, remote as my topic may seem, there are a few matters relative thereto which, I think, are of sufficient general interest to bring before this group of active scientific men and women. I should like furthermore to say at the outset that by opportunities for botanical research in Central America I do not mean opportunities offered by elaborately equipped and well manned laboratories in endowed institutions, nor do I have reference to special grants generously made by scientific organizations in Central America to encourage botanical research. These things, as you all know, do not exist in that country.

I do want to call your attention, however, to the fact that Central America itself offers exceptional opportunities for research in botany—first on the part of the systematist; second, the ecologist; third, the plant geographer; and fourth, the one interested in the development of economic plant products.

It is true that the flora of Mexico, Guatemala, Salvador, Costa Rica and the Canal Zone, through the labors of Gray, Watson, John Donell-Smith, Coulter, Robinson, Rose, Brandegee, Pittier, Maxon, Standley and others, has been studied somewhat intensively during the past 25 or 30 years, but that work has been more or less intermittent, the publications are fragmentary, and there exists today no complete or comprehensive published flora of these countries; and as a matter of fact a vast amount of work must still be done before an exhaustive flora of Mexico or the other countries mentioned is possible.

British Honduras, Honduras, Nicaragua, and the Republic of Panama have been explored but little and the flora as yet is but superficially known. Indeed, only a few hundred specimens from these countries exist in American or European herbaria. To the taxonomist, therefore, the latter countries mentioned, particularly Nicaragua and Honduras, constitute an almost virgin field for exploration and research.

The natural conditions in Central America, namely, the geographical formations, the varied topography, precipitation, air currents, trade winds, temperature factors, etc., are such that the most pronounced changes in the character of the vegetation are evident in contiguous regions extending over relatively limited areas. Many of these regions present to the ecologist interesting and highly significant problems. This fact is shown conspicuously as one crosses the Republic of Costa Rica from east to west, namely, from Port Limon on the Caribbean Sea to Punta-Arenas on the Pacific.

An adequate description of this country in few words is beyond my ability to present. Briefly, however, the east coast is low, the rain fall is abundant, and the vegetation is tropical. Cartago and San José are located on an elevated plateau about 3000-3500 feet above sea level. At least three rivers have their origin on this plateau. To the north of San José and Cartago is the so-called Cordillera Central, consisting of several volcanic mountains, namely, Turrialba, Irazu, Barba, Poas, and others ranging in elevation from 8000 to almost 12000 feet above sea level. Immediately to the south of this plateau lies the southern Cordillera with enormous mountain masses, such as Buena Vista, Pic de la Vueltas, El Copey, and Cerro de la Muerte (the wall of death), almost as high as those peaks to the north.

The general course of both Cordilleras is northwest and southeast. The prevailing winds, at least during the winter months, come from the east or southeast; there is, therefore, an abundant precipitation on the eastern and southeastern slopes of both Cordilleras. The country to the west of these great mountain masses, namely, west of the continental divide, receives only a limited amount of rain fall, especially during the winter months, and the vegetation there is relatively sparse and presents a marked contrast with that in the eastern part of the country. The change in the character of the vegetation is quite abrupt, and is noticeable especially between San José and Punta-Arenas. Chemical content in the soil here plays little or no role in the growth of plants; it is mainly a matter of moisture.

Permit me to mention another similar situation in Guatemala. In southeastern Guatemala is a region lying mainly along the Motagua River which is one of the most notable deserts in all Central America. On either side of the river is a range of mountains, off-shoots from the Sierra Madre; their general course is almost northeast and southwest, as is most of the mountain ranges which make up the great Honduras-Nicaragua peninsula. The prevailing winds here also are from the east or southeast, and the precipitation is confined mainly to the mountains east of the Motagua River or to the high slopes of the mountains to the northwest of the river. There is a very limited amount of precipitation in the valley, and the result is a typical cactus desert miles in extent, centering about the region of Zacapa and known locally as the Zacapa desert. Farther northeast and at lower altitudes in this same river valley where there is little to obstruct the moist-laden trade winds, namely, in the vicinity of Puerto Barrios, there is one of the most luxuriant tropical palm-vegetations to be found anywhere in Central America. These may seem to be very simple matters in ecology. They are; but they are significant nevertheless, not only in determining the character of vegetation on local areas but also in determining the distribution of vegetation in the American tropics. A particular opportunity, however, to which I should like to call the attention of the ecologists is that of a study of plant succession in volcanic craters. For example, there are on Mount Poas in Costa Rica several volcanic craters representing eruptions which have taken place at different times, and each crater has, more or less, its distinctive flora in accordance with its relative age.

What now are the specific opportunities in Central America for the plant geographer? No one can say at present with any degree of certainty how far the Andean flora of South America extends into Central America, or to what extent the reverse migration has taken place. In other words, our knowledge of the flora of these two countries is not yet sufficient to enable any one to say what floral elements are common to the two countries or what the proportion of occurrence of floral elements in one country is to that of the other. Presumably there has been a northward trend of tropical vegetation since the glacial period. In this connection it may be of interest to site a few cases of specific plant distribution.

In Colombia one of the most common types of vegetation is to be found on the paramo or dry ridges. This type of growth consists largely of Compositae of a shrubby or suffruticose habit; and it includes several species of *Eupatorium* and *Senecio*. One of the common plants of the paramo of Colombia is *Senecio vaccinioides* Wedd. Curiously enough either the same thing or a very closely related species, described as *Senecio firmipes* Greenm., occurs on the Vueltas and on the Cerro de la Muerte of the southern Cordillera in Costa Rica at an altitude of 3100 meters or about 10000 feet. Only two stations are known for this plant in Costa Rica, and it has never been reported from Panama. The *Senecio vaccinioides* is very common in Colombia and whether the two things are conspecific or not, it is fair to assume that the Costa Rican form has descended from the South American type, and probably represents a northern migration which has taken place since the glacial times. Certain other natural groups of *Senecio,* consisting of several little known trailing or climbing species, are represented both in South America and Central America. The affinities or relationships of these species are such as to show clearly a South American origin; and the present distribution of these species is such as to indicate a northern migration from the Andean region of Ecuador and Colombia into Central America. In at least one instance this northward migration has extended to that great elevated mountain region of Orizaba in Southern Mexico. In most cases, however, these plants do not occur north of the Southern Cordilleras in Costa Rica.

May I mention one more specific example? I found growing, and apparently indigenous, on the great mountain mass known as Mount Poas in Costa Rica, a species of *Solanum* which is conspecific with the South American *Solanum tuberosum L.* from which our common Irish potato has been derived. It would seem that we have here also a case of northern migration of an Andean species. Further investigations along these lines would unquestionably yield interesting and valuable results in determining the relation of our Central American flora to that of Andean South America; and a most profitable region for investigation in plant distribution is that of these great east and west ranges of Costa Rica, Nicaragua, and Honduras.

It is, of course, well known that Central America for many years, mainly through corporation interests, has been a source of supply for certain staple food and other economic plant products, particularly bananas, coffee, dye woods, fibers, etc. The natural resources, however, have been barely touched; but as a matter of fact the possibilities for development and increase of out-put of these and similar products are more promising today than ever before. There are already limited facilities for botanical research at the laboratory in connection with the hospital at Ancon in the Canal Zone, and certain research work is there under way. There is also a small government station at Frijoles in the Canal Zone where certain experimental work on tropical fruits is being conducted under the direction of Doctor David Fairchild. The various corporations, like the United Fruit Company, employ their own specialists to take care of their special botanical problems. Furthermore, as you doubtless know, a movement is under way to establish somewhere in the American tropics a station where it will be possible to carry on various lines of botanical activity. Transportation facilities between the different Central American countries are being extended by the Ferro Nacional or National Railway. Indeed, one can now travel by rail all the way from any railway point in the United States to Guatemala City, and it will be only a short time before that railway system will be extended through Salvador; and eventually it will be continued to the Canal Zone. Railways and roadways are being built in Honduras and Salvador which will open up the interior of those countries.

Recently a chemical manufacturer in Chicago said to me, "We import hundreds of tons of plant materials from India, China, Ceylon, etc., from which we make oils, perfumes, soaps, et cetera. Why can't we get these raw products from Central America?" Many of them could be obtained there and in the West Indies also if we only had a better knowledge of the flora and conditions of those countries and could develop their natural resources. The United States must turn to the American tropics not only for an increased supply of fruit products, but also for an increased supply of varied raw plant products. The rapidly expanding commercial relations between the United States, Central America, and South America render the present time most opportune to enter the tropics of Central America for more intensive botanical research.

A COMPARISON OF THE TRANSPIRATION RATES OF CORN AND CERTAIN COMMON WEEDS

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That the presence of weeds in a corn field is detrimental to the intake of moisture, the reception of light and the manufacture of food by the corn plant has been demonstrated by experiment (15). Such experiments, however, do not show either the amount or the rate of removal of water from the soil by the weed invaders. It is the purpose of the present paper to present data concerning the relative rates of water loss by transpiration from the leaves of corn and of corn field weeds growing under the same environmental conditions.

The study of transpiration from the leaves of growing plants is by no means new. Trelease and Livingston (19), for example, measured the relative transpiring power of a number of plants. These authors were interested, however, in the diurnal fluctuations of this transpiring power rather than with the differences between different plants. Bakke (1) also measured the index of transpiring power of various plants and the same might be said of several other authors. A fairly complete bibliography of the subject is given by Kiesselbach (10). No historical resumé of the literature will be attempted here but it may be pointed out that most of the writers have been concerned with the relative transpiring power of plants as compared with evaporation from a free water surface, the latter, rather than any living plant, being the standard for comparison.

In the experiments described in the present paper the corn plant, rather than a free water surface, is the standard for comparison. The data presented do not give quantitative information as to the rate of water loss but they do show comparative rates of transpiration from a given area of corn leaf and equal areas of weed leaves, thus demonstrating which transpires more rapidly area for area. The experimental work was carried on by Miss McGinnis mostly in the botanical greenhouses at the

University of Illinois, Urbana, Illinois, between February sixth and April tenth, 1920. Only a few measurements were taken out of doors because it was necessary to finish the work before the end of the college year. This is regretted by the authors because they believe implicitly that ecological work should be done in the field. However, since the objective was comparative and not quantitative results it is believed that the data in this case are as valuable as though obtained in the field, for the differences between greenhouse and field environmental conditions should affect all plants used comparably.

MATERIALS AND METHODS

The corn used in this experiment was of the variety known as Reed's Yellow Dent, the seed being purchased from Vaughan's Seed Store, Chicago, Illinois. The weeds used were Polygonum pennsylvanicum, Sida spinosa and Setaria glauca, the seed of which was collected from cornfields near Urbana, and Ambrosia artemisiifolia and Abutilon Theophrasti, the seed of which was kindly supplied by the Agricultural Experiment Station of the University of Illinois.

These five kinds of weeds were grown in the greenhouse side by side with corn in such a way as to insure practically identical environmental conditions for all. The well known cobalt chloride paper of Stahl (18) as described by Livingston (12) and more recently improved by Livingston and Shreve (13) was used for making the tests, care being taken to use the same leaves each day, or, if not the same, those having the same relative position on the stem. This latter precaution was taken because of the fact pointed out by Bakke and Livingston (3) that leaves of different ages and occupying different positions on the stem may vary markedly in their transpiring power. The lateral leakage of moisture which undoubtedly takes place, as stated by Shive and Martin, when tripartite cobalt paper slips such as used by Livingston and Shreve are employed may be disregarded in this experiment since any such leakage that occurred must have affected readings from all plants used to the same extent.

In every case transpiration readings were taken from both the upper and lower surfaces of the leaves used and the average of the two was taken as the result to be recorded. Also, whenever possible, readings were repeated one or more times and all readings taken were averaged for each plant. The data given in the following table, therefore, consist of averages rather than the results of single readings.

RESULTS

The results are given in tabular form below. The figures in columns A, B, C, D, E, and F give the number of seconds required to change the color of the cobalt paper by the transpiration of the plant named at the head of the column. The columns headed A-B, A-C, etc. are difference columns and show the number of seconds more or less that were required to change the color of the cobalt paper on the foliar surfaces of the weeds than on that of the corn. A plus sign in these columns indicates that the number of seconds required for the color change was more in the case of the corn than in that of the weed while a minus sign indicates a greater number of seconds for the weed than for the corn.

TABLE 1.

	Corn A	Ambrosia B	Polygonum C	Setaria D	Abutilon E	Sida F	A-B	A-C	A-D	A-E	A-F
Feb. 6	87.3	63.7	56.5	178.7	167.4	.....	+23.6	+30.8	—91.4	—80.1	....
12	89.8	38.5	30.4	116.7	45.7	47.7	+51.3	+59.4	—26.9	+44.1	+42.1
13	128.3	54.2	83.3	119.7	100.7	89.9	+74.1	+45.0	+8.6	+27.6	+38.4
14	222.2	68.3	43.9	89.0	233.2	76.9	+153.9	+178.3	+133.2	—11.0	+145.3
16	112.3	47.7	47.3	.....	111.5	54.8	+64.6	+65.0	......	+0.8	+57.5
18	153.9	41.0	52.2	183.1	66.0	93.0	+112.9	+101.7	—29.2	+87.9	+60.9
23	220.6	41.4	96.3	.....	231.6	.....	+179.2	+124.3	......	—11.0	....
25	371.1	64.5	97.8	150.7	180.1	125.0	+306.6	+273.3	+220.4	+191.0	+246.1
27	164.9	44.5	68.0	230.7	93.2	57.9	+120.4	+96.9	—65.8	+71.7	+107.0
Mar. 3	99.3	24.6	45.2	156.2	95.1	61.0	+74.7	+54.1	—56.9	+4.2	+38.3
5	106.0	56.3	49.8	200.5	50.7	57.2	+49.7	+56.2	—94.5	+55.3	+48.5
13	88.0	33.7	21.0	153.8	92.0	24.9	+54.3	+67.0	—65.8	—4.4	+63.1
15	146.4	21.4	30.9	114.8	.....	.....	+125.0	+115.5	+31.6	......	....
18	183.2	38.3	18.7	126.2	127.6	64.6	+144.9	+164.5	+57.0	+55.0	+118.6
20	51.4	8.2	26.9	14.4	10.9	25.2	+43.2	+24.5	+37.0	+39.0	+26.2
22	86.1	19.4	20.6	74.3	15.1	24.5	+66.7	+65.5	+11.8	+71.0	+61.6
25	92.2	24.0	22.8	58.3	30.2	27.0	+68.2	+69.4	+33.9	+62.0	+65.2
26	91.6	21.6	20.5	65.1	28.7	22.4	+70.0	+71.1	+26.5	+62.9	+69.2
29	158.9	11.5	11.6	44.6	20.6	28.1	+147.4	+147.3	+114.3	+138.3	+130.8
Apr. 3	84.1	21.0	20.3	55.4	21.8	19.1	+63.1	+63.8	+28.7	+62.3	+65.0
7	63.7	17.5	17.8	61.4	27.1	54.2	+46.2	+45.9	+2.3	+36.3	+9.5
10	46.7	11.4	12.6	54.1	35.6	21.7	+35.3	+34.1	—7.4	+11.1	+25.0
Average	129.9	35.1	40.6	112.3	84.9	51.3	+94.8	+89.3	+17.6	+45.0	+78.6

DISCUSSION

In order to interpret the above data correctly it is necessary to keep in mind the fact that the figures in columns 2 to 7 represent in each case the number of seconds required for the color change in the cobalt paper to take place. A large number therefore indicates a low transpiration rate while a small number indicates a high transpiration rate. Likewise a plus in the difference columns indicates a high transpiration of the weed as compared with corn, while a minus shows that the rate in the case of the weed was low as compared to corn. With these facts in mind it is seen readily from the averages at the end of the table that all of the weeds used have higher transpiration rates, per unit area, than corn. Setaria, which is a grass and therefore closely related to corn, has a transpiration rate only slightly higher than corn since the average difference (column A-D) is only 17.6 seconds. The four dicotyledonous weeds, however, all have rates considerably higher than that of corn, the average differences varying from 45 seconds in the case of Abutilon to 94.8 seconds in the case of Ambrosia.

As seen from the table, the plants used, when arranged in the order of decreasing transpiration rate, stand as follows: Ambrosia, Polygonum, Sida, Abutilon, Setaria and corn. This order is fairly consistent with the number of stomata per unit area on the leaves of these plants. Corn and Setaria have approximately equal numbers of stomata per unit area and they are about evenly distributed on the upper and lower leaf surfaces. The numbers are very small, however, as compared to those found on any one of the dicotyledonous weeds, though the latter have many more stomata on the lower than on the upper surfaces.

The work described in this paper proves that corn transpires more slowly area for area than the weeds with which it was compared. Whether or not this fact is an economically important one under any conditions has not been demonstrated. Kiesselbach (10) showed conclusively that weeds do rob corn of some needed moisture, but other factors such as food supply, light relations, etc., have usually been considered of more importance. It is logical to suppose, however, that in case the moisture content of a soil were low, the withdrawal of even a small portion of this water by weeds might prove very serious to the life of the corn and, in this case, the rate at which weeds take water from the soil and transpire it into the atmosphere would be a factor of great practical importance.

SUMMARY

1. The relative rate of transpiration of Zea Mays, as indicated by cobalt paper, is lower per unit area than that of Polygonum pennsylvanicum, Sida spinosa, Ambrosia artemisiifolia, Abutilon Theophrasti and Setaria glauca.

2. Of the weeds compared with Zea Mays, Ambrosia artemisiifolia has the highest rate of water loss.

3. The transpiration rates of Zea Mays and Setaria glauca are more nearly similar than those of the corn and any of the dicotyledonous weeds studied.

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THE DETERMINATION OF THE AGE OF FISHES FROM SCALE CHARACTERISTICS

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Most people will be interested in the statement that many of our common kinds of fish carry about with them a record of the number of winters which they may have passed, and that the record is accessible to anyone who is familiar with the code, and who will take scales from a suitable place on the body of the fish and examine them with a microscope of rather low power. There is much difference in the ease and certainty with which such records can be deciphered, but among some groups, including sunfishes, black bass, and allied kinds, age determination is accomplished quite easily.

The presence of "winter marks" or annuli on scales of certain kinds of fish has been known for many years to specialists, and there is already an extensive literature dealing with age determination of marine and fresh-water fishes of Europe, and a few papers have appeared dealing with age studies of certain marine fishes of North America. Last year four papers from the University of Toronto dealt with rates of growth of Lake Erie fishes, including ciscoes, wall-eyed pike, yellow perch, and white-fish; and within the past few weeks a paper has been published by the Bureau of Fisheries at Washington which contains the results of similar studies on the orange-spotted sunfish which is a small form, common in Illinois and in various parts of the Mississippi Valley. This last paper is sold by the Superintendent of Documents, Washington, D. C., and is designated as: Bureau of Fisheries Document No. 938. It contains illustrations showing the appearance of scales and the annuli or winter marks when examined with the microscope.

It seems almost surprising that so little attention has been given thus far to such studies on fishes of the Mississippi Valley and of Illinois, but a beginning has been made and much greater interest doubtless will be evident in the near future. An extensive series of studies on Michigan fishes by zoologists of the University of Michigan is now in progress, and a beginning has been made at the University of Illinois on certain Illinois fishes.

Information that is not only interesting but that may be quite important becomes available when one can learn readily the age of fishes collected in various kinds of habitats. Two year old yellow perch from a small lake in northern Michigan are only two-thirds as long as perch of the same age from Lake Erie, and a five year old perch from the former lake may be scarcely as large as a three year old one from the Great Lakes. A law fixing the same minimum size of perch that may be taken from the two kinds of situations cannot be equally well adapted to both. A decision concerning the planting of young fish of any particular kind into a certain body of water might reasonably be greatly influenced by a knowledge of the rate of growth of that kind of fish in such a body of water.

Scale studies also permit a fairly close approximation to the size which any individual fish had attained at the times when its various winter marks were formed.

SEEDLING VASCULAR ANATOMY OF NELUMBO LUTEA

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This investigation was begun in 1913 in the hope of throwing further light on the origin of the monocotyls and dicotyls. During the progress of the work the development of the megasporangium, the megaspore, the female gametophyte (embryo sac), the proembryo and the embryo has been retraced. My preparations seem to be in agreement with the work of Lyon (6), York (7), Cook (2), and Conard (1). The only addition that I make to what is already known is the seedling vascular anatomy.

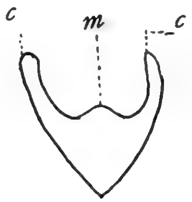
Material was obtained from the Illinois River at Meredosia, Illinois; from the Huron River at Huron, Ohio; from Grass Lake, Wisconsin; and from seedlings grown in the greenhouse of the Botany Department of the University of Chicago.

Seedlings which had "germinated" naturally in the Illinois River were collected at Meredosia, June 3, 1913 (Fig. 1). As there was a severe flood that year germination must have been unusually late. The seedlings were in some cases still in the top-shaped flower receptacles, but had developed so far as to have rhizomes and adventitious roots. Some freed seedlings were found. These showed how evanescent is the primary root; for it had never grown beyond the cotyledons. Adventitious roots had developed.

The development of megaspores and microspores, pollination, fertilization, the development of the embryo and seed formation, must proceed very rapidly; for all these stages were obtained from flowers and fruits collected on a single day, August 25, 1914, at the mouth of the Huron River. The seeds of course were not mature, the cotyledons were green and the seed coat had not been formed; but they were normal in size. In the fall the receptacles drop to the bottom of the stream, lie dormant during the winter, and the seeds "germinate" probably the succeeding spring.

FORMATION OF THE COTYLEDONS

The proembryo is spherical. I find no suspensor. My preparations seem to conform to those of Lyon (6) and York (7). However, in the light of later ideas of plant phylogeny I should place new interpretations upon them. The spherical embryo at first slightly elongates in the line of the long diameter of the embryo sac, (Figs. 2, 3). Soon it widens at right angles to the preceding elongation (Fig. 4), showing two actively growing points on



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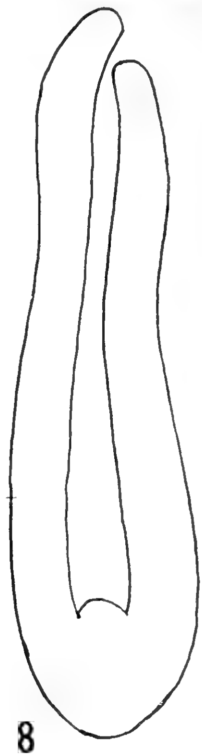

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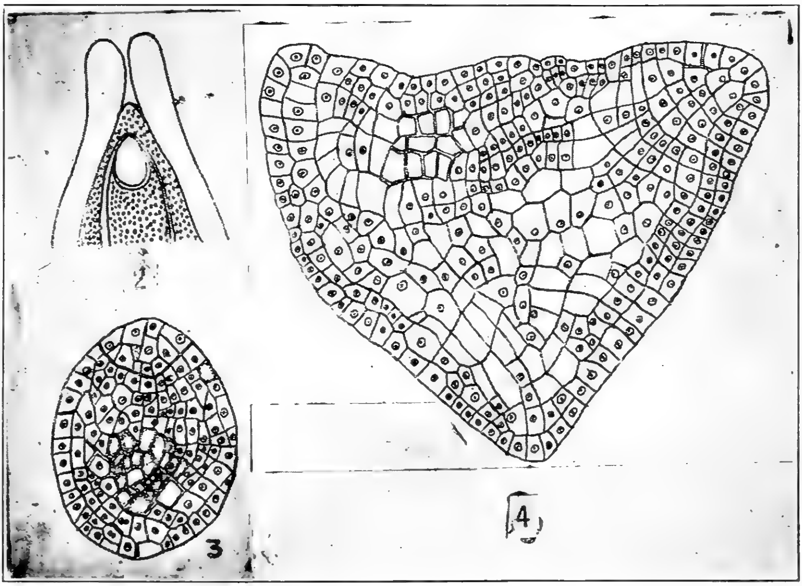
Figs. 7 and 8.

opposite sides of the periphery and a meristematic tip in the center. One of the peripheral growing points is much more active than the other, producing a single cotyledon (Fig. 5). Shortly after this the second growing point increases its activity and a second cotyledon appears (Fig. 6). The region between the two cotyledons grows very slowly. So rapid is the growth of the second

Fig. 1.



Figs. 2, 3, 4.

cotyledons that both are soon practically of the same size (Figs. 7, 8).

Desmogen strands show distinctly in a seedling having cotyledons 15 mm. in length with an epicotyl 4 mm. in length (Fig. 9). Phloem and xylem are not distinctly differentiated in the strands; but they can be traced easily. There are four root strands and one strand to each cotyledon. The latter forms three desmogen

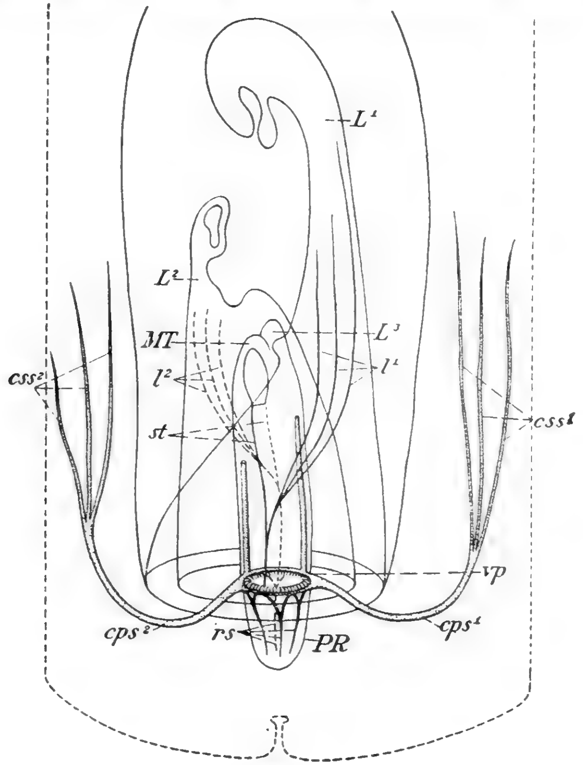


Fig. 9.

strands. The first and second leaves show early traces of similar strands. A single strand shows on each side of the epicotyl. The primary root is present, but no adventitious roots.

A slightly older embryo proved most helpful. Both longitudinal and transverse sections were made. A reconstruction of the arrangement of the vascular bundles was made from the transverse serial sections by means of two wax models; one of the region of the cotyledonary plate, the other the region of the epicotyl. This seedling has a short, thick, evanescent primary root, which never emerges from the surrounding embryonal tissues. Primary roots have four protoxylem strands. Each half of each strand separates from its fellow and these eight strands form a ring at the base of the cotyledonary plate, the phloem being placed outside of the xylem. As

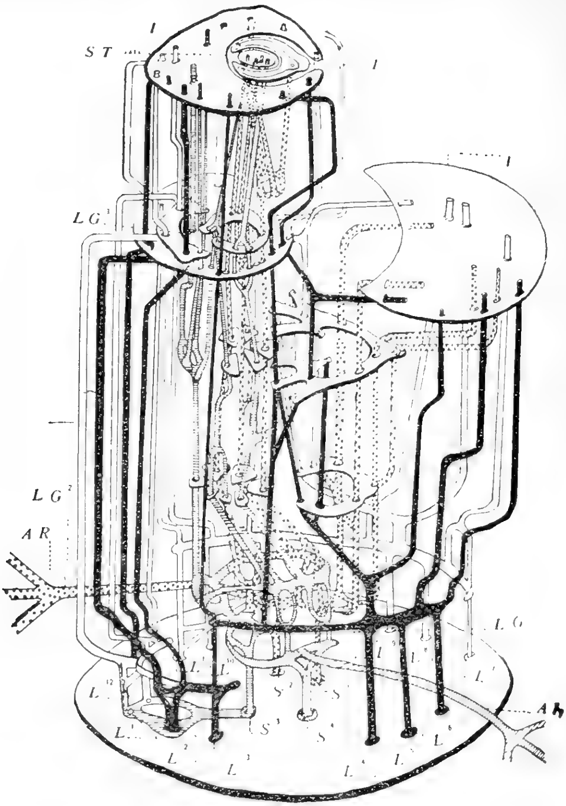


Fig. 13.

the embryo grows, one broad bundle from each side of the ring is laid down in each cotyledon. Each of these proves to be a complex of a number of bundles, twelve in this seedling, which can be separated into three groups, the various bundles meeting and parting again, thus forming the lattice work vascular structure of the typical monocotyledon, a polystelic vascular system (Fig. 12).

Fig. 5.

Fig. 6.

EPICOTYL ANATOMY (FIG. 13)

The following is the arrangement of the fibro-vascular bundles in the lower part of the epicotyl. In the center are four very prominent central bundles. Surrounding these are twelve smaller bundles, roughly describing a circle. The cotyledons were cut off between these bundles and the peripheral bundles. The latter are of course cotyledonary bundles, not epicotyl bundles. This arrangement continues for a considerable distance, but is disturbed at the level where the adventitious roots are given off. Six were formed in the seedling from which the model was made. They are the first permanent roots, and arise from an almost complete ring formed by the central bundles. The first leaf is supplied by strands

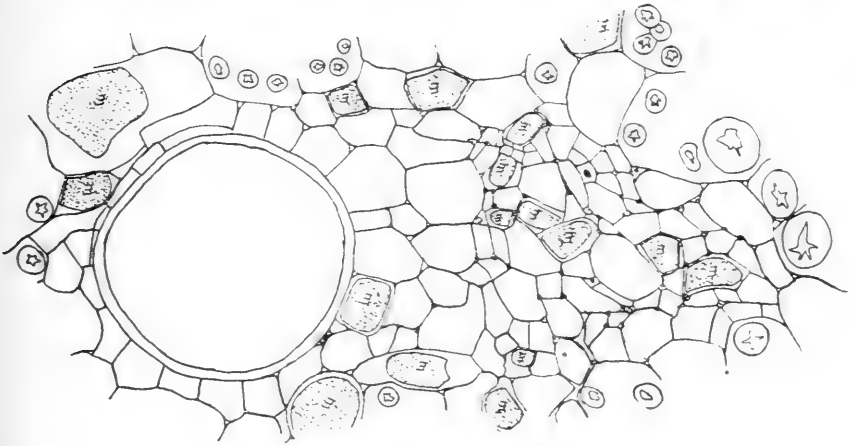


Fig. 14

which connect with one of the four central bundles, by peripheral strands, and by fusion strands connected with these two types. However, the suceeding leaves are supplied by fusion strands from all the epicotyl bundles. The arrangement of three desmogen strands to a leaf shown so clearly in the younger seedling has given place to a fusion type of structure. At this stage the petiole of the first leaf does not show fusion of strands. The adult leaf of *Nelumbo lutea* was cleared by immersion in equal parts of hot absolute alcohol and glacial acetic acid followed by immersion in clove oil and later by immersion in xylol.

It was then evident that although most of the vascular strands were closed, some of the small strands had blind endings. This would mean a dicotyl leaf venation, which was very close to monocotyledony. Immersion in a saturated chloral hydrate solution for twenty-four hours was tried for the same purpose, but with poorer success.

The fusion of bundle strands to form partial rings is a prominent feature. In some of these, leaf gaps may be seen.

The rhizome of *Nelumbo lutea* was studied. It is polystelic and shows collateral bundles without cambium, a monocotyl character (Fig. 14). However a few dicotyls are polystelic. Comparison of this rhizome with that of *Nelumbo albiflorum* shows the same type of bundle for both. Longitudinal sections of adventitious root tips of these two species were studied also, and are both of the usual dicotyl type. They differ only in that the outer cells of *N. albiflorum* have pitted walls. Conard states (1) that the Nymphaceae have this type of root structure.

Why the cotyledons of *Nelumbo lutea* should develop so peculiarly is difficult to understand. In embryos with a single cotyledon, the latter develops in contact with the ovule wall, which is markedly thicker there than the rest of the wall. This may mean larger food supply and therefore faster growth at that point. Later the second cotyledon grows with increasing rapidity and very soon overtakes the first. At the same time the meristem in the center grows slowly, the tissues between the cotyledons very slowly, and we have an apparent dicotyl plant. Before the second cotyledon has grown to any size, the thickening of the ovary wall has disappeared.

The researches of Coulter, Land, and Farrell show that monocotyledony and dicotyledony mean little and are very easily interchangeable. Farrell (5) found four growing points on the cotyledonary zone of Cyrtanthus. All except one slowed up and a single cotyledon was formed. Coulter and Land (4) found in Agapanthus one completely dicotyledonous seedling, while all the oth-

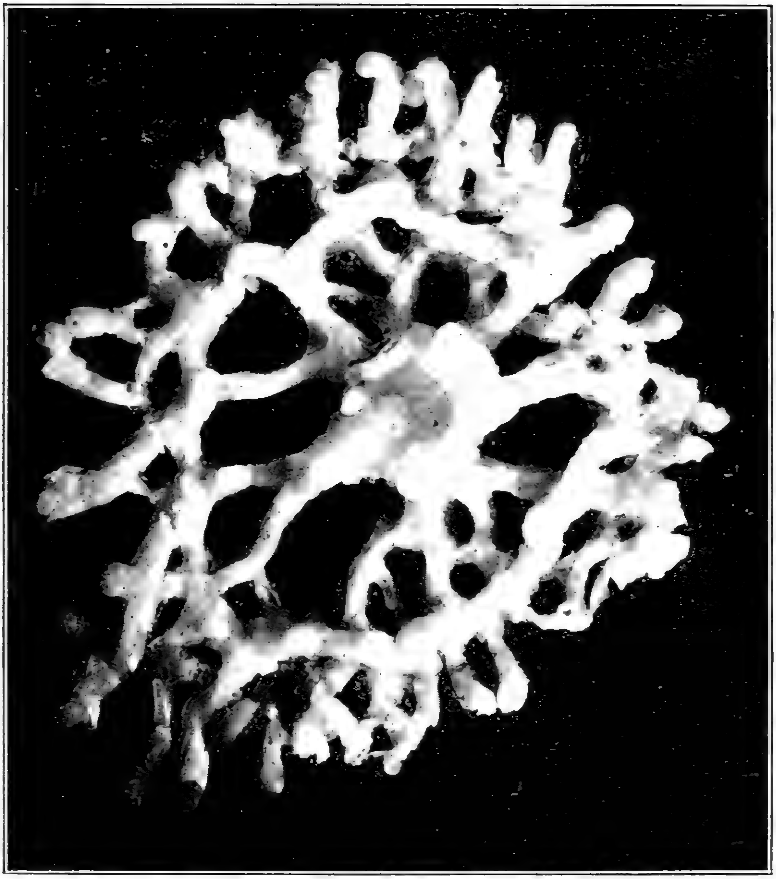


Fig. 12.

ers were monocotyledonous. The same authors show that even the grasses have in many cases a suppressed cotyledon (3).

SUMMARY

1. The massive spherical proembryo without a suspensor is considered to be a primitive characteristic.

2. The root, perhaps the most conservative organ, appears to show the prevailing dicotyl type, having a region of undifferentiated cell tissue from which calyptogen and dermatogen are ultimately derived. This arrangement corresponds to DeBary's third type of root tip.

3. The other vascular bundles of the plant are of the generally accepted monocotyledonous type as is shown by:

(a) Three vascular strands to each leaf and cotyledon in the juvenile stages.

(b) Polystelic bundle arrangement. However it must be remembered that while most monocotyls have this arrangement, some dicotyls also have it.

(c) Rhizome and epicotyl bundles are collateral and without stelar cambium. However a very few of the dicotyls are without stelar cambium and some monocotyls are said to show traces of stelar cambium.

(d) The venation of the adult leaf is dicotyledonous.

(e) One cotyledon precedes the formation of a second cotyledon.

CONCLUSION

Nelumbo lutea is phylogenetically one of the higher angiosperms having both monocotyledonous and dicotyledonous characteristics. The fibro-vascular bundles are strongly monocotyledonous but they throw no light on the origin of the seed plants.

Finally, I wish to express my sincere thanks to Dr. J. M. Coulter, to Dr. W. J. G. Land, and to Dr. C. J. Chamberlain for kind assistance given me while making this investigation. Also to Dr. W. E. Davis of Manhattan, Kansas, to the authorities of the Missouri Botanical

Garden, and to Miss Gladys Gladfelter for helping me to secure material difficult to obtain. Also to Dr. L. C. Petry of Syracuse University for making the photograph of the vascular structure of the cotyledonary plate.

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LEGENDS FOR FIGURES.

Fig. 1. Seedlings which had germinated naturally, in the Illinois River.

Fig. 2. Micropylar end of young ovule.

Fig. 3. Spherical proembryo from Fig. 2. Begins to show traces of the traces of the formation of the root and cotyledons.

Fig. 4. Older proembryo.

Fig. 5. Photograph of a wax model of a young embryo with a single cotyledon.

Fig. 6. Photograph of a wax model of a slightly older embryo. The first cotyledon is large and in the background; the second cotyledon is small and is in the foreground.

Fig. 7. Diagram giving the shape of an older embryo: c, cotyledon; m, meristemic tip.

Fig. 8. Diagram giving shape and relative size as compared with Fig. 7, of an older embryo.

Fig. 9. Diagram of the desmogen strands of a young seedling made from serial longitudinal sections. Actual size of embryo. Length of cotyledons 15 mm. Length of epicotyl 4 mm. PR, primary root; vp, cotyledonary ring; $L^1L^2L^3$, first, second and third leaves; MT, meristematic tip; rs, root strands; cps^1, cps^2, primary cotyledonary strands; st, stem traces; css^1, css^2, secondary cotyledonary bundle traces; l^1, l^2, leaf traces.

Fig. 12. Photograph of a wax model made from serial transverse sections of the cotyledonary plate of the same seedling. The sections were 10 u thick. Four central bundles usually termed "stem bundles" are seen. Surrounding these are two concentric rows of bundles. The cotyledons were cut off from the stem between the inner and outer peripheral rows of bundles. The lattice work arrangement of the vascular strands is evident.

Fig. 13. Diagram of bundles in the epicotyl of the same seedling. Constructed by means of a model from the serial transverse sections 10 u thick. The base plate shows the arrangement of bundles thru the lower part of the epicotyl, from the region where the cotyledons are cut off, to the region where the adventitious root strands (AR) arise.
S^1, S^2, S^3, S^4,—central epicotyl bundles.
F^1, F^2, F^3,—first, second, and third leaves.
LG^1, LG^2, LG^3,—first, second, and third leaf gaps.
L^1, L^{12},—peripheral vascular strands.

Fig. 14. Transverse section of a bundle from the rhizome of Nelumbo lutea.

NOTE: In the preparation of the model of the oldest seedling pictured, comparisons were made with still older seedlings to determine certain points difficult to ascertain in so young a seedling. Some of the ideas thus gained are incorporated in the model.

THE BRAIN OF COENOLESTES OBSCURUS

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Coenolestes is a small ratlike Americal marsupial about five inches in length from tip of snout to root of the slender tail. It is a native of the high Andean forests and has been known to science since 1860, so far by rare and usually incomplete specimens from Colombia, Ecuador and Peru. Dr. Wilfred H. Osgood of the Field Museum recently collected eleven specimens, which he made the basis of an extensive monograph published in 1921. The brain of one specimen was sufficiently preserved for study, and Dr. C. Judson Herrick described and figured its dorsal, lateral and ventral surfaces in an appendix to the monograph. Cut into serial sections and stained by the iron-haematoxylin method to show both cells and fibres, it forms the basis of the present study.

The brain of this creature is especially interesting for two reasons. First, because it is one of the simplest and most generalized of mammalian brains, since both the monotreme brain's are rather highly specialized. Second, because the classification of Coenolestes in one or the other of the two marsupial suborders, Polyprotodontia and Diprotodontia, has given rise to a long and lively controversy.

In his account of the external features of this brain Dr. Herrick drew attention to its extreme simplicity, as evidenced both by the enormous development of the visible olfactory regions (olfactory bulbs, olfactory tubercles, lateral olfactory cortex) and by its small and smooth cerebral cortex, which he thought to be probably the least extensive, relative to the total weight of the brain, in the whole mammalian series, as so far described. He noted also that in external conformation the brain of Coenolestes resembled much more closely those of two Australian polyprotodont forms, the bandicoot Perameles and the marsupial mole Notoryctes, than it did that of the American opossum.

The lateral olfactory cortex, the cortex of the pyriform lobe (lob. p.), occupies more than half the lateral surface of the brain (Fig. 1). Both anteriorly and posteriorly it is in continuity with the median olfactory cortex or hippocampus (hip.). Dorsally (Fig. 2) the two are split apart by the wedgelike neopallium, which occupies the dorsal surface of the hemisphere. Its lines of contact with the two olfactory cortices are marked by two

Fig. 1

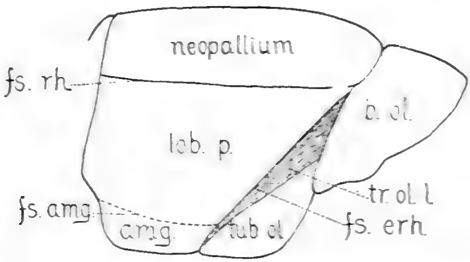


FIG. 1. Lateral view of the cerebral hemisphere of Coenolestes obscurus, as reconstructed from serial sections.

Reference letters: *amg.*, amygdaloid complex; *b. ol.*, olfactory bulb; *fs. amg.*, amygdaloid fissure; *fs. erh.*, endorhinal fissure; *fs. rh.*, rhinal fissure; *lob. p.*, pyriform lobe; *tr. ol. l.*, lateral olfactory tract; *tub. ol.*, olfactory tubercle.

Fig. 2

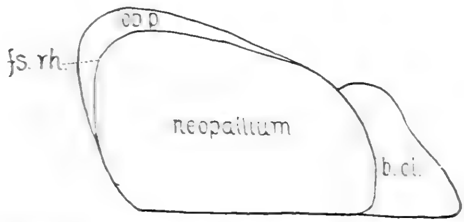


FIG. 2. Dorsal view of the cerebral hemisphere of Coenolestes obscurus, as reconstructed from serial sections.

Reference letters: *b. ol.*, olfactory bulb; *fs. rh.*, rhinal fissure; *lob. p.*, pyriform lobe.

Fig. 3

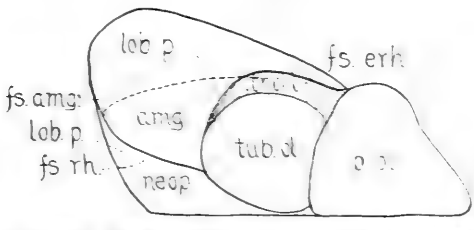


FIG. 3. Ventral surface of the cerebral hemisphere of Coenolestes obscurus, as reconstructed from serial sections.

Reference letters: *amg.*, amygdaloid complex—dotted outline indicates internal extent; *b. ol.*, olfactory bulb; *fs. amg.*, amygdaloid fissure; *fs. erh.*, endorhinal fissure; *fs. rh.*, rhinal fissure; *lob. p.*, pyriform lobe; *neop.*, neopallium; *tr. ol. l.*, lateral olfactory tract; *tub. ol.*, olfactory tubercle.

fissures—the hippocampus fissure (fs. hip.), where it meets the hippocampus, and the rhinal fissure (fs. rh.) where it meets the pyriform cortex (lob. p.)

Ventrally (Fig. 3) also these two olfactory cortices, lateral and medial, are separated by another wedgelike mass composed of two structures, one behind the other, both enormously developed in this brain. The anterior one is the great rounded olfactory tubercle (tub. ol.), lying just behind the huge olfactory bulb (b. ol.). It is encircled by a deep fissure, whose lateral portion is called the endorhinal fissure (fs. erh.). This is an important landmark and will be referred to later. The posterior of the two structures is the enormous amygdaloid complex (amg.). It lies just behind the olfactory tubercle and fills the rest of the basal surface of the brain.

Both these structures are complex as well as very large. In microscopic sections the olfactory tubercle presents a highly spectacular picture of convoluted and rolled cell masses or sheets, composed of cells of many sizes and types—the so-called "islands of Calleja". The olfactory tubercle receives great numbers of secondary olfactory fibres from both the lateral and median olfactory tracts, and emits a great quantity of tertiary fibres which join those from the pyriform lobe and sweep beneath the ventricle in a broad stream up into the median wall of the hemisphere to make connections with the hippocampus.

The amygdaloid complex (amg.), whose enormous superficial extent has already been emphasized, exceeds internally this area both in breadth and length (Fig. 3, dotted outline). It consists of five distinct nuclei and perhaps more subsidiary ones. The anterior ones are in continuity with the cell bed of the stria terminalis, the great complex fibre stream which connects the amygdaloid region with other parts of the brain. The posterior lateral ones are in part continuous with the lower edge of the pyriform cortex, from which they appear to have been derived along a line of infolding whose external manifestation Dr. Johnston has called the amygdaloid fissure. This fissure, externally very obscure but internally obvious, continues the endorhinal fissure (fs.

erh.) backward, and the two together mark the ventral border of pyriform cortex.

The median surface (Fig. 4), known only in reconstructions (since the brain was cut entire), strikingly conforms to the simplicity of the exposed surfaces. It is typically marsupial, but the dorsal or hippocampal commissure (com. d.), which assumes a more or less pronounced bilaminar form in marsupials, is here triangular, with only a hint of bilaminarity. In this respect it approaches nearer to the solid rounded monotreme form in Coenolestes than it does in the other marsupials.

Fig. 4

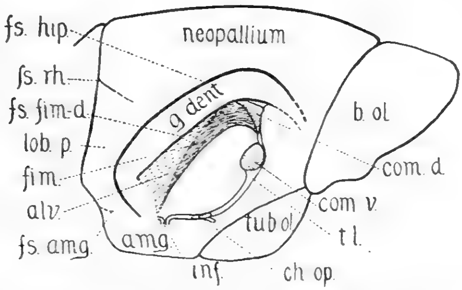


FIG. 4. Median section of the cerebral hemisphere of Coenolestes obscurus, as reconstructed from serial sections. The thalamus has been cut away. The gyrus dentatus appears on the exposed median surface between the hippocampal and fimbrio-dentate fissures (the latter of which is posteriorly really an alveo-dentate fissure in this case, since the extra-ventricular alveus covering the hippicampus inversus or upturned median flap of the ammon's horn, intervenes between this part of the fissure and the fimbria).

Reference letters: *alv.*, extraventricular alveus; *amg.*, amygdaloid complex; *b. ol.*, olfactory bulb; *ch. op.*, optic chiasma; *com. d.*, dorsal commissure; *com. v.*, ventral commissure; *fim.*, fimbria; *fs. amg.*, amygdaloid fissure; *fs. fim.-d.*, fimbrio-dentate fissure (alveo-dentate fissure posteriorly); *fs. rh.*, rhinal fissure; *g. dent.*, gyrus dentatus; *inf.*, infundibulum; *lob. p.*, pyriform lobe; *l. t.*, lamina terminalis; *tub. ol.*, olfactory tubercle.

Two great arched fissures mark the position of the hippocampus (hip.), which occupies a great part of the median wall of the hemisphere. Anteriorly the upper or hippocampal fissure (fs. hip.) extends very far forward, in the manner characteristic of this type of brain. Posteriorly it is considerably less developed than in the opossum, and apparently even less than in Notoryctes. No suitable figure of Perameles was available for comparison on this point. Internally this fissural situation is correlated with an extremely simple condition of the posterior or temporal end of the hippocampus. In this brain the temporal end of the hippocampus, which marks the morphological anterior end of the temporal lobe in higher mammals, lies very near the posterior pole of the hemisphere, a condition recalling that found in the reptiles. There is only a very slight forward curvature of the hippocampal formation in this region. The hippocampus is, as it were, caught in the very act of "turning the corner". The opossum hippocampus has already done so very neatly, by means of the formation of a forwardly directed pouch of cells.

Turning now from a study of the general anatomy of this brain we may consider the second phase of interest connected with it, which concerns the light which it might shed upon the di-polyprotodont controversy, with its important bearings on the geographical and chronological distribution of marsupials. The most exciting single feature of the brain of Coenolestes is that one which constitutes the evidence on this point—the only evidence, apparently. Writing in 1902, Prof. Elliot Smith stated that upon examination of all marsupial brains (except Coenolestes) he found that all diprotodont brains without exception possessed an anatomical peculiarity which was not to be found in any polyprotodont brain or in any other mammalian brain, and which therefore constituted a true diagnostic character of diprotodont brains. This structure he named the 'aberrant bundle". It is the upper part (Fig. 5, f. ab.) of the anterior or ventral commissure which splits away from the lower part to gain the corona radiata by way of the internal capsule (cap. i) instead of by the usual route in the external capsule (cap. e). It appears in every diprotodont brain regardless of size, from the giant kangaroo, five feet long from snout to root of tail and weighing 200 pounds, to the pygmy flying phalanger, two and a half inches long exclusive of the tail. It is absent in every polyprotodont, American or Australian, including the largest, the Tasmanian wolf, which it is said a number of dogs will hesitate to attack. I have not been able to detect it in Coenolestes. If it be accepted as a criterion of diprotodont brains, Coenolestes should be classified with the polyprotodonts. This reverses Dr. Osgood's conclusions, based on careful and exhaustive sifting of all lines of evidence save that from the nervous system. Thus America is left with only extinct diprotodonts, the internal anatomy of whose brains we can, unfortunately, never know. One might, of course, take the position that the "aberrant bundle" is a character of the Australian

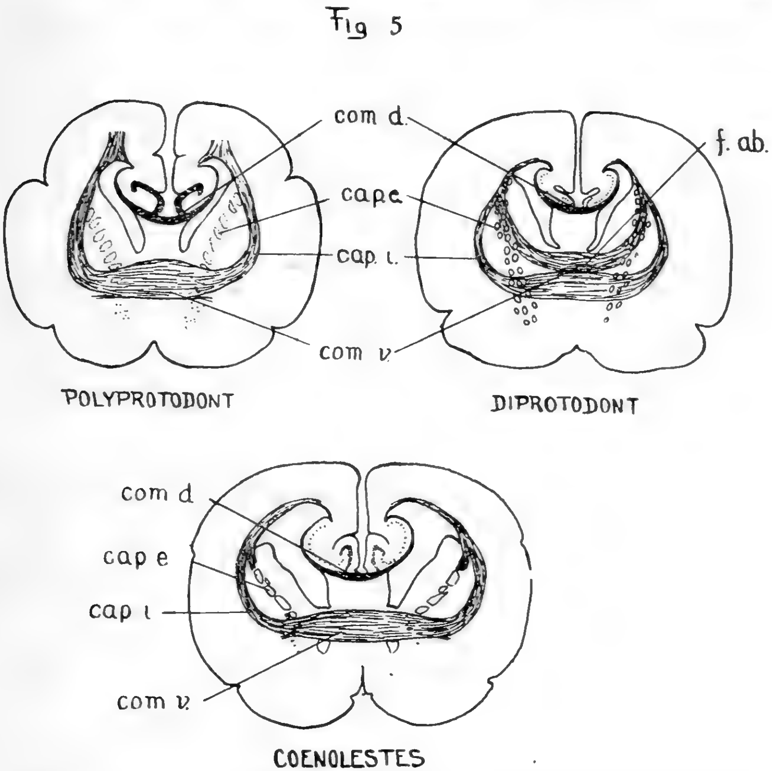


FIG. 5. The aberrant bundle. Corresponding sections through the brains of a polyprotodont and a diprotodont (from Elliot Smith), and Coenolestes.

Reference letters: *cap. e.*, external capsule; *cap. i.*, internal capsule; *com. d.*, dorsal commissure; *com. v.*, ventral commissure; *f. ab.*, aberrant bundle.

diprotodonts alone, developed after the diprotodont stem split in two, an Australian and an American. Dr. Osgood in the final paragraph of his monograph says that the classification of Coenolestes with the diprotodonts "does not emphasize its supposed phylogenetic relationship to the [polyprotodont] peramelids, but recognizes its advance beyond them to greater morphological similarity to the specialized diprotodonts. On the basis of present findings, the only logical alternative would be to remove the peramelids from the Polyprotodontia and unite them with the coenolestids in a group co-ordinate with (1) the Australian Diprotodontia and (2) the remaining Polyprotodontia. This, however, could not be done consistently without further division, especially of the polyprotodonts, which does not seem advisable in the present state of knowledge."

But regardless of the position of Coenolestes within the marsupials, its brain is certainly an example of an exceedingly simple and unspecialized mammalian brain, perhaps the most generalized one we know. And as such it stands closer to the line along which the Australian diprotodonts have developed than do the more specialized polyprotodonts of America.

STUDY OF EGG LAYING AND FEEDING HABITS OF GALERUCELLA NYMPHAEAE

HELEN M. SCOTT, KNOX COLLEGE

This investigatin on Galerucella nymphaeae was done at the Biological Station of Michigan during the summer of 1918 at Douglas Lake. The investigation was carried on in conjunction with certain field and laboratory courses at the station, so that but part time could be given to the study of the problem.

Observations were made in the field among the natural relations of this beetle, as well as in the laboratory where conditions could be somewhat more effectively controlled and the reactions carefully noted. The adults and larvae were brought into the laboratory on lily pads and were placed in aquaria. Some of these were placed on the leaves of white nymph (Castalia) and the common pond-weed (Potomageton), while others were left on the yellow waterlily pad (Nymphaea) on which they were found. These leaves were floated on lake water in the aquaria and cheese cloth was tied over the top to prevent the escape of the beetles.

LIFE HISTORY

The life history of this beetle is similar to that of all Coleoptera in having metamorphosis. The egg hatches into a larva with a black head possessing two, three-jointed tuberculous antennae. The thorax and abdomen are black except at the sutures where white fuscous lines divide the black into distinct areas. There is a similar line on the meson of the notum of the three thoracic segments and likewise on each abdominal segment, dividing it into two parallel transverse bands, the posterior of which is the longer. Prolegs are developed on the ventral surface of the last abdominal segment only.

The pupa is black except in the region of the sterna of the thorax and abdomen. The apical segment of the abdomen, however, is covered by the cast off skin of the larva. The very young pupa is lighter in color and the legs, wing pads, and antennae are not closely joined to the body.

The adult is small, oval, and of a dull yellow color, having the head usually distinct with an easily discerned median impressed line. The side margins of the elytra are lighter than other regions, and the length of the beetle when metamorphosed is 4.5—6 mm. The antennae are as long or longer than half the body, and the third joint is somewhat longer than the fourth.

FEEDING HABITS OF THE LARVAE

Larvae were placed upon leaves of the white nymph (Castalia) and upon those of the common pondweed (Potomageton) to determine whether or not they would feed on the foliage other than the yellow waterlily (Nymphaea). Both the yellow and white lily pads occur in the same region on Douglas Lake, but only the former were found to be eaten by the larvae. The Potomageton leaves were not touched, and in one aquarium where the white nymph pads were placed there were no evidences of the larvae feeding. In another aquarium under observation, containing a white nymph pad, the leaf was punctured but there were no evidences that it had been eaten. The larvae in all of the aquaria pupated in a relatively few days after they were placed on the different kinds of leaves; although it does not follow that the food relations were a factor in pupation.

FEEDING HABITS OF THE ADULTS

Three aquaria, two of which contained leaves of Potomageton and one of white nymph, were set up on the morning of July 30th. Into each of these several adult beetles were introduced. In one of the two aquaria containing Potomageton the leaves became infested with a fungus growth and had not been eaten by the insects up to the time that they were removed on Aug. 7th. In the other aquarium containing Potomageton two of the beetles died on Aug. 13th, two more were dead Aug. 18th, but the leaves up to this time had not been touched. Likewise in the aquarium in which had been placed leaves of the white nymph, the beetles had failed to eat any of the foliage when the experiment was discontinued on Aug. 20th.

In one aquarium where there were adult beetles the egg mass was eaten and only the chorion or egg shell remained.

BREEDING HABITS

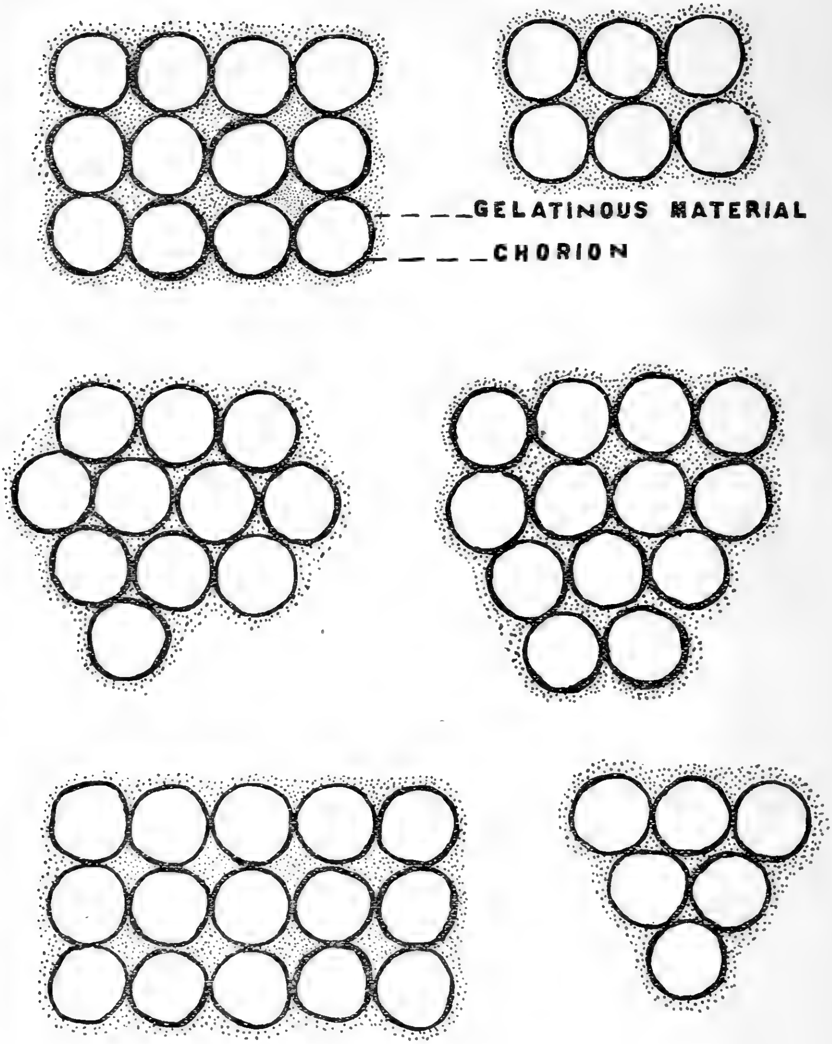
The eggs are oblong cylindric, 0.24 mm. wide at the end attached to the leaf, 0.48 mm. at the opposite end and 0.72 mm. long. The eggs are yellow when first laid, but within a few hours change to ivory in color. The surface of the chorion or egg shell is covered with small pits.

Thirty-seven egg masses were counted, and the number of eggs in them varied from 6 to 15, confirming Needham's work on this beetle in which he describes from 6 to 20 in the mass. The eggs are arranged in rows varying from one to five in each row. The following diagrams will show several different arrangements.

Four aquaria were set up with yellow waterlily leaves in them, and adults that were found mating in the field were brought in and one pair introduced into each aquarium. The aquaria were set up July 15th. In one of them egg masses consisting of 12 eggs were laid successively on July 28th, Aug. 2nd, 4th, and 6th. Of the other aquaria that contained the breeding beetles two pairs had not laid any egg masses when the experiment was discontinued Aug. 20th. In one aquarium the male died Aug. 3rd, and another was put in Aug. 5th, but no egg masses were laid.

In one case the female was observed from the time she began to deposit the eggs until she finished. It took her one hour and twenty-eight minutes to deposit eleven eggs.

These are only a few observations and experiments made on Galerucella nymphaeae, but the writer hopes to do more on this problem in the near future. Very little is known of the habits of this beetle.


GELATINOUS MATERIAL
CHORION

THE ANATOMY OF A DOUBLE MONSTER PIG

George M. Higgins, Knox College

INTRODUCTION

The literature upon various teratological forms is rather extensive; and of the cases reported, syncephaly is quite frequent. Fisher ('04) in his Teratology Handbook records about 80 cases of syncephaly among domestic animals and 50 cases within the human family. Since that time additional records of a similar condition have been made. Carey ('17) described a case of syncephalus asymmetros in a pig in which two distinct cerebro-spinal axes were present and two hearts of unequal size in distinct pericardia, thus differing from any other case previously described. William and Rauch ('17) likewise described a case of syncephaly, also in a pig, in which the heart was single, but the nervous system was fused to a much greater degree, the spinal cords alone being duplicated.

This dissection of another syncephalous pig is presented because it is somewhat intermediate between those mentioned above. In the but partial fusion of the brain, the independence of the corpora quadrigemina, cerebellar hemispheres and medulla, as well as in certain other peculiar modifications of the anatomy, the writer feels that publication is justifiable.

This pig was presented to Professor George W. Hunter of the Knox Biological Laboratory in October, 1922, by the farmer upon whose farm the pig had been born. The writer was assisted by Professor Hunter in the earlier dissection, and acknowledgements are made for this assistance as well as valuable suggestions throughout the entire dissection.

EXTERNAL ANATOMY

This monster, one of a litter of six pigs, was born alive but died at birth. It has a normal head with eyes, ears, nares and snout in proper positions and proportions. In the mid-dorsal line of the occipital region an additional pair of external ears of normal size are fused at their bases around a single auditory aperture, which opens into the posterior part of the skull. Just in front of this median fused auditory structure is a small tubercle, similar to that described by Carey, which represents a remnant of a fused lens vesicle; for just beneath it is a vestigial optic cup connected by nervous structures to

Fig 2

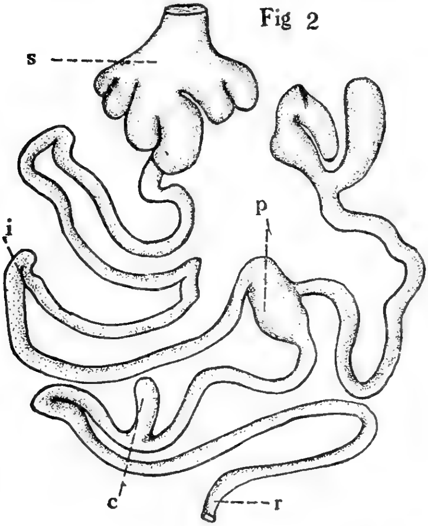


Fig. 1

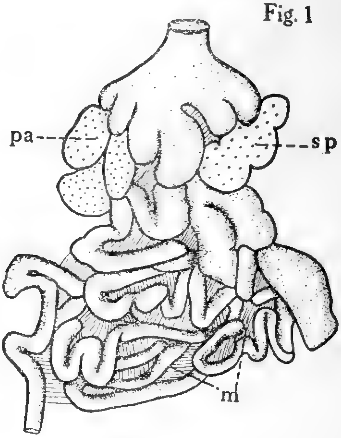


Fig. 3

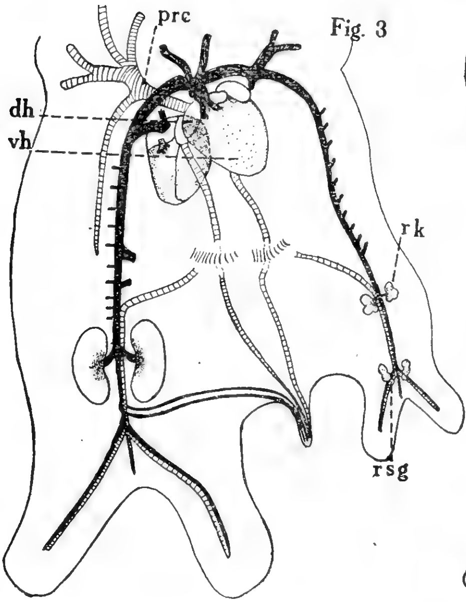


Fig 4

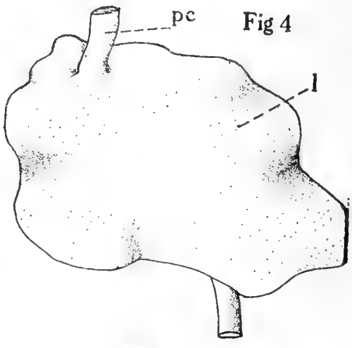
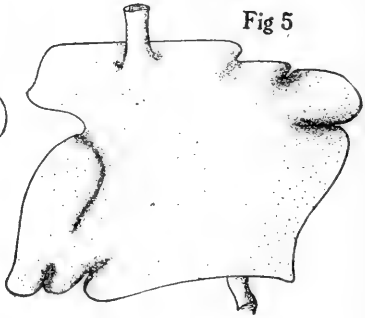


Fig 5



the floor of the brain at the chiasma of the two normal optic nerves. This relationship will be discussed in more detail in the section of the nervous system in the sequel.

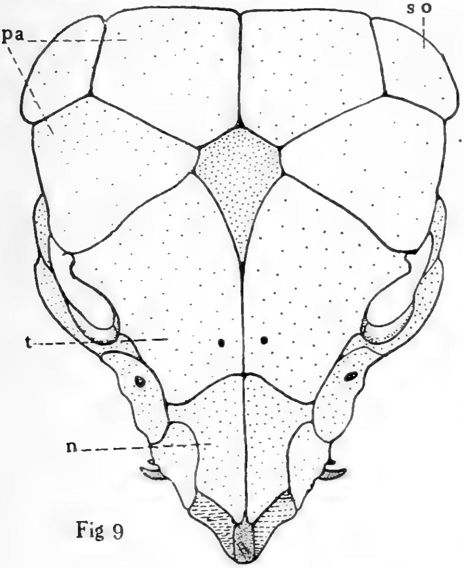


Fig 9

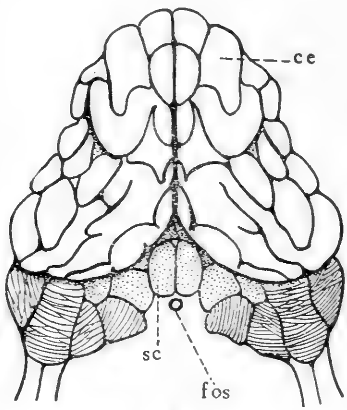


Fig. 7

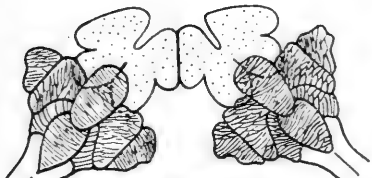


Fig 8

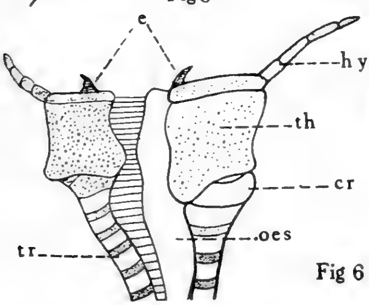


Fig 6

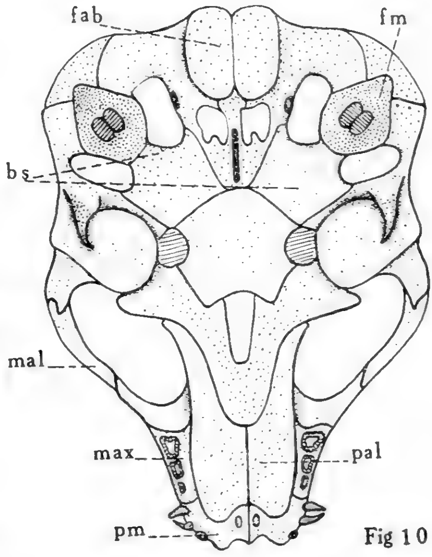


Fig 10

It is quite evident that these accessory external sensory appendages have developed through a fusion of the embryonic structures in such a way that the left organ of one of the embryos has fused with the right organ of the other embryo. Accordingly, the normal eyes and ears are to be interpreted as the right and left organs of the two primitive embryonic stages.

Two trunks, joined to each other in the mid-ventral thoracic regions, are attached to the posterior lateral angles of the head. These trunks are of unequal size. The larger is on the right side, considered from the standpoint of the head, and measures 25 cm. from crown to rump; while the smaller animal, similar on the left side, has a corresponding measurement of but 18 cm. The bodies are joined as far back as the unpaired umbilical cord, which contains upon examination two arteries and two veins. There are eight legs, completely developed, which occupy proper positions upon their respective girdles. The smaller animal is devoid of tail as well as external genitalia and rectal openings; while the larger one possesses all these structures and is of the female sex.

INTERNAL ANATOMY

The metacoeles of the two bodies are continuous, so that the peritoneum of the one continues directly into that of the other; thus but a single metacoele may be identified. The common viscera lies almost entirely in that portion of the metacoele which lies within the larger animal; although a relatively small part does extend over into that portion of the metacoele in the smaller pig. A fused diaphragm, resulting from the greatly modified development, cuts off two anterior pleural regions from this common metacoele, and extending back along the dorsal surface of each body reaches to a line just anterior to the paired kidneys.

THE ALIMENTARY TRACT

The buccal cavity and the pharynx are entirely normal, as well as those structures within them. From the pharynx two larynges with normal epiglottes extend posteriorly, and between them, definitely opening from the more ventral larynx, is the single oesophagus which continues posteriorly between the two tracheae into the metacoele.

The alimentary tract is complete only in the larger animal, and consists of a greatly modified stomach which continues into an elongate undifferentiated intestine. The stomach is not readily differentiated into the usual cardiac and pyloric regions but it consists of five simple lobes, each connected with a centralized portion (Fig. 2). The lining of this stomach is conspicuously ridged, and the lumen into each pouch is constricted greatly by the approximation of these gastric folds. Upon dissection each pouch was found to contain coagulated masses of green material, suggesting a possible accummulation of bile secretions. Characteristic mammalian duodenum and ileum can not be identified; but an intestine, strangely twisted and coiled, continues back from the median pouch of the stomach through a small pylorus. Differentiation of the intestine into ileum and colon portions can not be made, for the entire tube is of uniform diameter throughout, except for a single enlargement where the shorter tract of the smaller pig continues into that of the larger (Fig. 2, p.).

A secondary stomach, that of the smaller pig, consists of a two-lobed structure, and is bound firmly to the left wall of the larger stomach by heavy strands of connective tissue. The cavities of the two are not continuous, neither is there a connection of the smaller stomach with the oesophagus; so that no digestive function could ever have been ascribed to this organ. Through a small pylorus, this secondary tract continues into a short intestine, one-fourth the length of that of the larger pig, which joints its mate at an enlarged region 15 cm. anterior to the caecum (Fig. 2, p.). From point of junction the two tracts are confluent and from thence continue as a single tract to the rectal opening of the larger pig.

This relationship differs from that of Carey's monster, in which the alimentary tract is entirely single to a point 16 cm. anterior to the caecum, where it bifurcates into two regions, each of which is related to its own rectal aperture. The mesentery of this monster, peculiarly twisted with the coils and twists of the intestine, is possessed of an abundance of lymphoid and glandular tissues, a fact possibly correlated with the peculiar development of the monster.

The entire tracts are held within a region embraced by the livers. Of these, one lies above and the other below the fused viscera, the upper being slightly the larger of the two. In both livers characteristic lobulation is absent; for each consists of a single enlarged structure bearing two or three smaller lobules (Figs. 4, 5).

Two post-cavae are present, and from their relations to each other it would appear that the larger liver, more dorsal in position, is of the smaller pig; likewise the ventral liver belongs to the larger animal. Normal mesohepars are present, and normal gall bladders pour their secretions into normal bile ducts related to their respective intestines. A two-lobate pancreas is fixed by heavy membranes to the lobes of the larger stomach only; but normal spleens are present in both animals. Pancreatic ducts were not identified.

URO-GENITAL ORGANS

Normal kidneys, ureters, bladder and urethra are present in the larger pig, as well as ovaries, oviducts and a well-defined uterus. In the smaller animal, on the other hand, two pairs of greatly reduced structures lie in the pelvic region, and it is entirely probable that these represent rudimentary kidneys and sex glands. Neither ureters nor reproductive ducts were identified in the smaller animal; but the presence of genital arteries and veins as well as renal arteries suggest the identification of these structures. Microscopic identification has not yet been made. There are no external genitalia upon the smaller animal.

CIRCULATORY SYSTEM

Differing from the hearts of the animal described by Carey (1917), this monster has two hearts of approximately equal size, each contained within its own pericardial cavity in a normal thoracic position. These hearts are both normal, and have normal relations to the main circulatory trunks of its respective body. The hearts are so placed that their dorsal surfaces are opposed to each other; and because of their relations to the two post cavae, it would appear that the larger heart, the more ventral one, is of the smaller pig, while the slightly smaller one is likewise of the larger pig.

Just anterior to the larger heart the main dorsal aorta, coursing from its right ventricle, bifurcates to form the two aortae, each of which passes to a normal position in its respective animal. That aorta supplying the larger animal is joined at once by a secondary aortic arch coming from the right ventricle of the smaller heart; so that the two hearts thus have a common bond in these connections to the aortae. Posteriorly each aorta gives rise to the normal intercostals, coeliac and mesenteric arteries; although in the smaller animal these branches are greatly reduced and largely devoid of blood content, and thus were relatively difficult to trace. Renals, iliacs and umbilical arteries are present in the larger animal, but no umbilicals were recognized in the smaller. Furthermore, a variation is to be noted in the point of attachment of the umbilicals to the aorta; instead of attaching to the internal iliac as we would expect, here the umbilicals connect with the aorta considerably anterior to the iliacs.

The carotid arteries have not retained their identity of relationship to each animal; but all are united to the common aorta (Fig. 3). A single brachiocephalic artery arises from the arch of the smaller aorta and divides into two carotids, from which later arise a corresponding subclavian artery, distributed to the respective limb. From the bend of the aorta, just in front of the larger heart, a pair of arteries continue forward into the head region and form the paired carotids and the left subclavian of the larger animal; while the right subclavian of the larger animal arises independently from the aortic arch of the smaller heart (Fig. 3). The complete distribution of these arteries into the head region was not ascertained, as the absence of the blood content made their identification extremely difficult; and accordingly no knowledge is available of the relation of the paired internal carotids to the circle of Willis, so graphically figured by Carey in his description of this region in his monster.

In contrast to the fused relations of the arterial systems, the venous systems were found to be completely independent of each other. Post cavae are normally present, and these are joined in each liver by respective umbilical veins, from whence a single vessel continues forward into the right auricle of the respective heart. These are joined by precavae coming from adjacent regions, although the two anterior vena cavae are independent of each other.

Within the hearts, normal relations were found to exist. Completely four-chambered structures were developed and normal canals and valves separated the chambers from each other. Well-defined Botall's ducts were identified between the pulmonaries and the adjacent aortic arches.

THE RESPIRATORY SYSTEM

Two complete sets of lungs are developed, and these lie in independent pleural cavities, separated by double folds of visceral pleurae. These cavities lie around the heart, and each pair of lungs is connected to its respective heart by normal pulmonary arteries and veins. The ventral lungs, characteristically lobulated, are slightly larger than the more dorsal pair and are understood to belong to the larger pig as evidenced by the vascular connections. Normal bronchioles and bronchi with normal cartilage supports are developed, and from the junction of the two bronchi, normal tracheae extend forward to the neck into the pharynx. As indicated above, these tracheae lie one above and the other below the unpaired oesophagus.

Anteriorly, each trachea continues into a larynx, apparently normal, with the three characteristic cartilages present, but somewhat distorted and partially fused. A greatly modified basihyal cartilage is present, and this is continuous with the hyoid apparatus, consisting of four parts. The hyoids, which are continuous with the ventral larynx, are more nearly normal, and the distal tympanohyals join the auditory bulla of each temporal bone. On the other hand, the hyoids of the more dorsal larynx are greatly reduced, because of the cramped position; but each continues upward through the connective tissue region to join a peculiar structure, the fused bulla of the other pair of temporal bones (Fig. 10, fab). The skull is understood to be a fused structure, as will appear in the discussion on the skeleton; and thus it would follow that the normal bulla are but opposites of the adjacent heads, and that the related hyoids, although apparently normal on the ventral larynx, must be of independent origin (Fig. 6).

The oesophagus joins the dorsal wall of the ventral larynx, so that the ventral tracheae and oesophagus are confluent here. A single opening, the glottis, connects this region with the unpaired pharynx above. Likewise a glottis is present on the dorsal larynx, and associated with it is a normal epiglottis, a similar one existing in connection with the ventral larynx above described.

THE NERVOUS SYSTEM

Two spinal cords are present, enclosed within separate neural canals. Posteriorly, that of the small pig reaches only to the sacrum, where it abruptly terminates; while that of the larger pig is more normal, terminating in a typical cauda equina. Lumbar and cervical swellings are present as well as normal spinal nerves.

Anteriorly, each cord passes forward through a foramen magnum on the posterior angle of the fused cranium, and then each joins its mate to form a partly fused encephalon. Myelencephalon and metencephalon are independent of each other and are joined to their respective cords; but the superior colliculi of the mesencephala represent the most posterior point of fusion of these parts, for here a firm junction is established and fiber tracts cross as in a chiasma.

Just posterior to these fused superior colliculi and in the region between the hind brains is a compound nervous structure, evidently formed by the fusion of the left optic stalk of the right encephalon with the right optic stalk of the left encephalon. This peculiar structure continues posteriorly and dorsally from the normal position of the optic chiasma, and terminates in connection with the small amorphous structure on the median dorsal line of the skull just anterior to the fused external ears. On this interpretation, therefore, the optic nerve to the right lateral eye is of the right encephalon; while that on the left, likewise belongs to the left encephalon.

The compound cerebrum is difficult of interpretation. Its anterior is more nearly typical of the normal telencephalon; but it is quite evident that the posterior portions are parts of a fused unit. Although normal sulci and gyri abound, yet identification of frontal, temporal and occipital lobes as such is impossible (Fig. 7).

THE SKELETON

Correlated with the double cerebro-spinal axis, there are two spinal columns, two sets of ribs and two sterna. Each column is conspicuously twisted and curved; that of the larger animal is the longer of the two and consists of some forty vertebrae, while but twenty-six are present in the smaller column. The terminal vertebra of the latter is a mal-formation, and evidently is composed of portions of the vertebrae in the posterior lumbar region which have fused into a knob-like structure held between the paired ilia of the greatly reduced pelvic girdle. The numbers of vertebrae in the more anterior regions are identical for both animals, there occurring, however, a considerable reduction in the lumbar, sacral and caudal regions of the smaller animal.

The pelvic girdle is normal in the larger pig, but in the smaller one it represents the most posterior skeletal structure in the trunk. It is a peculiar Y-shaped structure. The arms of the Y are represented by normal ilia which support the end of the truncate spinal column; while the median posterior part is formed by a fusion of the two ischia and pubis bones. They are both greatly reduced and are held together by heavy strands of fibrous tissue.

THE SKULL

The skull is a fused structure. Its anterior half is normal; but the posterior half comprises corresponding halves of adjacent skulls. Consequently, two occipitals and four parietals are identified upon the dorsal surface, while upon the ventral surface a similar fusion is evidenced: so that paired sphenoids, temporals and auditory bulla are duplicated in the structure (Figs. 6, 9, 10).

EXPLANATION OF FIGURES.

Fig. 1. Visceral mass of double monster pig.
Fig. 2. Stomachs and intestines of visceral mass teased apart.
Fig. 3. Paired hearts and main trunks of circulatory system.
Fig. 4. Ventral view of liver of large pig.
Fig. 5. Ventral view of liver of smaller pig.
Fig. 6. Tracheae, oesophagus and larynges with their connections.
Fig. 7. Dorsal view of compound encephalon.
Fig. 8. Dorsal view of posterior portion of compound encephalon.
Fig. 9. Dorsal view of fused skull.
Fig. 10. Ventral view of fused skull.

ABBREVIATIONS USED.

bs basisphenoid
c caecum
ce cerebrum
cr cricoid cartilage
dh dorsal heart
e epiglottis
fab fused auditory bulla
fm foramen magnum
fos fused optic stalk
hy hyoid
i intestine
m mesentery
mal malar bone
Max maxillary bone
n nasal bone
oes oesophagus
p pouch
pa pancreas
pal palatine bone
par parietal bone
pc post cava
pm premaxillary bone
prc pre cava
r rectum
rh rudimentary kidney
rsg rudimentary sex gland
sc superior colliculi
so superior occipital
sp spleen
st stomach
t temporal bone
th thyroid cartilage
tr trachea
vh ventral heart

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THE NASAL CAPSULE IN NATRIX CYCLOPION

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INTRODUCTION

Thus far little work has been done on the chondrocrania of reptilia. More investigations have been made upon fishes and amphibia than on the reptiles, birds and mammals.

Kunkel (1912) on "The Development of the Skull of Emys lutaria" gives a good description of the chondrocranium of this reptile, and includes several plates. Parker (1878) describes the structure and development of the common snake, Tropedonotus Natrix; and again in 1879 discusses in considerable detail the skull of the lizard. Parker gives more attention to the character of the older stages and less to the actual developmental process of the earlier larvae, thus making his contribution of less value to this investigation since he has little concern for the ethmoidal region. Gaupp (1900) describes the chondrocranium of Lacerta agilis, one of the lizards, showing a typical ethmoidal region which in some ways is a repetition of the work of Born (1876) on the nasal organ and the related structures of both the amphibia and certain amniota. Seydel (1896) gave several new facts concerning the nasal capsules.

Higgins (1920) in his work on "The Nasal Organ in Amphibia" figures a capsule of an older Amblystoma which bears a striking resemblance to that of Natrix, as will appear in the sequel.

This paper was undertaken with the idea of ascertaining the relation of the reptiles to the more specialized amphibia as well as to the higher amniota. Natrix cyclopion was selected as the reptilian type; although perhaps not the most primitive, yet it possesses certain characters that relate it to primitive conditions.

The material which forms the basis of this study consists of two embryos of different ages which were secured through the kindness of Prof. L. A. Adams of the University of Illinois. The method of removing the embryos from the females is most satisfactory, for it insures complete identity of the species thus worked upon. The work was done in the Knox Biological Laboratory, and the writer regrets very much that earlier and later stages were not available so that a more complete study of the development of the capsule could be made.

These embryos, measuring respectively 75mm. and 63mm., have been sectioned and studies made upon the development of the nasal capsules and their relation to the nasal organs. Reconstructions by the Born wax-plate method have been made of these structures in both embryos. Drawings of these models and the sections of the nasal organs have been made showing the relation to the capsule itself.

This work was carried on under the supervision of Dr. G. M. Higgins, to whom the writer is indebted greatly, not only for his invaluable assistance during the preparation of this paper, but also for his inspiring influence.

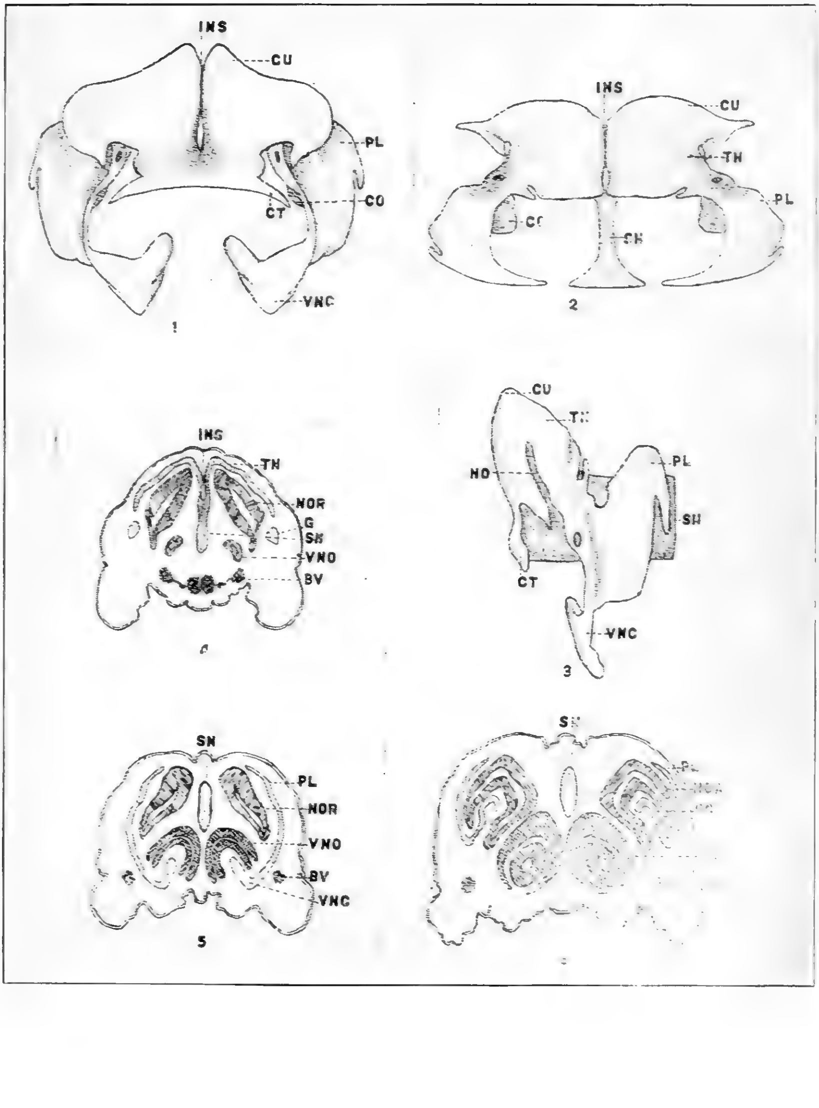
In the younger of the two embryos, that of 63mm. total length, chondrification is not complete, and the deeper structures of the head are exposed through large gaps in an incomplete chondrocranium. The nasal capsules with which this investigation is primarly concerned, consists in this stage of two curving plates of cartilages, connected to each other in the median line.

The trabeculae, which form the floor of the chondrocranium in the brain region, unite anteriorly to form a prominent bar of cartilage, the septum nasi, which separates the two nasal organs from each other (Figs. 2, 4). This structure probably represents a prism of the paired trabeculae which form so important a part of the nasal capsules of the amphibia. Anteriorly this septum nasi expands along its ventral margin into a pair of small perpendicular plate-like cartilages, which extend laterally a considerable distance and end in prominent processes ventral to, but in a plane with the external naris (Figs. 1, 3). It would appear that these cartilages are remnants of primitive cornu trabeculae, so prominent in capsules of lower forms, but have lost in the reptiles all association with the nasal organ itself, being considerably ventral and anterior to the nervous structures.

From the anterior third of the dorsal margin of the septum nasi, two curving plates of cartilages, separated by a narrow internasal space, extend upward a short distance and curve laterally and ventrally to cover the anterior portion of the nasal organ (Figs 1, 2). This structure is a complete cupola and forms the anterior wall of the chondrocranium. It is connected ventrally in front with the dorsal margin of the cornu trabeculae, above described, its upper margin extending laterally a considerable distance to form the anterior wall of the naris (Fig. 1). Lateral to the narial opening, the margin of the cupola extends ventrally and terminates in a prominent process, so that a broad deep notch is included between it and the lateral margin of the cornu trabeculae (Fig. 1).

The roof of the capsule, formed, as above indicated, from the septum nasi and continued anteriorly with the cupola, is known as the tectum nasale (Fig. 2). It continues laterally, and inclining somewhat ventra-posteriorly, is reduced to a narrow plate of cartilage which forms the lateral wall of the capsule in this region. The remaining portion of the lateral wall is continuous with that portion just described, and consists of a broadly curving plate of cartilage, the planum lateralis, which entirely covers the lateral surface of the posterior part of the nasal organ (Figs. 2, 3). Its anterior ventral margin is curved conspicuously and forms a prominent process which lies slightly lateral and considerably below the ventral margin of septum nasi. This process has an intimate relation to the vomero-nasal organ, as shown in Figure 5, and is known by Gaupp as the Capsule of Jacobsen's Organ.

Two large fenestrae occur within the walls of the capsule. Of these one is dorsal, lying back of the posterior margin of tectum nasale between palnum lateralis and septum nasi; while the other is of irregular shape and lies on the floor of the capsule, continuous with the lateral narial aperture (Fig. 3). Thus the nasal organ, of this stage, is exposed upon its entire ventral and posterior dorsal surface. The anterior part of planum lateralis is pierced by a single foramen, through which the profundus branch of the trigeminal nerve passes to the anterior region of the snout.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In the older stage, that of 75mm. total length, chondrification is more advanced. The nasal capsule of this stage consists of two curving plates of cartilages connected in the median line, forming the body of the capsule as in the earlier stage.

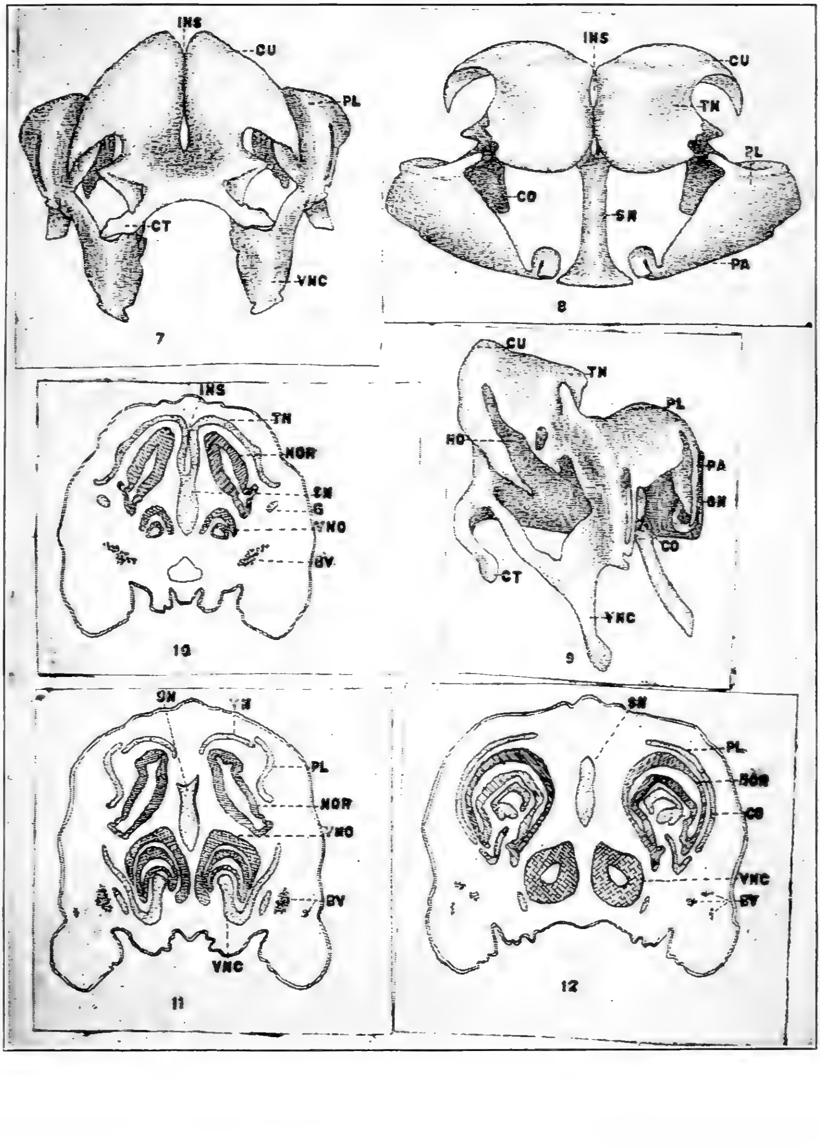
The trabeculae, which form the floor of the chondrocranium in the region of the brain as before, unite anteriorly to form the septum nasi, now considerably broader and longer than in the earlier stage (Fig. 8). The cornu trabeculae, which are the anterior expansions of the septum nasi, are more elongate and extend ventrally and somewhat posteriorly, ending in a process ventral but still in a plane with the external naris (Fig. 7).

The part of the nasal capsule which covers the anterior portion of the nasal organ is now more curved in appearance. The tectum nasale reaches more posteriorly, and bending ventrally covers a considerable portion of the nasal organ (Figs. 8, 10). Anteriorly, it is continuous with the cupola, as in the younger stage, which forms the anterior covering of the nasal organ, and forms part of the wall of the capsule in this region (Fig. 9). The prominent process formed by the ventral extension of the cupola lateral to the narial opening curves posteriorly, and although ending bluntly here, would in all probability unite with the small lateral process of the tectum nasale to form a complete oval narial fenestra (Fig. 9). Such a fusion has already occurred in the older lizard embryo described by Gaupp, and no doubt is true here as well.

The planum lateralis, which forms the lateral wall of the posterior part of the capsule, becomes more expanded than before, and bending in a median ventral direction, ends in a knob-like process which makes a conspicuous U-shaped bend closely applied to, but not connected with the septum nasi (Figs. 8, 9). This new plate covering the posterior parts of the nasal organ now forms the posterior wall of the nasal capsule, and following the terminology of authors may well be called the planum antorbitale. The lateral and ventral margin of this curved planum antorbitale is conspicuous by three deep indentations, thus giving it a marked serrate appearance. These notches appear to be unrelated to any nervous structure and may simply represent regions of incomplete chondrification.

Anteriorly, in a plane midway to the anterior end of the capsule, this planum lateralis bends abruptly ventrally and forms a vertical plate, extending laterally and ventrally so that the cavum nasi may be said to be roughly divided into two regions, the anterior one related to the cupola and tectum nasale above described, the posterior covered by planum lateralis and antorbitale (Fig. 9). The dorsal margin of this vertical portion of planum lateralis continues medially into a cylindrically shaped process, which as a small beak is inclined anteriorly and is superimposed upon a small enlargement of the posterior margin of tectum nasale (Figs. 8, 9). Thus there is formed between the two a small bay, continuous with the large fenestra in the roof of the capsule. No nervous structures were found to be associated with this bay. Just below this beak-like process, the medial part of the ventral margin of planum lateralis is continued by a broad cartilage plate into the posterior lateral angle of the tectum nasale forming the only cartilage support for the nasal organ in this region. It is pierced, however, by a small foramen, the homologue of a similar opening described in the earlier stage (Fig. 9).

The ventral margin of this vertical plane continues forward into a prominent curved process which lies ventrally, medially and below the plane of the ventral margin of the septum nasi (Fig. 7, 9). Following Gaupp, who figures a similar structure in the skull of the lizard, this process, closely applied to the anterior surface of Jacobsen's organ, as well as the part of it extending into the organ, may be called the vomeronasal capsule (Fig. 11). The vomeronasal capsule arises from the planum lateralis by a narrow arm which widens ventrally and turns posteriorly midway between planum lateralis and the septum nasi, and becomes more elongate and more pronounced than in the earlier stage. From the ventral margin of this capsule a prominent process curves posteriorly and ends in the surrounding tissue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limiting it in this region. It is connected with the cupola by a cylindrically shaped rod which bends medially and laterally, forming an obtuse angle, and uniting with the ventral margin of the cupola at its junction with the cornu trabeculae (Figs. 7, 9).

The ventral half of the planum lateralis, just before it bends to form the anterior vertical plate, is pierced by a long slit-like foramen which appears to be unrelated to any nervous structure and may represent merely an incomplete chondrification here (Figs. 7, 9). On the posterior median surface of this vertical plate is an S-like formation which has just started to form in the younger stage (Figs. 6, 12). This structure is continuous with the planum lateralis. In the older stage a rod-shaped cartilage bar extends from the upper portion of it posteriorly at an angle of 45 degrees to the median line of the skull (Fig. 9). This is unquestionably a nasal concha, and is evidently homologous to that concha shown by Gaupp (1900) in his description of the skull of the lizard.

This description of the development of the nasal capsule of the snake is of considerable interest in itself; but its greater interest lies in the comparisons that exist between it and the other capsules of the reptilian class as well as capsules among the amphibia. In following Kunkel in his description of Emys, it appears that considerable identity of structure exists in the ethmoidal regions. The chondrocranium of the turtle is apparently more compact than that of the snake, although homologous regions may be identified readily. Furthermore, it would appear that considerable similarity exists between the capsules of certain urodeles and this capsule of Natrix cyclopion. To attempt to establish any basis of phylogenetic continuity upon such a resemblance would be unscientific; and yet one cannot fail to note this relationship. In both, the roof of the capsule is pierced by a large rhomboidal fenestra which appears to be bounded by homologous regions. Similar capsules cap the anterior end of each organ, and similar internasal spaces separate the two.

The special attention of the writer is drawn to that portion of the capsule which forms the posterior wall. In the work of Higgins (1920) the term planum tectale is used to designate that same portion of the capsule which Gaupp in his discussion of the lizard has called planum antorbitale, a term continued in use throughout this discussion. Regarding the use of the term antorbitale, the writer recalls the fact that in all the nasal capsules of the amphibia, where the facts are known, the antorbital process arises from the trabecula as a lateral diverticulum just posterior to the choana. Subsequently this structure unites with other portions of the capsule to form this posterior wall. In the reptiles there is no association between these two regions, and it would seem that the structure known as planum antorbitale could not have arisen as a normal antorbital process, and consequently the use of this term is questioned.

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EXPLANATION OF PLATES.

Fig. 1. Anterior view of model of nasal capsule of Natrix cyclopion, 63 mm. ×58.

Fig. 2. Dorsal view of model of nasal capsule of Natrix cyclopion, 63 mm. ×58.

Fig. 3. Lateral view of model of nasal capsule of Natrix cyclopion, 63 mm. ×58.

Fig. 4. Cross section through tectum nasale of Natrix cyclopion, 63 mm. ×35.

Fig. 5. Cross section through vomeronasal capsule of Natrix cyclopion, 63 mm. ×35.

Fig. 6. Cross section through nasal concha of Natrix cyclopion, 63 mm. ×35.

Fig. 7. Anterior view of model of nasal capsule of Natrix cyclopion, 75 mm. ×58.

Fig. 8. Dorsal view of model of nasal capsule of Natrix cyclopion, 75 mm. ×58.

Fig. 9. Lateral view of model of nasal capsule of Natrix cyclopion, 75 mm. ×58.

Fig. 10. Cross section through tectum nasale of Natrix cyclopion, 75 mm. ×35.

Fig. 11. Cross section through vomeronasal capsule of Natrix cyclopion, 75 mm. ×35.

Fig. 12. Cross section through nasal concha of Natrix cyclopion, 75 mm. ×35.

BV Blood vessel
CO Nasal concha
CT Cornu trabecula
CU Cupola
G Gland
INS Internasal space
NO Narial Opening
NOR Nasal Organ
PA Planum Antorbitale
PL Planum Lateralis
SN Septum nasi
TN Tectum Nasale
VNC Vomeronasal capsule
VNO Vomeronasal organ

THE NASAL CAPSULE IN BUFO AMERICANA

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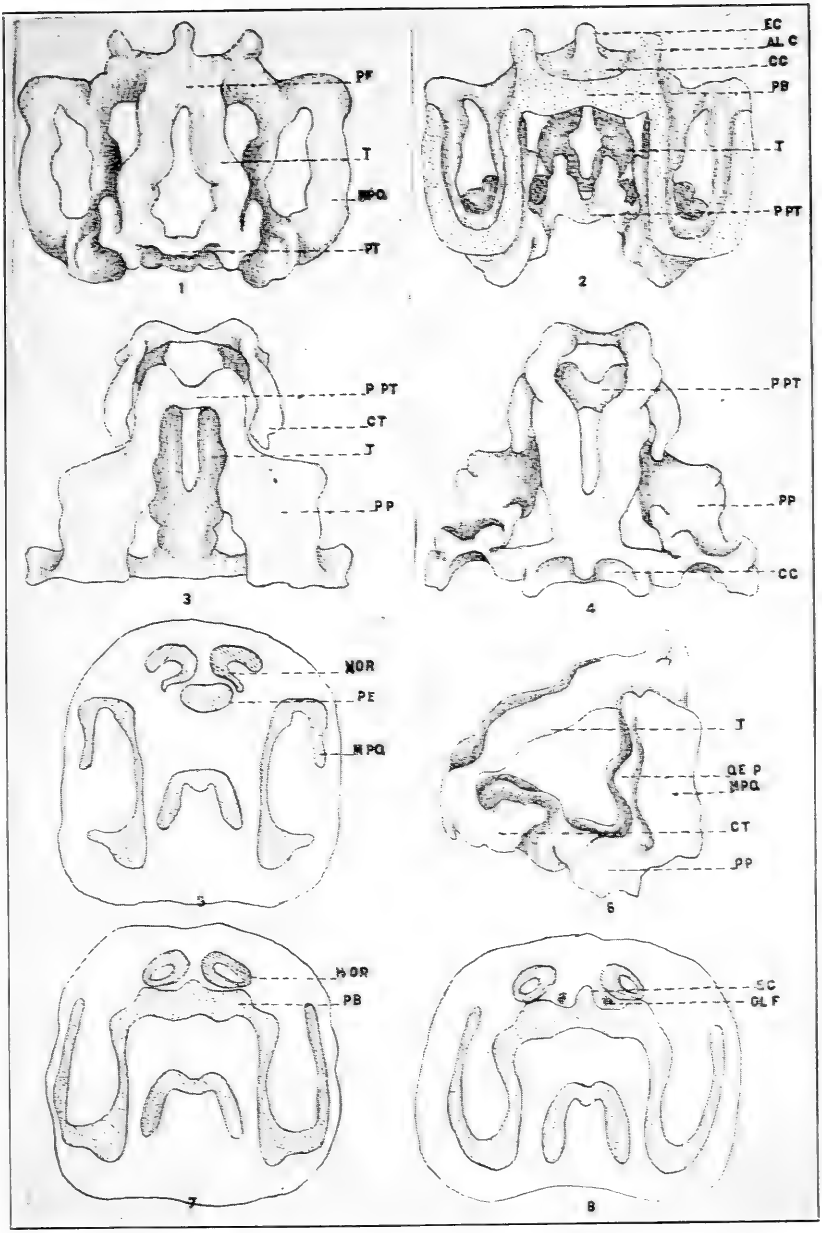
INTRODUCTION

The literature up to the present time on the development of the chondrocranium of fishes and amphibia is considerable. More work, however, has been done upon the latter class of vertebrates, the Urodeles and the Anura especially.

The first adequate account of the development of the skull in the Anura was given by Parker in a paper published in 1871. This paper, with three others published in 1876, 1877, and 1881, fail to give any very detailed account of the process of chondrification. Born (1876) describes in detail the chondrification of the skull in Triton cristatus, and Stőhr (1879) also describes this process in Triton. Terry (1906) compares the process of chondrification in Amblystoma with that of Triton, finding that the two agree closely. Gaupp (1893) gives a thorough-going detailed study of the skull of Rana fusca.

Most of the work on the developing chondrocranium of amphibia has been made on the later stages, rather than upon the early larvae. Considerable work has been done upon the earlier stages of Rana, but a less amount of intimate detail is available for use on the early chondrification of the toad. Later stages have been described by Higgins (1920); but nothing is known of the early process of chondrification in this order. Since such knowledge is indispensable to a complete understanding of the proper system of classification, the writer approached this study of the toad to determine if possible what light, if any, the study of the nasal organ would shed on this problem of relations drawn from previous workers on classifications of the Anura.

This work has been done in the Biological department, Knox College, upon Bufo americana (the common toad) which is very abundant in this region. The material used for study was fixed in Bouin's fluid, washed, dehydrated, sectioned, mounted, and stained with Delafields haematoxylin and eosin. A model was made after the Born wax-plate method and then studied. Drawings of the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capsule have been made; also drawings of the nasal organs, showing the relation of the organs to the capsule.

The study of the nasal capsule was undertaken upon the suggestion of Dr. G. M. Higgins, to whom the writer is indebted greatly, not only for the supervision and helpful suggestions of the work and the preparation of this paper, but also for the material used.

In a single toad larva, 14mm. total length, which has formed the basis of this study, a completely chondrified nasal capsule has not yet developed. Several structures, however, are already formed so that satisfactory comparisons may be made, not only with the older stages previously described, but with the capsules of corresponding stages of Rana.

The cavum cranii (CC), the cavity containing the brain, is only partially formed, so that the nasal cavity is practically continuous with that of the brain. The floor of the brain case in its anterior part is formed by a rather thick cartilage plate, the planum basale (PB), which is continuous laterally with the lower margin of the alisphenoid cartilages (AL C).

From the median line of the planum basale, just anterior to the telencephalon, a small cylindrical process extends dorsally (Fig. 2) a short distance, to end in the mesenchymatous tissue above. This is the beginning of the posterior wall of the nasal capsule, and is ultimately to separate the nasal cavity from the cavum cranii. It is quite evident that this process, the ethmoidal column (EC), is the first appearance of that structure later known as the pons ethmoidalis, which connects the dorsal margin of the alisphenoids just anterior to the brain.

Anterior to the ethmoidal column, the planum basale continues into that cartilage plate which forms the Planum ethmoidalis (PE, Fig. 1). This structure, more narrow along its posterior part, gradually increases in its lateral dimension and forms a trapezoid whose anterior margin exceeds the length of the posterior by one third. The medial and posterior portions of each nasal organ rest lightly upon the corresponding lateral surfaces of this planum (N OR, Fig. 5), but the larger part of the organ lies above and lateral to it. This portion of the capsule, relatively small at this stage, forms in the later larva the entire floor, and supports the nasal organs as well as the nasal glands found within the cavity.

At the anterior end of the nasal organ the planum ethmoidalis bifurcates, forming the cylindrically flattened trabeculae (T, Figs. 1, 6), which diverge forward, pointing ventrally in the mouth region. The trabeculae, although separated throughout their entire length by a triangular internasal space, are joined distally by a cartilaginous plate, the pons trabeculae (PT, Fig. 1). At the region of the junction of the pons, each trabecula curves ventrally for a short distance, and then by a broad curve forms a prominent corna trabeculae (CT, Fig. 6), which ends in a small posteriorly directed process closely applied to the pterygoid cartilage of the upper jaw. Contrary to the usual position of the cornu trabeculae of the Urodeles, each cornu of the toad is directed ventrally and posteriorly instead of laterally, although the general shape of these structures is quite identical in these groups. A further contrast is to be noted in the relation of the nasal organs to the cornua. In the Urodeles the external naris is terminal and the anterior portion of the nasal organ lies directly upon the cornu trabeculae which thus supports it. In the toad, on the other hand, the narial aperture is more dorsal and considerably back from these anterior parts of the capsule, so that here there is no intimate association between the nasal sac and the cornu. Later, however, it is probably true that as development ensues, each cornu forms an integral part of the capsule, and as the nasal organ assumes greater proportions comes to rest upon it.

Although not definitely a part of the nasal capsule, yet rather intimately connected with it in the earlier larval stages is a prominent curved plate of cartilage connected with the anterior margin of the planum basale at its junction with the alisphenoid cartilage. This is the muscularis process of the quadrate (MPQ, Figs. 1, 6) which in the earlier stages is attached to the anterior portion of the chondrocranium, but later migrates posteriorly and at metamorphosis takes its position in relation to the suspension of the jaws. This structure is strikingly U-shaped in section (Figs. 7, 8), the other limb being entirely free from the inner except at the anterior margin where both limbs are joined dorsally by a small bar of cartilage. This small cartilage is absent from the skull of Rana, where the limbs of this muscularis process are entirely free from each other except ventrally, where even as in this stage of Bufo they are joined to continue forward to a prominent pterygoid process. The anterior margin of the inner limb of the musculars process bears a prominent round structure which, although lacking any reference to the nasal organ as such, is known as the quadrato-ethmoidalis process, and corresponds with a similar region in the frog (QEP, Fig. 6).

Continuing forward from the anterior ventral surface of the muscularis of the quadrate is a broad band of cartilage, the pterygoid process (PP, Fig. 6). Each pterygoid continues forward to the position of the mouth and joins its mate at a point considerably posterior to the pons trabeculae, above described, and in a manner similar to it, thus forming the pons pterygoidii (PPT, Figs. 2, 3). In its posterior part each pterygoid is conspicuously broad; approximately flat on its upper surface, but possessed of a conspicuous keel on its lower. Just anterior to this broad portion each pterygoid bends abruptly toward the median line and expands into a prominent vertical plate which extends dorsally to a point just below the vertical margin of the trabecula. This portion of the pterygoid (Figs. 3, 6) is conspicuously concave on its external surface, and lies just within the expanded cornu trabeculae, the inner surface of which is markedly convex, so that there comes to be formed a conspicuous oval fenestra between these portions of the capsule. Thus it is evident that the anterior portion of the capsule, consisting of trabeculae, pons and cornua, form a hood-like structure which fits over the anterior portions of the pterygoids and the pons, uniting them (Fig. 3).

As we contrast this nasal capsule, just described, with that of the older toad at the time of metamorphosis, it is quite easy to recognize the changes that have taken place in the transformation. These changes concern only those portions definitely related to the nasal organ, and thus involve planum basale, ethmoidal column, planum ethmoidalis, the trabeculae and the cornua.

In the adult the nasal organs are entirely separated from each other as well as from cavum cranii by thick cartilage walls, pierced only by foramina for the olfactory nerves. Contrasting the two capsules, it is easy to see that the median vertical plate, the planum verticale, which separates the two nasal organs is but an anterior-dorsal chondrification of the ethmoidal column along the median line of the planum ethmoidalis. At the same time it is evident further that the posterior wall of the nasal capsule, separating the cavum nasi from the cavum cranii, has arisen by a chondrification dorsally of the planum basale, coupled with certain contributions from the alisphenoids, in the transverse plane of the ethmoidal column. In my single stage, although not mentioned in the section describing the capsule, the olfactory nerve passes anteriorly from the telencephalon through the wide notch between the ethmoidal column and the alisphenoid cartilage (Fig. 8, OLF). Later, as chondrification advances, cartilage layers form around this nerve, so that in the adult the olfactory nerves are found to pierce this posterior wall of the capsule, passing thence to the various parts of the nasal organ.

The floor of the nasal capsule of the older toad is considerably larger than the planum ethmoidalis of this stage, and it would appear that it has been formed by a further fusion of the trabeculae forward to the region of the cornua. No trabeculae as such are identified in the older stage, and it follows that they have lost their identity in the formation of the complex anterior part of the older capsule. The floor is wider than before so that a large portion of the nasal organ now rests upon it, giving it support, as well as additional protection. Anteriorly the cornua trabeculae persist even into the adult stage, where they take a more lateral direction and form what are known as the alinasal cartilages which support the anterior part of the nasal organ and form the floor of the external naris.

There remains for consideration the roof of the older stage, and if we may accept the evidence of such types as Hyla, the tree toad and the earlier stages of Rana, as described by Gaupp, a conclusion entirely warranted, it would appear that the roof of the capsule is but a lateral chondrification of the dorsal margin of the planum verticale. So the entire roof of the capsule, as well as the planum verticale, above described, is but a further chrondrification of the single median ethmoidal column of the earlier larval stage, together with certain additions from the planum ethmoidalis.

The foregoing comparison shows that there is a definite relationship between the younger and the later stages. It was found that the two trabeculae, separated by the internasal space in the younger embryo, were united, later forming the floor of the capsule in the older one. The planum basale, here as well as in the earlier stage, forms the floor of the cavum cranii; also the cornua remain, but have assumed a different position.

It follows that the nasal capsule of the younger toad is but a further development of those structures appearing in my earlier larva. Development is a continuous process, and in the final result a more specialized but reduced capsule is attained.

According to the zoological classification of Amphibia, this class is divided into four orders: Anura, Urodela, Gymnophiona, and Stegocephala. This paper is concerned only with that class Anura and its subdivisions, and upon the evidence of the nasal capsule it would appear that the existing order of Amphibian classification is entirely supported by this investigation.

EXPLANATION OF PLATE.

Fig. 1. Anterior view of model of nasal capsule of Bufo americana, 14 mm. total length. ×54.
Fig. 2. Posterior view of same model.
Fig. 3. Ventral view of same model.
Fig. 4. Dorsal view of same model.
Fig. 5. Transverse section through posterior part of nasal capsule.
Fig. 6. Lateral view of model of Fig. 1.
Fig. 7. Transverse section through planum basale and muscularis process of the quadrate.
Fig. 8. Transverse section through planum basale and olfactory nerve.

ALC Alisphenoid cartilage
CC Cavum cranii
CT Cornu trabeculae
EC Ethmoidal column
MPQ Muscularis process of the quadrate
NOR Nasal organ
OLF Olfactory nerve
PE Planum ethmoidalis
PB Planum basale
PP Pterygoid process
PPT Pons pterygoidei
PT Pons trabeculae
QEP Quadrato-ethmoidalis process
T Trabecula

SOME OF THE FACTORS INFLUENCING THE DISTRIBUTION OF ANIMAL PARASITES*

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Many things influence the geographical distribution of parasitic animals. In the past, it has been a common fallacy to assume that the geographical distribution of a parasite is coincident with the range of its host. This idea fitted well with the belief in host specificity, but recently there have been numerous demonstrations that many animal parasites are capable of utilizing various species as hosts. Furthermore, parasites common in a species of one locality may be entirely wanting in individuals of the same species in other parts of its range.

Especially in those forms which involve an alternation of hosts in the course of their development, do we find circumstances which stand as limiting factors to the distribution of parasites. Through the operation of these limtiting factors the indefinite spread of some parasitic species is prohibited. In some instances species artificially introduced into new territory are prevented from becoming established there through the operation of the same agencies, even though organisms suitable as hosts may be available. In the following paragraphs, some of these limiting factors are discussed, though no attempt has been made to give an exhaustive classification or treatment.

FACTORS OF THE PHYSICAL ENVIRONMENT

There are some organisms which pass their entire existence as parasites within other organisms. In some such instances, the eggs or larvae never leave the body of the host individual which shelters the mature parasite. Obviously, under these circumstances, conditions of the environment outside the body of the host could have no influence upon the parasite and its chances for development. More frequently, however, animal parasites pass through one or more stages when the parasitic organism is liberated from the body of the host. This period of

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* Contributions from the Zoological Laboratory of the University of Illinois No. 230.

free existence is frequently during the egg or larval stages of the parasite, but in the hair-snakes (Gordiacea) the mature worms are free-living and produce their eggs while living free in the water. An environment lacking water offers obstacles to the development of the Gordiacea, for the worms leave the bodies of their insect hosts when the insects fall into water.

The hookworm of man (Necator), which causes such heavy economic losses to the region of infestation in the South, offers no problems in our latitude. Even hookworm sufferers introduced here could not become sources of serious infestation to others because of limiting factors which are operative. The eggs leave the body of the host along with fecal matter and live for some time in the polluted soil. In this free stage the larvae are unable to withstand freezing temperatures, so in this latitude persons could not be exposed continuously to sources of infestation such as exist in the South. Furthermore, improved sanitary conditions do not permit contamination of the soil where human beings would come into contact with the infecting larvae.

Many trematodes, which produce diseases in man and in other animals, are restricted in their distribution to regions where suitable larval hosts occur. Since molluscs are the usual larval hosts of trematodes and since most of the molluscs are aquatic, presence of waterbodies is favorable toward trematode occurrence, while lack of water minimizes the possibilities of trematode infestations.

Many other animal parasites are so affected by conditions external to their hosts that they are excluded from certain areas wherein physical conditions suitable for their development are lacking.

ABSENCE OF ESSENTIAL LARVAL HOSTS

When a parasite which involves an alternation of hosts in its cycle of development invades new territory which is not occupied by one of its hosts, it fails to become established in the fauna of that region unless it is able to acquire as a host some other form of life represented in the local fauna. Both malaria and yellow fever are protozoan diseases which are transferred from man to man through the sole agency of certain species of mosquitoes. Absence of these essential carriers of the disease producing organisms precludes the possibility of either disease becoming established in any locality. Thus migration of a malarial patient into new territory would not extend the range of malaria unless suitable species of mosquitoes were present.

In these facts may be found an explanation of the condition wherein a host species is free from a given species of animal parasite in part of its range though the species may be a normal host of the parasite. In some instances, however, a parasite has been known to utilize several hosts and thereby in its range exceeds the range of distribution of any one species among its hosts.

DIFFERENCES IN HABITS OF THE HOST

Differences in habits, and especially in food habits, go far toward explaining why some individuals of a given species are infected by certain internal parasites while others of the same species are relatively or entirely free from infestation. Individuals of the same species may show marked differences in food preferences. This is just as true of other animals as it is of man. In the human species tapeworms of a given species are acquired only through eating raw or rare beef. Obviously a strict vegetarian could not acquire such a tapeworm. In like manner trichinous infestation is a consequence of eating pork infested with the larvae, so as a race orthodox Jews are exempt from this parasite.

In many animals the young are more heavily parasitized than are the adults and in some instances the parasites characteristic of the parasitic fauna of the young are lost in later life. This is usually correlated with changes in food habits though in some cases it seems probable that active immunity is acquired by the older organisms. The omnivorous, non-sanitary habits of children in part help to explain their susceptibility to parasitic infestations.

ISOLATION

Among non-migratory animals, spread of parasitic infestations may be prevented by a natural quarantine resulting from isolation. Lack of communication between groups of individuals in different localities may be a factor helping to explain why individuals in one locality may be heavily and generally infested by certain parasites while those in another region are exempt.

CONCLUSION

In view of the numerous limiting factors, only part of which have been touched upon here, it becomes evident that there are many obstacles to the attainment of cosmopolitan distribution by any parasite involving two or more essential hosts. These limiting factors on the one side determine that a parasite may not extend its range to the full range of its normal host and on the other hand permit some forms to exceed the range of any one host species through utilization of several host species. Man, who has extended his distribution over much of the surface of the globe, is subject to attack by numerous different species of endoparasitic animals, but many of these are limited to rather sharply defined areas, while in other instances he shares them with the animals of the native fauna.

Among the Acanthocephala or thorny-headed worms, there is a genus, Moniliformis, which presents unique conditions favoring cosmopolitan distribution. Members of this genus live as adults chiefly in rodents. The rat is one of the commonest hosts. Embryos, covered by highly resistant shells, are deposited by the worms but never leave the confining membranes until they are swallowed by a suitable host. Insects, of which the cockroach seems to be one of the most important, serve the larvae as hosts. Thus, with rats as common adult hosts and cockroaches as larval hosts, these parasites have both of the essential stages in their development provided for by practically cosmopolitan hosts, and have been distributed to practically every quarter of the globe.

THE SHIFTING OF THE MAMMALIAN FAUNAS, AS SHOWN BY THE PLEISTOCENE REMAINS OF ILLINOIS*

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A study of the fauna of any region, extending over a short period of time, will show certain changes in the animal population that are due entirely to natural causes; since conditions change, food animals become reduced in numbers through drouths or extended winters, and the correlated animals must move and re-adjust their numbers. Many of these shifts in the population appear to be without cause and are due simply to the wandering spirit, while others are correlated closely with actual changes in conditions. A study of a region for a long period of time will show marked changes and a great reduction or a complete dropping of the large groups. Sometimes descendants are left in the original home; sometimes survivors are to be found in regions far distant from the original home; sometimes entire groups disappear and leave no traces behind them but their bones in the rocks.

When man enters a region, rapid changes are likely to take place in a very short time. He first hunts and traps until certain animals are reduced or exterminated. The hunter is followed by the rancher who fences large areas, or leaves it open and grazes it, and as a consequence eliminates certain types of the fauna. The next man to follow is the farmer or agriculturist who fences and cultivates the land, cuts off the forests, drains the lakes and swamps, and changes the water courses. As cities grow up, the water courses are contaminated with their waste until they cannot support life, and another portion of the fauna disappears. A survey of Illinois for the last hundred years will show just such a shift, with the larger animals and many of the smaller ones driven out or reduced by the activities of man. The bison, deer, bear, beaver, and even the wolves have left us, although the wolf will remain longer than almost any

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* Contribution from the Zoological Laboratory of the University of Illinois.

other medium sized animal. On the western plains the coyote breeds and raises a family almost within the limits of towns of fifteen thousand. Smaller forms, such as mink, muskrats, and foxes, now find few localities where they can live in anything like their natural conditions.

A study of the life of a longer period will show changes in which man has had no part and has been no factor. It is of this period that this paper gives a sketch. If we go back into Tertiary times we find the Americas populated with a strange assemblage, a small part of which foreshadows the life of the present day. Ancestral horses, camels, the rhinoceroses, tapirs, and many other interesting forms were working out their evolution in different parts of the country. The horse went through his evolution from the five to the one toe, sending migrants to Europe at some stage of his development, which was a fortunate thing for us, since our magnificent horse fauna died out long before America was discovered by Columbus, and we have been forced to replenish our horses from those same European migrants of an earlier day. It is difficult to imagine the reason for the extinction of this horse group, for they lived here in abundance and in many forms that were suited to live under many different conditions. It has been suggested that we place the blame for their extermination on some of the protozoan parasites that continue their work even to the present day. The American horses were of all sizes and types. Forms as large as the draft horses of the present day, and ponies of many types were scattered over the plains of the latter part of the Tertiary.

The camels, a pure American product, also went through their evolution on the plains of the middle west and western America. They adjusted their bones to the running adaptation with joined metacarpals to form the cannon bone. A large fauna, varying from delicate deer-like types to the great giraffe camel of a later day, scattered their bones in profusion over the land in which they lived. The camels of the present day are the end form of this great population. A migration to Europe is represented by the camels now found in the east, while a southern migration is represented by the llamas and guanacos of South America.

The rhinoceros came into existence in America and developed into many interesting types here, such as the short legged Teleoceras, the large Metamynodon, the horselike, running Hyracodon and the commoner Caenopus. Migrants from this primitive stock gave Europe and the adjoining continents the present day rhinoceros, found now only in southern Asia and Africa. All that we have left are the large masses of bones to be found in the fossil fields of the west. This exchange of animals with the other side was by no means a one sided affair, for we received in return some of our most picturesque types, such as the bear, elephant, moose, elk, caribou, deer, musk ox, mountain sheep and mountain goat.

Woods (1910) in a paper published by the Natural History Survey says that an elk was killed in the state about 1830 and that the bisons were common about 1800. A deer was seen near Homer about 1880. These are the last of the large mammals to remain wild in the state.

If we drop back to Pleistocene times, we shall find a very different fauna living in this state and region. The animals of this period are the ones to be considered in this sketch of the old fauna. The following paragraphs will take up some of the mammals that have lived in or near to this region. Probably all of them could be counted as ancient residents.

The Edentates were represented by three large forms, all migrants from the old stock of South America. Megalonyx was to be found from coast to coast, Mylodon was very generally distributed, while the southern species just reached the borders of the state. The only related form now living in the United States is the armadillo of Texas.

No camel has been reported from this region, as they were to be found in the west.

The Bovidae were numerous and some forms continued down to comparatively recent date. The bisons left the state about 1800. In time prior to this two other bisons were to be found here, Bison latifrons and Bison antiquus. These last two were from an older stock that was replaced by the modern bison. Two musk ox are recorded from the state, a very old one, Symbos cavifrons, and the modern Ovibos moschatus that probably followed the ice from his northern home.

A peccary was fairly common here in the form of Platogonus compressus. His relative, the peccary of the south, now lives in parts of Texas and south of the Rio Grande.

The tapir was of an old type, Tapirus haysii. The tapir fauna of the present day is to be found only in Central and South America and in Southern Asia.

Of the large horse group only two have been found in this region, Equus complicatus and Equus fraternus. They died out with the rest of the horses and left their bones in the state.

The elephants, of African origin, came over early in the Tertiary and scattered over the Americas. Three of this magnificent group lived in this region, Elephas primigenius or the mammoth, Elephas columbi, a much larger type, and the swamp loving Mastodon of the wet, wooded regions, Mastodon americanus. At the present time the elephant is to be found only in Africa and Asia.

All of the larger members of the deer group were to be found in this region, the elk, moose, the caribou, and the smaller Odocoileus virginianus. Although all of these forms are still to be found, they are far removed from this central region.

The bear left sometime before 1800, and has been driven gradually to more uncivilized parts where he is not in such close contact with man.

One very interesting mammal, Castoroides, a large beaver-like animal, lived here as the original deforesting agent. As large as a small black bear in size, his onslaught on the trees must have been terrific. If the modern beaver can cut a cottonwood four feet in diameter, what must have been the size of the trees that this fellow would cut? This form was quite widely scattered over the country.

This picture of the shifting of the faunas delights the students of geographical distribution and enlivens the labors of the palaeontologist and the student of comparative anatomy, but unfortunately, such movements will never occur again, for the larger mammals are located probably where they are to meet their doom, for those unprotected by man are on their way to extinction. The highest mammal, man, now covers the face of the earth and any other mammal must give way to make more room for him. It is pitiful to see the last stand of the buffalo on his protected ranges where man keeps a rigid watch over him to protect him from other men. The free running antelope finds himself running between great stretches of barbed wire, where once nothing but the horizon bounded his domain. The elk must depend upon the bounty of man for his winter food, since his winter ranges with their supply of hay have been utilized by the rancher for his herds. The African game is going the way of the buffalo in America. The enormous herds of roving mammals have been thinned to the danger point, and will disappear shortly unless they are protected in certain restricted and suitable ranges, where they can be kept for the future generations to see and enjoy.

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TESTING LAMARCK'S THEORY

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The first clear and distinct theory of evolution was advanced by the French scientist, Jean Baptiste de Lamarck. With the exception of that of Darwin, the theory of Lamarck has been discussed more than any other, and it is the least understood of any theory which has been discussed at all. Considering the vast literature and almost total lack of understanding, Lamarck's theory presents what is perhaps the most remarkable case in the history of science.

The causes leading to the misunderstanding of this theory would fill a book, so we will confine ourselves here to explaining what the misunderstanding is rather than the causes which led to it. To make the matter clear it will be necessary not only to state what the theory is, but to point out what it is not.

Lamarck's theory is stated in his Zoological Philosophy published in 1809, when Lamarck was sixty-five years of age. A partial translation of this work was made by A. S. Packard and published in 1901. A complete translation was made later by Hugh Elliot and was published in 1914. It is to these translations we must go for an understanding of the theory. At this point it may be noted that neither translator clearly understood the theory he was translating. In their comments, both translators make statements which are contradicted by the texts which they translated. When the translators themselves misconstrue what they translate, it is not surprising that others should do the same.

About thirty years ago many cases of supposed inheritance of mutilations were advanced as evidence of the truth of Lamarck's theory. This was attacked successfully by August Weismann, who cut off the tails of mice for many generations in succession and found that tails grew just the same as before. This was looked upon as a full refutation of Lamarck's theory, and a great many persons so consider it at the present time.

It happens that Lamarck discussed mutilations under the term of "accidental defects", and he states that they are not inherited. He says:—"Hence it is that in man, who is exposed to so great a diversity of environment, the accidental qualities or defects which he acquires are not preserved and propagated by reproduction." (Packard's translation, pages 246, 319; Elliot's translation, page 124.)

Here we see that the long and acrimonious dispute over the supposed inheritance of mutilations was based on a misunderstanding which orginated no one knows where, and which had no bearing on Lamarck's theory. As we shall see later, the idea that mutilations might be inherited is entirely foreign to the theory and had no excuse for existence.

Darwin advanced the theory that by selecting variations, changes might be brought about which would result in the production of new species. He did not explain the origin of variations but said that with variations in existence, selection would accomplish wonderful results. The often repeated statement that selection does so-and-so has come to mean, even among biologists, that selection is the real and actual cause. They forget that the variation must come into existence before it can be selected, and that the cause of the variation must be something other than the subsequent selection.

The same kind of confusion of ideas has come into the popular consideration of Lamarck's theory in regard to environment. The idea that the environment may cause modifications has been popular since before Lamarck's time, and is so now. Even the biologists of the present time subject guinea-pigs, rats, mice, rabbits, etc. to environmental actions in efforts to produce heritable modifications. Among the things done has been subjecting animals to prolonged applications of alcohol, to X-rays, to radium emanations, to injection of the juice of eye lens, to rotation in cages, and so on.

Lamarck had a great deal to say about the environment, but he did not claim that the environment caused change any more than Darwin claimed that his selection produced the things selected. Lamarck said that animals lived in the environment, and that the environment directed the actions of the animal, but that it did nothing of itself to produce a change. To make his meaning clear, Lamarck said:

> "Here it becomes necessary for me to explain the meaning I attach to the expression *circumstances influencing the form and structure of animals*—namely, that in becoming very different they change, with time, both their form and organization by proportionate modifications. Assuredly, if these expressions should be taken literally, I should be accused of an error; for whatever may be the circumstances they do not directly cause any modifications in the form and structure of animals." (Packard's translation, page 294; Elliot's translation, page 107.)

Here we have a clear statement which shows that Lamarck was not an environmentalist, and the other parts of his writings bear out that statement. It is not what is done *to* the animal by the environment, but, as we shall see, it is what the animal *does* of itself to itself, which counts. The environment is that which is outside of and surrounds the animal. What the animal does represents something occurring within the protoplasm of the cells which compose the animal. It is a misconception to refer to the action of an animal as being in the same class of things as the environment. The two things stand in contradistinction to each other.

Lamarck was a contemporary with the later life of Linnaeus, and was one of the pioneers in the classification of plants and animals. In fact, he was the originator of a considerable part of the classification as it now exists. After he had spent twenty-five years as a botanist, largely in classifying the largest botanical collections then existing, he was placed in charge of the largest zoological collection in the world. Here he spent more years in classification, and among other things he was the first to distinguish vertebrate from invertebrate animals by the presence of the vertebral column. "The problem of taxonomy has never been put more philosophically than put by him."

In doing this work, Lamarck became impressed with the fact that the classification of species and genera was artificial. He, and not a Creator, was determining what constituted species and genera, and what were their limits. He was impressed also with the fact that the distinctions between one species and another were trivial in the extreme, and that intergrades frequently obliterated those distinctions. For the purpose of making this matter clear, and for laying a foundation for his new theory, he devotes the first chapter of his book to "Artificial Devices in Dealing with the Productions of Nature." After referring to the "artificial aids" of classification, which he says are necessary in dealing with such masses of material, he goes on to say:

> "Nature has made nothing of this kind: and instead of deceiving ourselves into confusing our works with hers, we should recognize that classes, orders, families, genera and nomenclatures are weapons of our own invention. * * * We may rest assured that among her productions nature has not really formed either classes, orders, families, genera or constant species, but only individuals which succeed one another and resemble those from which they sprung."

From his consideration of these things he got a new idea. That idea was that the "order of nature" was determined by what animals *did*, and not by what they *looked like*. He knew that species were not real things in nature, and that animals changed. From what he observed he could see that certain changes were brought about by the manner in which animals lived and acted, and not by reason of the existence of any particular environment. Hence, he conceived the idea that animals evolved by the *inside forces* developed within them by their own actions and efforts, and not by the *outside forces* of the environment. His theory is condensed into two laws, as follows:

FIRST LAW

"In every animal which has not passed the limit of its development, the more frequent and continuous use of any organ gradually strengthens, develops and enlarges that organ, and gives it a power proportional to the length of time it has been so used; while the continuous disuse of any organ imperceptably weakens and deteriorates it, and progressively diminishes its functional capacity."

SECOND LAW

"All of the acquisitions and losses wrought in individuals by the predominant use or permanent disuse of any organ are preserved by reproduction in the new individuals which descend from those which have acquired the modifications."

(Packard's translation, page 303; Elliott's translation, page 113. The above statement of these laws is a composite of the two translations, and is simplified by the omission of parenthetical matter.)

It is not enough to glance at these two laws, and then pass on to something else. They should be examined carefully and critically to see what they mean. They should be examined as a lawyer examines the wording of a contract. The failure to give them such careful consideration is undoubtedly the primary cause of the wide spread misinformation as to what Lamarck's theory is.

We all know that exercising any organ, as a muscle, increases the power of that organ, but Lamarck refers to "frequent and continuous" exercise, and says that the acquired development in the individual is "proportional to the length of time" that the organ is exercised. The "frequent and continuous" exercise means continued activity of some kind, and the "length of time" necessarily involves the age of the animal, if we are to make any measurements of what the acquirements are. That any test of Lamarck's theory necessarily involves determining the degree of activity of the animal, and its age at the time of reproducing, is evident from the second law which says that "all of the acquisitions and losses" are preserved by reproduction on the part of those individuals which have gained by exercise or lost by idleness.

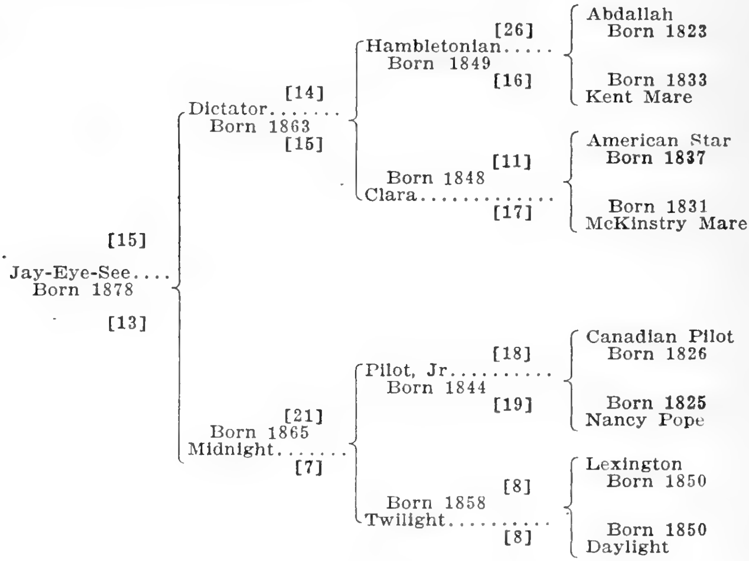
Lamarck says that this development of powers by exercise occurs in "every animal which has not passed the limit of its development," but he does not state where that limit is. He simply assumes that it continues for some time but furnishes no evidence as to how long that time is. However, I have furnished that evidence in my "Human Heredity," in my article in Volume XIII, page 59, of the Transactions of the Illinois State Academy of Science (1920), and in numerous other contributions. Under continuous exercise, powers continue to develop up to practically the end of life; and under lack of exercise, powers continue to degenerate as long as the lack of exercise continues. While the observed gains and losses are irregular, there is much evidence to indicate that the real gains are directly proportional to the degree of activity above the normal, and the length of time that excess activity continues. Also. that the losses are directly proportional to the deficiency of activity and the length of time that deficiency is continued.

This theory is known as the theory of the inheritance of acquired characters, or, as I usually term it, the inheritance of acquirements. Power in the organs of an individual is a character which existed before, but the increase of the amount of such power is an acquirement. To be technical, the verb *to acquire* means to obtain something by effort, exertion or the performance of work on the part of the individual which makes the acquirement. In amputating the tails of mice, the acquirement is in the muscles of the amputator, and not in the taillessness of the mice. Taillessness means the loss of something, and the verb to acquire does not mean to lose.

The American trotter is the product of the nineteenth century and represents what is probably the most remarkable example of the rapid development of powers in any animal. A hundred years ago the highest trotting speed was a mile in three minutes. Now the extreme speed is better than a mile in two minutes. This improvement in trotting power has been nearly but not quite uniform during the intervening years. It will not do to say that this improvement is due to improved tracks, sulkies and training. The trotting breed started in crosses of the thorobred on American farm mares, and the product of such crosses at the present time are valueless for the production of fast trotters. It has been more than fifty years since there was any advantage in using the thorobred in trotting stock.

The gain in trotting power in the trotting horse is a development of the particular thing to which Lamarck's theory is directed, and it is a challenge to that theory. The development of the individual trotter by training is in exact accordance with Lamarck's first law, and race track records show that there is a continued development of power under continued training, up to near the end of life. The race records of the nineteenth century show that each generation of trotters in succession, in certain lines, inherited more trotting power than their parents inherited. Did that gain in inherited power come in accordance with Lamarck's second law, or in some other way? That is a question of fact to be determined by examining the records, and for the purpose of showing the process of testing Lamarck's theory there is provided a pedigree of the first horse to trot a mile in two minutes and ten seconds.

The first time a horse ever trotted a mile in two minutes and thirty seconds was in 1845, and that horse is not in this pedigree. By examining the dates when the great-grandparents of Jay-Eye-See were born, it will be seen that they came from ancestors, no one of which was capable of trotting a mile in 2:30. The pedigree therefore covers all of the animals involved in a very considerable increase in inherited power. The trotting power which had no previous existence in the breed had its origin somewhere among these animals. It could not come from the environment because trotting power is something which does not exist in the environment.



Pedigree of the First 2.10 Trotter.

The figures in brackets between parents and offspring are Lamarck's factor of "length of time". Thus, there are 15 years between the birth of Dictator and the birth of his son Jay-Eye-See. These figures mean nothing of themselves, but we begin to see a significance when we compare them with the average age of parents in normal breeding, which is 10.4 years for sires and about 8.5 years for dams. As sires less than 7 years of age are as common in normal breeding as are sires more than 14, it will be seen that for the parents in all of the generations in this pedigree, Lamarck's factor for "length of time" is high.

There is a life history of nearly all of the animals in this pedigree, and from this history we can determine, approximately, Lamarck's factor of activity, and hence can determine whether there was a gain in the parents by "frequent and continuous" exercise before reproduction, or a loss from "continuous disuse". Thus, Dictator "was driven a good deal" when young, and "was worked considerably at Mr. Durkee's farm" up to the year before Jay-Eye-See was conceived. After that he was used for breeding purposes solely, and not worked. Very much the same story is told for the other animals in the pedigree, all of which show that in each pair at the time of reproduction there was a considerable excess development coming from "frequent and continuous" exercise for an unusual "length of time".

We will not go into the details of these histories because of the lack of space, and because it would be wearisome, but there is one matter which throws a flood of light upon the case. Dictator was not only the sire of the champion Jay-Eye-See, but he was full brother of Dexter, one of the most famous of all champion trotters. The reader will conclude naturally that Dictator was of choice selected stock and that the improvement came through selection, but there is a damper on that idea. Both Dexter and Jay-Eye-See were geldings. The fact that Dexter was sterilized shows that the breeders did not consider the Hambletonian-Clara combination as valuable at the time he was born, and the fact that Jay-Eye-See was sterilized shows that they did not consider the Dictator-Midnight combination valuable when Jay-Eye-See was born. Of the sires in this pedigree, Hambletonian is the only one used much for breeding purposes before the age at which he here appears, and he had harness work all his life. Daylight first went to the breeding ranks at the age of six, Midnight first went there at the age of eight, Clara first went there at ten, the Kent Mare first went there at the age of fifteen, and the McKinstry Mare was a famous road mare for many years before Clara was born. On this point there is no available record for the other two mares. Carefully selected brood mares usually go into the breeding ranks at about three years of age, and those which do not go early have to work for a living.

It has been said that my work on the trotters and other animals is nothing but statistics, but that is not true. Applying the Lamarckian factors of activity and age to the progenitors, one at a time, in the pedigree of Jay-Eye-

See for the purpose of testing the application of Lamarck's theory to the known improvement, is not statistics. Neither does that kind of work become statistics when it is applied to the different animals individually in a second pedigree, or to the animals in a thousand pedigrees. Statistics have been used in this work, but the demonstration of the accuracy of Lamarck's laws does not come from statistics. Neither does it come from the detailed examination of a case like that of Jay-Eye-See. And it does not come from finding a large number of cases of the same kind. It comes from a series of things.

1. The fact that gain in inherited power in offspring is never found in any case except those in which the immediate ancestors made excess acquirements in accordance with Lamarck's first law.

2. The fact that a reduction of either of the factors of activity or age in parents so that the product of those factors at the time of reproduction is less than the average for the breed, invariably results in a decrease in inherited power in offspring.

3. The fact that when a considerable number of cases are taken and tested out one at a time, and are compared with each other, it is found that the amount of gain or loss per generation in the inherited power is always proportional to the product of the Lamarckian factors, within the limits of unavoidable errors.

On this third point, just refer back to Lamarck's laws. The first law says that when there is "frequent and continuous use" of an organ, the development is "*proportional* to the length of time" of such use. The second law says that "*all* of the acquisitions and losses wrought in individuals by the predominant use or permanent disuse of any organ are preserved by reproduction".

Lamarck stated his theory so that it might be tested by the methods of exact science.

BLOOMING RECORDS OF THE APPLE

C. S. Crandall, University of Illinois

Recording plant processes that occur periodically is receiving more attention than formerly and there is increasing belief in the scientific and economic importance of records of this character. The making of flowering records is a comparatively simple matter; but, in order to make such records of value, they must be digested, brought into orderly form and interpreted in such manner as will develop principles and admit conclusions that may be formulated in a way to support some canon of science or guide economic procedure, and this is not a simple matter.

This applies not only to bloom records of apples, but to all other accumulated records touching any phase of the life of living plants. Problems that, at first, may appear simple soon develop an unexpected complexity; questions present themselves at every step, questions that may involve morphological studies, or inquiry into physiological functions or even determinations of chemical composition. The subjects are living organisms; they follow a fixed sequence of life events, but they vary in time and manner of meeting and passing these events.

The investigator may speculate on the causes of observed departures from expected occurrences, reach and announce conclusions that may or may not be correct, or he may by more or less prolonged experiments reach conclusions that will stand, or he may ignore the questions arising, merely state the facts and allow the reader to draw his own conclusions.

Bloom records to be considered were taken at the Illinois Agricultural Experiment Station; they include flowering dates and periods for 106 varieties having records of from ten to sixteen years.

For central Illinois the flowering period for apples is short; in some seasons very short. Heat waves, in some seasons, bring trees into full bloom with astonishing rapidity; flowers retain the ability to function for a brief period and the whole flowering process is over in a very few days. Other seasons are characterized by abnormally low temperatures, by excessive rainfall, or by rapidly alternating periods of heat and cold so that flowering is very irregular and the blooming period much prolonged.

Of the 106 varieties, 38 are recorded as having bloomed in each of the 16 years; 24 bloomed in each of 15 years; 23 in each of 14 years; 11 in each of 13 years; 5 in each of 12 years; 3 in each of 11 years, and 2 in each of 10 years. For the 16 years (1901-1916), flowering periods have ranged from 10 to 22 days; the average is approximately 16 days. Records of 1906 and 1911 are very near the average; seven years had periods one to six days longer than the average and seven years had periods one to six days shorter than the average.

The full flowering period for the 16 years is included between the dates April 2 and May 21 and is thus 50 days in length, but this includes one year so abnormal as to set it apart from all other years; I refer to 1910, in which year flowering began April 2 and ended April 19. Omit 1910 and the full flowering period has extended from April 18 to May 21, or 34 days.

Some varieties tend to bloom early, others late, but there is no variety holding place as earliest bloomer or as latest bloomer with constancy; they vary within wide limits. Causes for these variations must be looked for in seasonal differences in vigor of individual trees. All trees are subjected to the same atmospheric conditions and presumably the soil is uniform, but all trees do not behave in the same manner with reference to their functions; one tree, in a given year, makes greater growth than another, has more and better foliage and exceeds its neighbor in fruit production; in another year the performance of the two may be exactly reversed in all these particulars. In the same way response of flower buds to the stimulus of advancing spring may be quick and vigorous or tardy and weak, depending upon the condition of the individual.

The seasonal abnormality of 1910 was so great that it deserves brief mention. The bloom extended from April 2 to 19, a period of 18 days. A period of the same length was recorded for 1909, one a day shorter in 1904, another a day longer in 1905; nine of the 12 remaining years had periods from 2 to 8 days shorter and for three years the periods were three and four days longer. Individual periods ranged from 4 to 9 days much as in normal years. It appears that the whole flowering period was simply moved forward until the ending of bloom for the latest flowering variety overlapped, by but one day, the earliest opening of flowers in any other year.

The early bloom is directly attributable to abnormal weather in March. The month was dry, the rainfall only .38 inch; mean maximum temperature 63°, mean minimum 37.7°, and mean daily 52.3°. For the last half of the month the absolute maximum was 85°, the mean maximum 73.9°, and mean minimum 44.7°. For the period of bloom, April 2-19, the mean daily temperature was 53.4°, the mean maximum 65.6°, and the mean minimum 42.1°.

I wish now to compare this earliest blooming period of 1910 with the period for 1904 which was the latest recorded—May 5-21. The comparison covers 102 varieties that bloomed in both years. The full flowering periods for the two years differ but by one day, 17 days in 1904 and 18 days in 1910, but the beginning date in 1910 was 34 days in advance of the beginning date in 1904.

Flowering periods for individual varieties tend to concentration about the 6, 7, and 8 day periods in both years; the day-groups in 1904 number 8 with a range of from 4 to 14 days; in 1910 there were 6 day-groups with a range of from 4 to 9 days. The average period was 7.34 days in 1904 and 6.78 days in 1910, a half day longer (.56) in the year when the blooming period occurred 34 calendar days later than in the year of early bloom.

It would be reasonable to expect that in contrasting the blooming periods of two years, one of which was more than a month later in the season than the other, the periods of individual varieties would be shorter and concentrated under a less number of day-periods in that year in which the blooming period was latest in season, because the more powerful action of the sun and the presumed greater aggregate of heat units in the advanced season would so stimulate plant functions that blooming of varieties would proceed rapidly and result in concentration within narrow time limits of short individual periods, but in this case the reverse is true. Not only are the full flowering periods, although separated by more than a month, of nearly equal length, but individual periods have a shorter average in the early year and there are twice as many varieties having 4 and 5 day-periods as in the later year.

Fluctuations in length of varietal flowering periods are common to all varieties and all years; they are no more marked in the years 1904 and 1910—the earliest and latest years—than they are in other years. Grandmother, which had a 5 day period in 1910, had a ten day period in 1904, and Repka Malenka with an 8 day period in 1910, had a 14 day period in 1904. There were 50 varieties that had periods from 1 to 6 days longer in 1904 than in 1910, while 29 other varieties had periods from 1 to 4 days longer in 1910 than in 1904. These differences suggest the operation of influences entirely apart from temperatures, moisture, or other climatic conditions.

For the 16 years of record, average varietal flowering periods ranged from 5 days to 10 days; this average was 5 days in 1910 and 1915, 6 days in 1908 and 1912; 7 days in each of 6 years, 8 days in each of 3 years, 9 days in 1903 and 1914 and 10 days in 1907. The lengths of blooming periods for individual varieties may be near together in one year and widely separated in another year. There is great variation in this; thus, in 1907 the minimum of 3 days was represented by two varieties, the maximum period of 17 days by one variety, and each number of days falling between 3 and 17 was represented by from 1 to 13 varieties; this largest number—13—falling on the 12-day period. The total number of periods, each differing from its neighbor by one day, was 15; at the other extreme the year 1915 has the record, for the 100 varieties blooming in that year concentrated into 3 periods; 7 varieties each had a 4-day period, 57 varieties had each a 5-day period, and 36 varieties had 6-day periods.

Amount of bloom is not open to exact determination, but estimates are believed to be helpful in summation of characteristics of varieties and in separating those having well-defined tendencies towards insufficient bloom from those having the opposite tendency. Observations made year after year convey a very definite impression of wide seasonal differences in behavior of varieties and individuals; of very unequal response to exterior conditions observed and assumed to exert influence either as stimuli to increased activity, or as agents operating to retard or diminish plant processes and, further, of the fact that factors governing performance are complex and dependent upon physiological changes that are difficult to understand or rightly interpret.

Amount of bloom is not determined at blooming time, but during the preceding year at the time of bud formation and, whether the amount is large or small, must depend upon the condition of the trees and the conditions to which they are subjected during the bud forming period.

Classified as belonging to one or the other of two divisions, no bloom or not sufficient for a crop and enough for a crop, the 1696 records for the 106 varieties for 16 years divide as 636 with none or insufficient bloom and 1060 with sufficient for a crop. From examination of the records it appears that 1913 was the year of maximum performance, for in that year 101 or 95.29 percent of the varieties had sufficient bloom; next to this was 1915 with 97 or 91.51 percent with satisfactory bloom. At the other extreme, 1902 and 1907 had each only 41 or 38.68 percent of the varieties having sufficient bloom. In other years the distribution was irregular.

Very heavy or excessive bloom occurred 92 times on 58 varieties in 8 of the 16 years; 32 varieties appear in the list recording very heavy bloom but once; 21 varieties appear twice; 3 appear 3 times; one, 4 and another 5 times. For the 21 varieties each appearing twice, there were two cases in which the years of heavy bloom were consecutive, five cases of alternation with sufficient bloom in the intervening year and 14 cases in which the years of heavy bloom were separated by from 8 to 12 years.

The variety having very full bloom in 4 years was Oldenburg; the years were 1902 and 1904, and 1914 and 1916; between each of these pairs was a year of moderate bloom and for the 16 years the variety has record of 12 good and 4 poor years.

The variety Borsdorf has the highest record of any of the 106 in that in no one of the 16 years was there a deficiency; it had moderate bloom in 2 years, full bloom in 11 years, and very full bloom in 3 years.

There are wide differences in varieties as regards their blooming tendencies. Some are inclined to produce sufficient bloom nearly every year while others rarely attain satisfactory production.

Cases of alternation of full or heavy with light or no bloom occur occasionally, but they are less common than the occurrence of from 3 to 5 or even 6 consecutive years characterized by the same amount of bloom, either scant, moderate, or full.

In this fact is seen evidence of the inequality of response by different varieties to the same attendant conditions. Each variety appears to follow a course of its own, individuality stands out strongly and there appears no single agency or group of agencies that operate on more than very restricted lists of varieties for limited periods to govern performance in flower production.

Effort has been made to trace relationship between amount of bloom, in a given year, and conditions of temperature and moisture prevailing during the months of June, July, and August of the preceding year, but the irregularities found were such as to render existence of any definite relation doubtful; correlation cannot be established for the reason that temperature and rainfall are only two of a long array of factors, all of which may operate to influence bloom performance. Temperature and rainfall may be the most important, but taken alone they cannot lead to correct interpretation of observed results because other, and possibly equally important factors are left out.

Computations from incomplete data serve only to confuse; they do not aid in understanding observed phennomena and hence accomplish no good purpose. Even with full data at hand, determination of the causes of observed irregularities in flowering would be difficult because of the complex nature of the problem. Like any other problem involving the physiological processes of plants the factors that influence results are very numerous, these factors interact among themselves, they are difficult to isolate, and, to associate correctly any one of them with observed phenomena is possible only through close and prolonged study.

With all varieties there are marked irregularities in the alternation of long and short blooming periods, and, further, there are conspicuous departures from those relative lengths of periods of different varieties that might easily be assumed to be constant; thus, where two varieties, in any one year, have blooming periods differing in length by several days, one, say twice as long as the other, it would not be unreasonable to suppose that the varieties in question would hold to an approximation of the difference in other or all seasons. As matter of fact the relative lengths of the periods in one season may be reversed in the succeeding season.

This occurrence indicates plainly that temperature and general atmospheric conditions, commonly regarded as the chief determiners of lengths of blooming periods, do not act equally on all varieties in all seasons, or that varieties develop within themselves qualities that render them less susceptible to stimulation, or more resistent to adverse conditions in one season than in another.

In illustration, the records of Tolman and Whitney for the years 1903 and 1908 may be cited. The flowering period for Tolman in 1903, a year having a long average flowering period (9.2 days) for all varieties, was six days, while in 1908, when the average period for all varieties was short (5.94 days) the period recorded was 16 days. In contrast with this record, Whitney, with a variety average for 16 years of 7¾ days, had its flowering period lengthened to 14 days in 1903 and contracted to 5 days in 1908. Bringing these records side by side for ready comparison they appear as below:

	1903	1908
Blooming period for Tolman.....	6 days	16 days
Blooming period for Whitney....	14 days	5 days

The trees compared were of the same age, grew but a few rods apart and had received the same care each year.

Variations in lengths of blooming periods such as those cited are of common occurrence and cannot be caused by spring weather conditions alone; by their marked irregularities they suggest that the individual rather than the variety must be the basis from which performance is considered. Trees of one variety growing together in the same row do not act alike; one starts earlier, pushes stronger, and completes its period of bloom in less time than does its neighbor. It is said of such a tree that it was in better condition than the other, had more vigor and was thus enabled to outclass its neighbor; this is true, but when the question is asked, Why was the tree in better condition and possessed of greater vigor? the answer is not immediately forthcoming.

The tree of greater vigor may be constitutionally better than its neighbor; it may have had access to better food supply; it may have recovered more completely from a fruiting effort; it may have escaped a parasite that damaged its neighbor; any of these or possible other causes, singly or in combination, may have operated to bring about the recorded differences, leaving no evidence of operation that is apparent at the time bloom record is made.

AN ECOLOGICAL SURVEY AND FLORA OF LAKE KNOX

PAUL K. HOUDEK, KNOX COLLEGE

This is a first report of an ecological survey being conducted on a small area containing a pond and a swamp, near the eastern limit of Galesburg, Illinois. This work was begun late in the fall of 1921 in conjunction with a zoological survey by Miss Florence Adcock, which was published in the last year's proceedings of this organization.

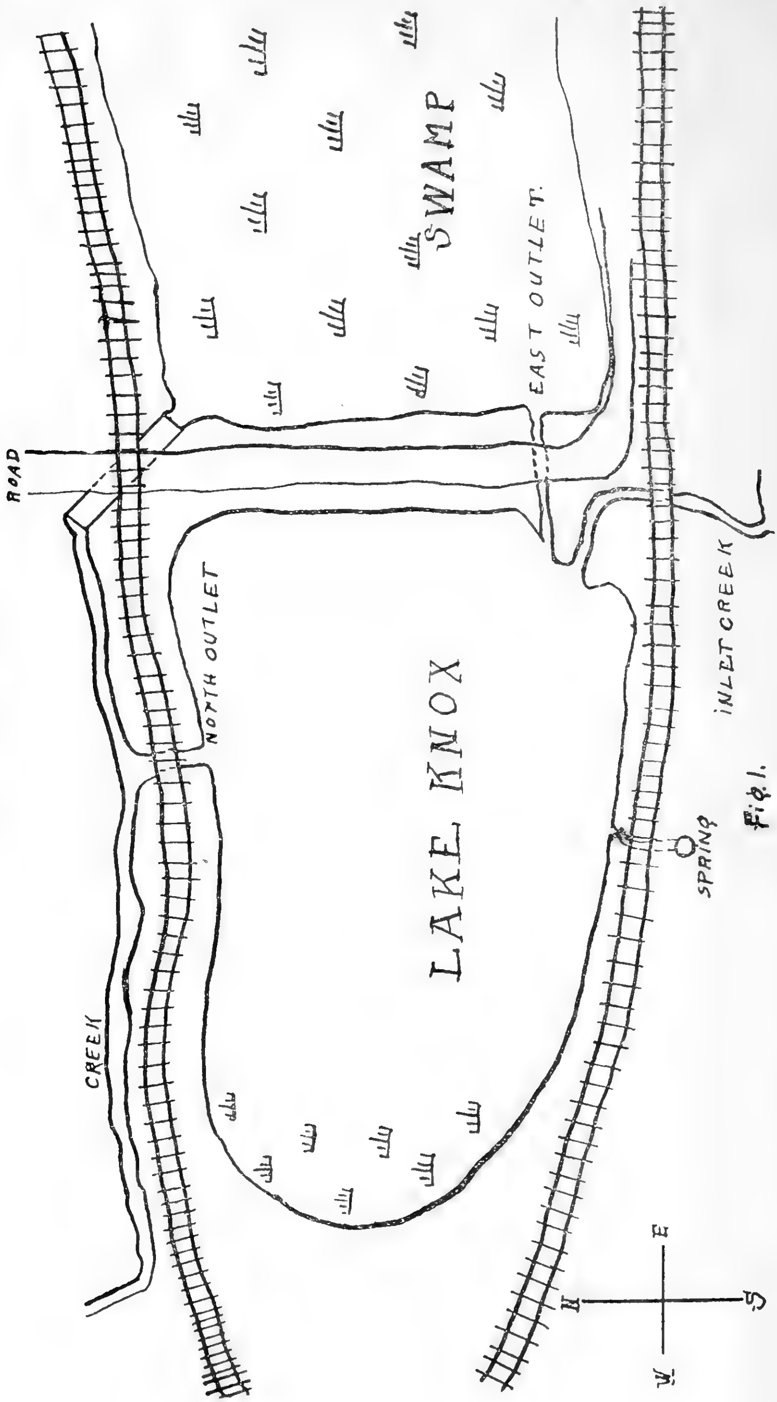
The lake lies in a triangular area formed by two embankments of cinders and rubbish. These embankments lie, one parallel to and the other at right angles with the axis of the broad ravine between the surrounding low hills. The lake itself is roughly triangular in shape, being 380 ft. long and 210 ft. wide at the east end.

Lake Knox originated about forty years ago, and until about 1911 was used to supply water to a nearby brickyard. Until it was abandoned, it was kept clear of any great amount of plant life.

The marsh lies directly east of the lake, across the embankment. The marsh area is about 200 ft. square and receives most of its water supply from Lake Knox. The development here has been rather rapid. I can remember fishing here about six years ago.

The main volume of water entering the lake comes through a creek from a similar lake to the south. A nearby spring also contributes its water. The overflow drains eastward into the marsh through two drains, the more recent of which caused the lowering of the lake by about eight inches. Except for the spring deluge and an occasional summer drouth, this area has a fairly constant and abundant water supply.

This region has been used for years as collecting ground for both Knox College and the High School Biology departments. It furnishes frogs, fish, turtles, snakes, crayfish, snails, a few bivalves and numerous protozoans, such as paramecia, vorticella, euglena and amoeba. Filamentous water plants and weeds have been collected here also.



Map of surveyed area.

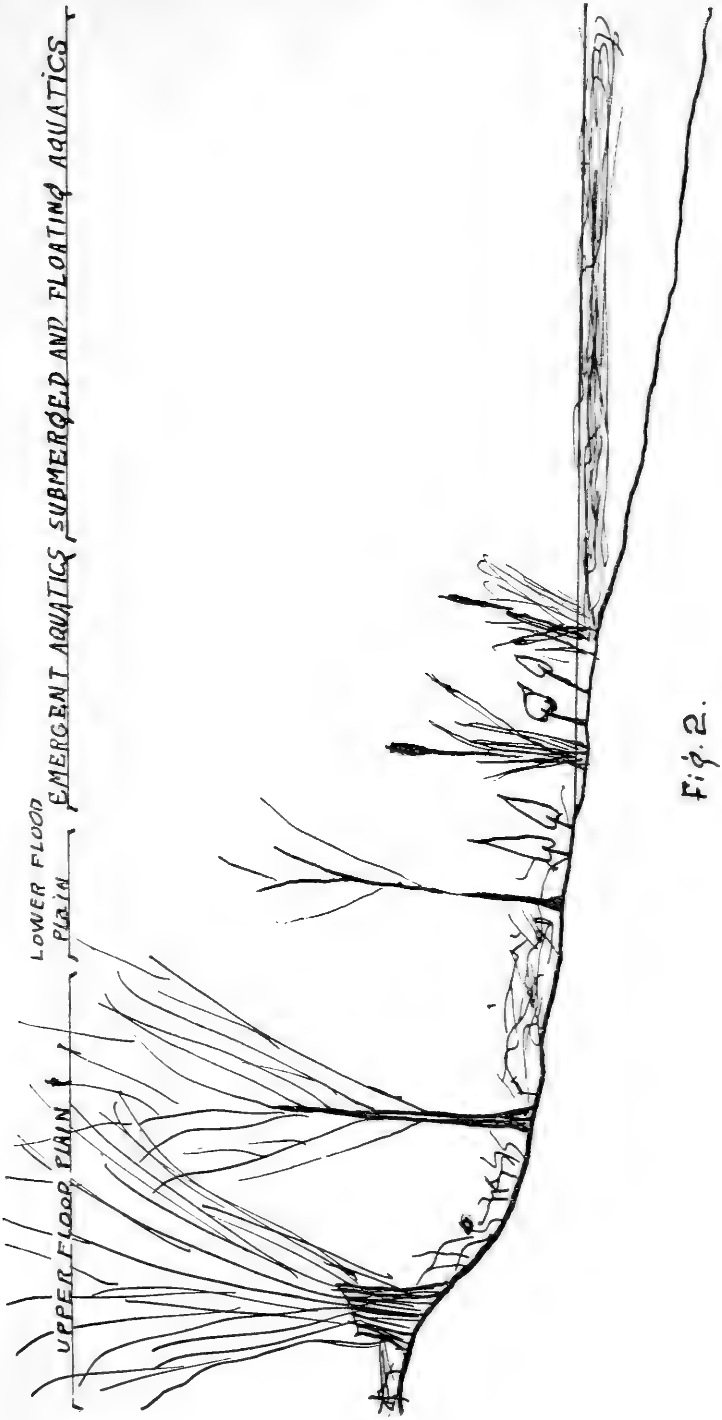


Fig. 2.

Societies of west shore line.

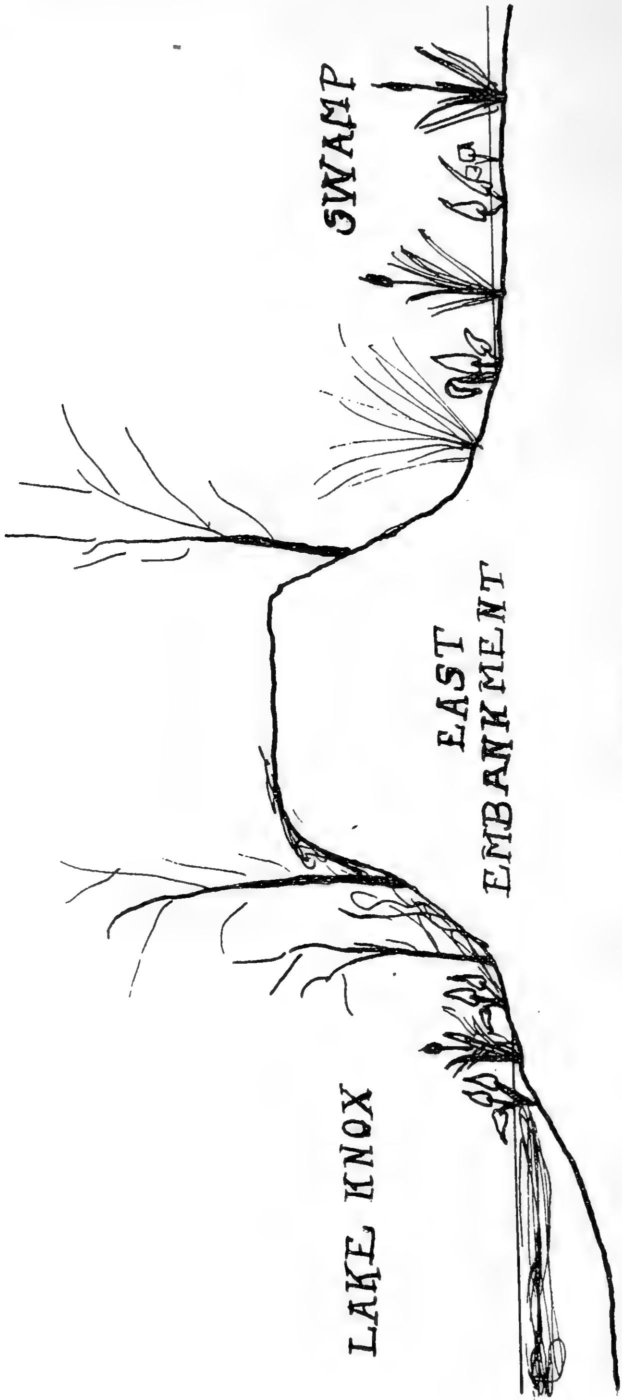


Fig 3.

Elevation of east end of lake and swamp.

Indications point to the fact that this lake is filling up: the narrowing circles of willows of different ages, the receding of the shore line on the west end, the great abundance of aquatic plants even near the center, and last year, a stranded group of cat-tails near the northwest corner are signs of the developmental process that is being carried on. Each season's crop of foliage is packed down on the succeeding layer. The inlet is bringing in constantly its contribution of silt and humus which is caught by the filamentous forms and roots of the hydrophytes or allowed to settle in the quiet regions of the center and west end. In collecting material for this survey, we have established stations in most of the typical regions and have attempted to confine our more intensive study to these smaller areas.

In the study of the filamentous forms of this area, some material was brought into the laboratory and after the forms were identified, it was allowed to stand undisturbed; in a short time, another form (hydrodictyon) appeared that had not been seen in the material when it had first been examined. This form had developed in the aquaria under conditions very different from those in the pond but had existed there in limited quantities under the unfavorable conditions. It is thought possible that this method of development under conditions different from those of the pond may lead to the discovery of some forms whose development is limited in the pond, or it may lead to some information on the conditions necessary for maximum development and possibilities for growth under unfavorable conditions.

In the more rapidly developing portions, it is possible to make out the following stages; submerged aquatics, floating aquatics, emergent aquatics, swamp society, and finally those of a river flood plain. If the pond is left undisturbed, it will all pass through the above stages. The plants of each stage prepare the way for those of the next one, and in doing so make conditions impossible for their own existence in that particular area.

In the submerged aquatic society, we find two types; first the free floating, largely made up of desmids and diatoms of the following types, Scenodesmus, Clasterium, Denticula, Navicula and Asterionella. The second type is that of the filamentous and attached forms, of which the most abundant species are Spyrogyra, Oedogonium, Oscillatoria, Cladophera, Elodea and Ceratophyllum. The floating leaved aquatics are rather poorly represented, only two species, Lemna minor and Wolffia columbiana, being found.

The vegetation in the swamp is predominated by Typha latifolia, Saggittaria latifolia, and Juncus effusus. The most typical swamp vegetation is in the area east of the pond. The lake was without this stage a year ago because of the permanent lowering of the water two years ago, leaving the plants of this society in conditions such as to make their development impossible. This society developed on the crescent shaped area at the west end exposed by the receding water and on a narrow strip on the steeper slope at the west end.

Another hydrophyte, water cress (Radicula Nasturtium acquaticum), is found in great abundance in the spring fed creek into which flows the north outlet from the lake. It is found only above, never below, the point where the lake drainage enters the stream; so we may understand that the water in the lake is very different from spring water.

The next stage is that of the terrestrial types, which are divided into the lower flood plain group, growing in soil that is saturated continually, and the upper flood plain group, growing in soil that is always moist but not saturated. These names are used because the development of a pond beyond the aquatic stage is very similar to that of a river flood plain. The lower flood plain society is best illustrated at the outer edge of the low area at the west end of the pond. The most notable species are Polygonum hydropipen (water smart-weed), Centricus carolinianus (sand bur), Xanthium spinosum (cockle bur), Ambrosia trifids (great ragweed), Bidens frendosa (begger tick), Taraxacum officinale (dandelion), Nepta cataria (catnip), Arctium minus (burdock), Salix alba (white willow), Postinaca stiva (wild parsnip), Oenathera biennis (evening primrose), Carex conjuncta, and Equisetum arvense (horse tail).

The upper flood plain is found in a narrow band on the east and north banks and at the west end. This area is rather wider than would be expected because when the pond was lowered, this society advanced and the outer boundary, owing to the adaptability of the species, remained the same. The species that characterize this society are, Ambrosa trifida (great ragweed), Arctium minus (burdock), Ulnus americans (elm), Salix longifolia (sand bar willow), Populus deltoides (cottonwood), Avena sativa (oat), Taraxacum officinale (dandelion), Trifolium repans (white clover), Nepta cartaria (catnip), Lepidium capsella, Lactuca integrate (wild lettuce), Trifolium pratense (red clover), Plantago rugelii (plantin), Salix alba (white willow), Asclepias syriaca (milkweed), Tradescantia virginiana (spiderwort), Postinaca sativa (wild parsnip), Cercium lanceolatum (common thistle), Poa pratensis (Kentucky blue grass), and Horedoum jaubatum (wild barley). The willows and elm trees at the west end are scrubs, but around the steeper banks on the east and north sides we find seedling cottonwoods and willows about three to five years old.

Lake Knox is an artificial pond. The banks on three sides are composed of rubbish and ashes dumped there when it was formed. On the south embankment, the railroad company periodically dumps ashes and cinders on the lake side. These layers have a very disastrous effect upon the vegetation on the bank and in the water. These cinder patches on the bottom of the pond give no foothold for the emergent aquatics. The few more hardy terrestrial types that are able to exist under these conditions are sand bur, smartweed, burdock, and if the bank is not disturbed in the spring, the great ragweed. Six sand bar willows and an elm have been struggling for several years to keep above the cinders. Only last month, the Street Railway Company dumped two or three car loads of brick and sand on the bank and into the pond at the north east corner. A scrub willow growing there is surrounded completely by about 12 inches of this material and the small willows near by have been obliterated.

The inhabitants of near.by dwellings also use the pond as a dump. It is not uncommon to find all sorts of debris when raking up material for laboratory examination.

The region that is of most interest to the ecologist is not that in which he finds one stage predominant. His real interest is in the contested ground, "no plants land" as it were. In the interzonal areas the conditions are such as to permit the development of species from the two zones on either side of it. No species or type can, however, predominate because of the presence of the other and the conditions that do not favor maximum development. No more valiant fight ever was staged on battlefield or gridiron than is being fought every year in these regions. The receding species do not give up easily; they contest every inch.

The arrow head, because of its adaptibility, is one of the more aggressive types. It seems to defy the deep water on one side and the smartweed on the other. Each spring during the flood period, it takes a grip on part of the lower flood plain and when the water recedes, it remains. The sand bar willow is struggling for a foothold on the lower flood plain. Last season a row of seedlings were established on the west end of the south side. This spring they are on the water's edge and a few are partially submerged. This season will determine whether or not the year old seedlings can survive such conditions even temporarily. Last year, a few willow sprouts were seen on the edge of a partially submerged row boat near the west end of the lake. This spring, there is no sign to indicate that they have survived. So the struggle goes on, the plants slowly changing the conditions of the area and the conditions determining the plants that shall survive.

IN CONCLUSION

Lake Knox, an artificial pond, was abandoned several years ago and, with the exception of man's influence mentioned, nature was allowed to take her course. At the present time, the lake is being filled in slowly with the silt and humus carried in by the inlet and the humus formed by the plants that live within and around its borders. Here we have a striking example of nature's developmental changes within a limited area.

SEASONAL CHANGES IN THE INSECT POPULATION OF AN ILLINOIS FOREST

(Abstract)

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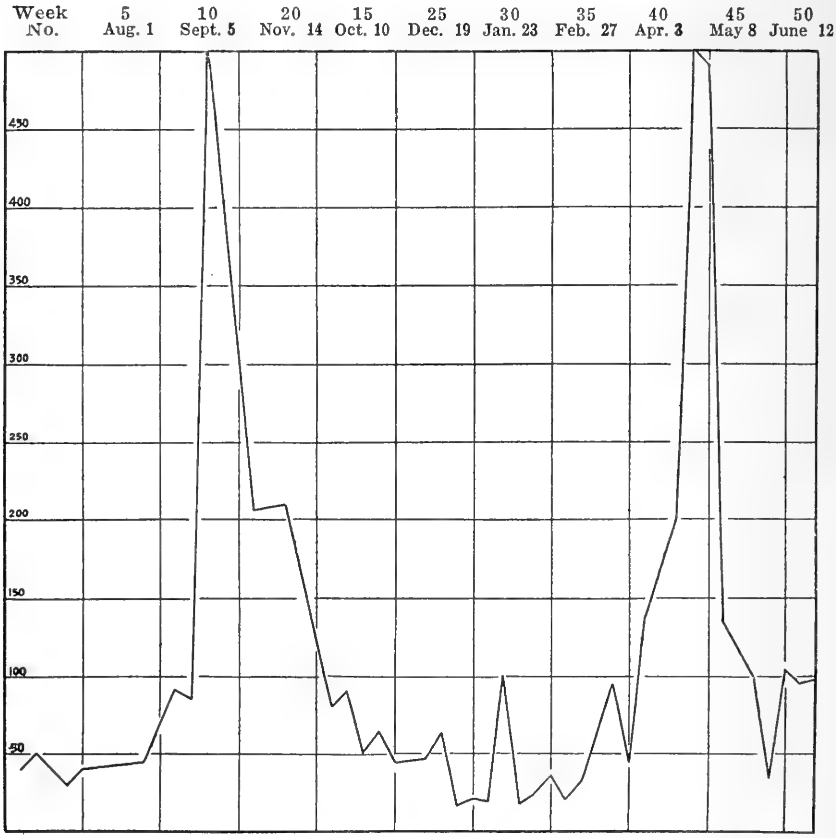
The observations on which this paper is based were made in a tract of woodland some sixty acres in extent, located about five miles from the main campus of the University of Illinois, at Urbana, known as the University Woods. The higher parts of the area are well wooded, the trees being almost entirely maple *(Acer saccharum)*, while a mixed stand, composed chiefly of maple and elm (*Ulmus americana*), occupies the lower parts. In the more open situations there is a considerable growth of underbrush, largely *Benzion* and *Asimina*. This area is one of the very few remaining bits of the woodland originally extending into the prairie of Central Illinois along the Vermillion River and its tributaries, and has of course undergone considerable modification accompanying the development of adjacent lands for agricultural purposes.

For a period of one year beginning July 1, 1921, meteorological observations on the succession and stratification of temperature, humidity, and the evaporating power of the air were taken, and an attempt was made to correlate with the data thus obtained the variations in the animal population of the area studied.

An attempt was made throughout the period of study to obtain collections, or rather samples, of the animal population as nearly equivalent as possible and in a manner at least roughly quantitative. All collections were made near the stations chosen for meteorological observation, and collections from the different strata generally were made on the same day. In the table and the text all collections are dated according to the last day of the week in which they were made, reckoning from Monday to Monday. This day was chosen for convenience because the theromograph and hygrograph sheets were arranged to be changed at this time.

Because of the difficulties attendant upon quantitative collection from the tree stratum no systematic samples were taken from this level. The remaining strata considered were the shrub, herb, and ground strata. Because of the constant presence in the forest of a blanket of leaves on the surface of the soil, the ground stratum was divided, for the purpose of this study, into two parts which will be referred to as the leaf and soil strata. Of the latter only the upper ten centimeters were considered.

Fig 1.



The unit of sample from the soil and leaf strata was taken from an area two feet square. The unit sample from the herb and shrub strata was that obtained by ten short sweeps through the vegetation with an insect net whose subcircular opening averged thirty centimeters in diameter. It is not claimed that there is an exact correspondence in the numerical data as obtained from the different strata by these methods, although the ratios so obtained are probably in the right direction and of the right order of magnitude. The method of collection was probably most efficient with respect to the leaf stratum, the soil stratum and the herb and shrub strata following in the order named. The numerical data obtained from samples taken in the manner described above are given in the accompanying table and illustrated graphically in Figure 1.

Examining the curve representing the total population in all strata we find a fall in the fourth week (the week of July 25), corresponding to an increase in the evaporating power of the air at that time. At the beginning of the period of study the woods were rather dry and the animal population was small. With the increase in moisture content of the air (and of the soil-leaf strata) during the week of August 1, there was a marked increase in the size of the collections. The increased humidity, however, does not account for the high maximum during the fourteenth week (ending Oct. 3). A gradual decline in temperature had been going on with a considerable increase in mean variability due to lower temperatures at night, so that while the initial increase was due certainly to a return to moisture conditions nearer the *optimum* for the species concerned, the sudden and great increase in the number of organisms taken in the samples was due almost entirely to the great autumnal migration toward places of hibernation. An analysis of the samples taken at this time showed that the great maximum was caused mainly by a few species of beetles and leaf-hoppers, all hibernating forms in course of migration from the forest margin to the leaf stratum of the more protected portions of the woods. Following this maximum the fall was again rapid as temperatures continued to fall (the first heavy frost was the night of Oct. 4). The peaks in the total curve after November 12, the date of the first ice formation, were caused by samples taken on warm days when insects partially emerged from hibernation or at least approached near enough to the surface to be collected. The spring maxima may be explained largely as the result of the reverse movement, This phenomenon will be discussed more fully in a later paper.

The most striking phenomenon of the entire period covered by the collections was the autumn hibernating reaction evidenced by migration inward from the forest margin and downward to the forest floor. In most of the species observed the stimulus initiating migration seems to be gradual increase in daily range of temperature and lower night temperature. Some species evidently require the additional stimulus of frost of greater or less intensity, while others which appear in the forest very early seem not to require this. The disappearance or maturation of food-plants may be a factor in some cases. In the forest the insects appear first in large numbers in the stratum corresponding to that in which the summer portion of their life history is spent. If the principal summer food plant is found in the high forest margin, the first appearance is in the shrub stratum. If the summer habitat is the low forest margin or meadow the insects first appear in the herb stratum. A downward migration follows under the stimulus of an additional fall in temperature or additional frosts. Insects from the shrub stratum seem in most cases to spend a short period of time in the intermediate herb stratum before seeking the final place of hibernation in the leaf or soil strata. Warm days may reverse the course of migration at any point. The fact that a large number of species react alike and at the same time to the same stimulus or combination of stimuli shows a large degree of similar adjustment of the climatic rhythm of the temperate savanna region on the part of the characteristic insects of the local area.

TABLE 1.

Animal Population of the Lower Strata of University Woods, Urbana, Ill.

July, 1921, to June, 1922.

Week Ending	Week No.	Soil Str. Coll.	Soil Str. Ave.	Leaf Str. Coll.	Leaf Str. Ave.	Herb Str. Coll.	Herb Str. Ave.	Shrub Str. Coll.	Shrub Str. Ave.	Total	Per Acre (Thousands)	Per Hectare (Thousands)
July 4.......	1	1	11	2	24.5	3	9	3	.6	45.1	496	1217
July 11.......	2	1	16	1	20	6	13.5	....	2	51.5	566	1390
July 18.......	3	1	10	1	14	3	15	3	4.8	43.8	481	1182
July 25.......	4	1	15	2	5	3	8.4	....	4.2	32.6	359	980
Aug. 1.......	5	3	14.7	1	11	....	11.5	....	3.9	41.1	452	1109
Aug. 8.......	6	2	14.5	1	12	3	14	3	3.6	44.1	485	1190
Aug. 15.......	7											
Aug. 22.......	8	1	18	1	15	3	8	2	4.5	44.5	490	1101

Week Ending	Week No.	Soil Str. Coll.	Soil Str. Ave.	Leaf Str. Coll.	Leaf Str. Ave.	Herb Str. Coll.	Herb Str. Ave.	Shrub Str. Coll.	Shrub Str. Ave.	Total	Per Acre (Thousands)	Per Hectare (Thousands)
Aug. 29.......	9	1	19	1	21	5	5.8	1	1	46.8	515	1263
Sept. 5.......	10	..	14.5	..	32	5	18.2	5	3.4	68.1	749	1838
Sept. 12.......	11	1	10	1	43	1	22	1	15	90	990	2437
Sept. 19.......	12	1	17	1	24	1	30	1	15	86	946	2322
Sept. 26.......	13	1	15	..	60	2	54	2	78.5	207.5	2283	5602
Oct. 3.......	14	1	13	1	133	1	283	1	69	498	5480	13446
Oct. 10.......	15											
Oct. 17.......	16	1	7	1	49	1	128	1	24	208	2288	5616
Oct. 24.......	17											
Oct. 31.......	18	1	27	1	146	1	25	1	14	212	2352	5734
Nov. 7.......	19	1	16	1	125	1	23	1	5	169	1859	4773
Nov. 14.......	20	..	12	1	85	....	20	....	4.5	121.5	1337	3280
Nov. 21.......	21	1	8	1	54	1	16	1	4	82	902	2214
Nov. 28.......	22	1	14	1	33	1	37	1	9	93	1023	2511
Dec. 5.......	23	1	1	1	36	1	11	1	0	48	528	1296
Dec. 12.......	24	1	13	1	51	1	2	1	0	66	726	1782
Dec. 19.......	25	1	5	1	22	1	16	1	0	43	473	1161
Dec. 26.......	26											
Jan. 2.......	27	1	3	1	34	1	8	1	0	45	495	1215
Jan. 9.......	28	2	5.5	1	58	1	4	1	0	67.5	743	1822
Jan. 16.......	29	1	3	1	15	1	0	1	0	18	198	486
Jan. 23.......	30			1	22							
Jan. 30.......	31			1	22							
Feb. 6.......	32	1	7	1	90	1	3	1	0	100	1100	2700
Feb. 13.......	33	1	7	1	10	1	0	1	0	17	187	459
Feb. 20.......	34	1	6	1	16	1	10	1	0	23	258	621
Feb. 27.......	35	1	7	1	29	1	0	1	0	36	396	972
Mar. 6.......	36	1	10	1	7	1	4	1	0	21	231	567
Mar. 13.......	37	1	4	1	13	1	12	1	3	32	352	864
Mar. 20.......	38			1	23							
Mar. 29.......	39	1	14	1	74	1	6	1	1	95	1045	2565
Apr. 3.......	40	1	5	1	28	1	11	1	2	46	506	1242
Apr. 10.......	41	1	6	1	68	1	39	1	23	136	1496	3772
Apr. 17.......	42											
Apr. 24.......	43	1	0	1	34	1	3	1	163	200	2200	5400
May 1.......	44	1	13	1	39	1	51	1	398	501	5511	13527
May 8.......	45	1	1	1	26	1	400	1	64	491	5501	13257
May 15.......	46	1	22	1	9	1	52	1	51	134	1474	3618
May 22.......	47			1	9	1	4	1	63			
May 29.......	48	1	8	1	7	1	34	1	42	91	1001	2457
June 5.......	49	1	1	1	2	1.5	24	1.5	8	35	385	955
June 12.......	50	1	10	1	6	1	54	1	25	95	1045	2565
June 19.......	51	1	10	1	5	1	40	1	31	86	946	2322
June 26.......	52	1	0	1	0	1	55	1	32	87	957	2349
July 3.......	53	1	14	1	5	1	55	1	20	94	1034	2538

FIG. 1. Graph of the Animal Population of an Area of Four Square Feet in an Illinois Elm-Maple Forest, July, 1921-June, 1922, inclusive.

THE EFFECT OF SELECTION ON THE LENGTH OF SPINE IN DAPHNIA LONGISPINA

Mrs. Margaret Smith Young, Chicago

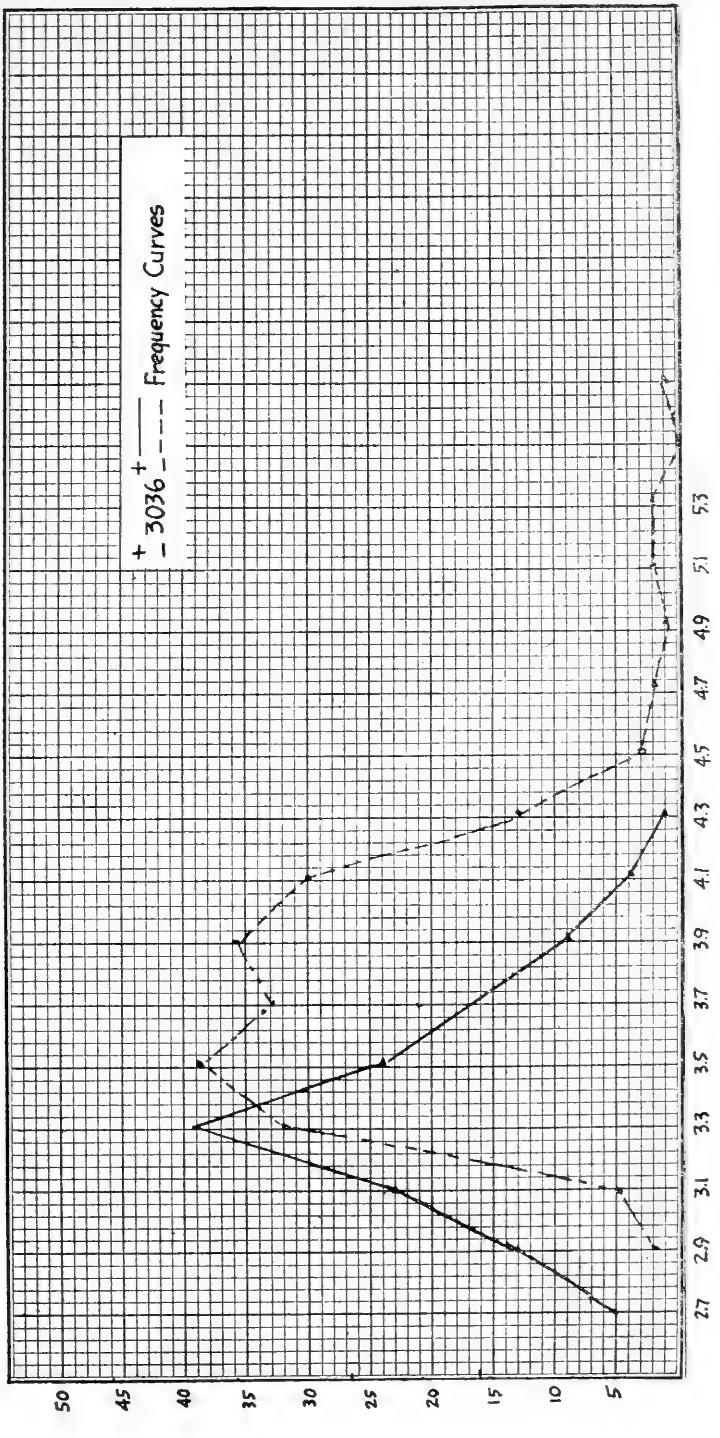
The work was started Dec. 27, 1922, and so far there have been ten generations. This paper is, therefore, merely a preliminary one.

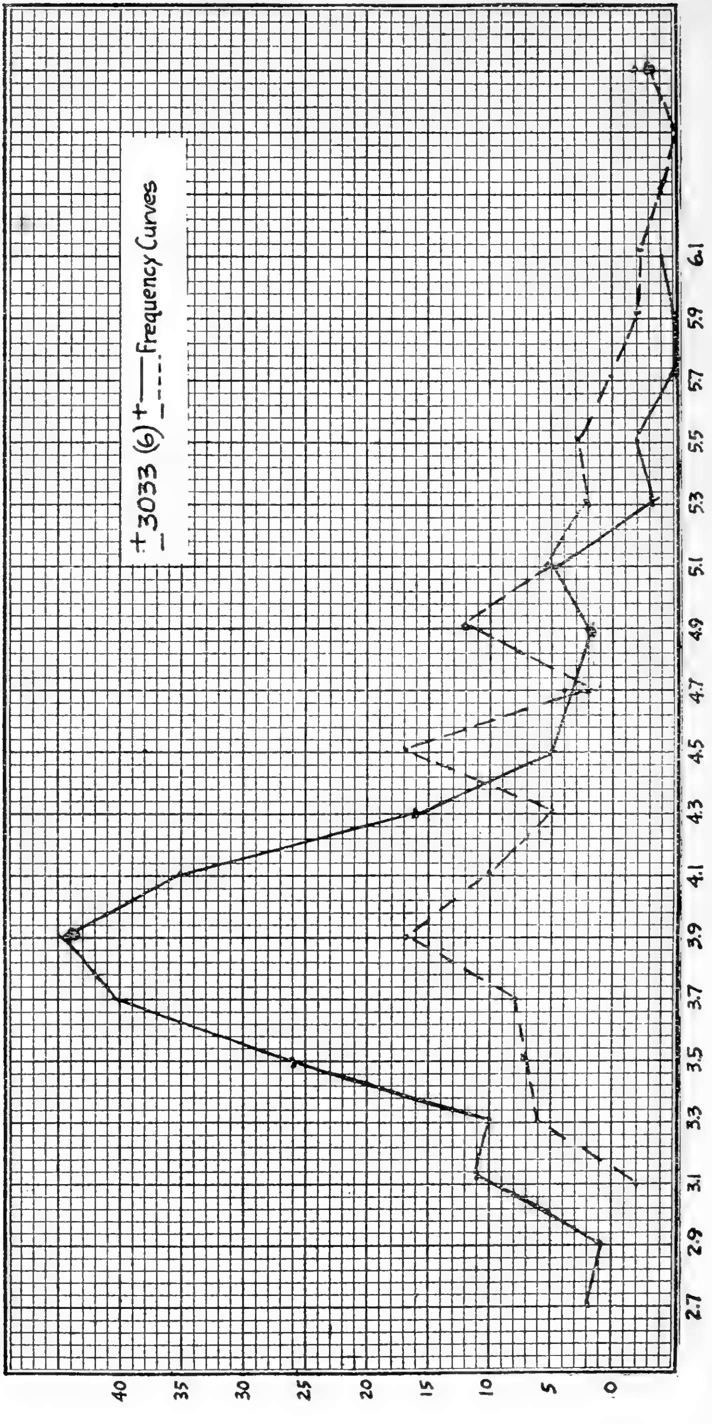
The Daphnia stock was obtained from the Laboratory of the University of Chicago where the work was carried on. The stock came originally from a fish fancier and had been kept in the laboratory for about a year before this experiment was begun.

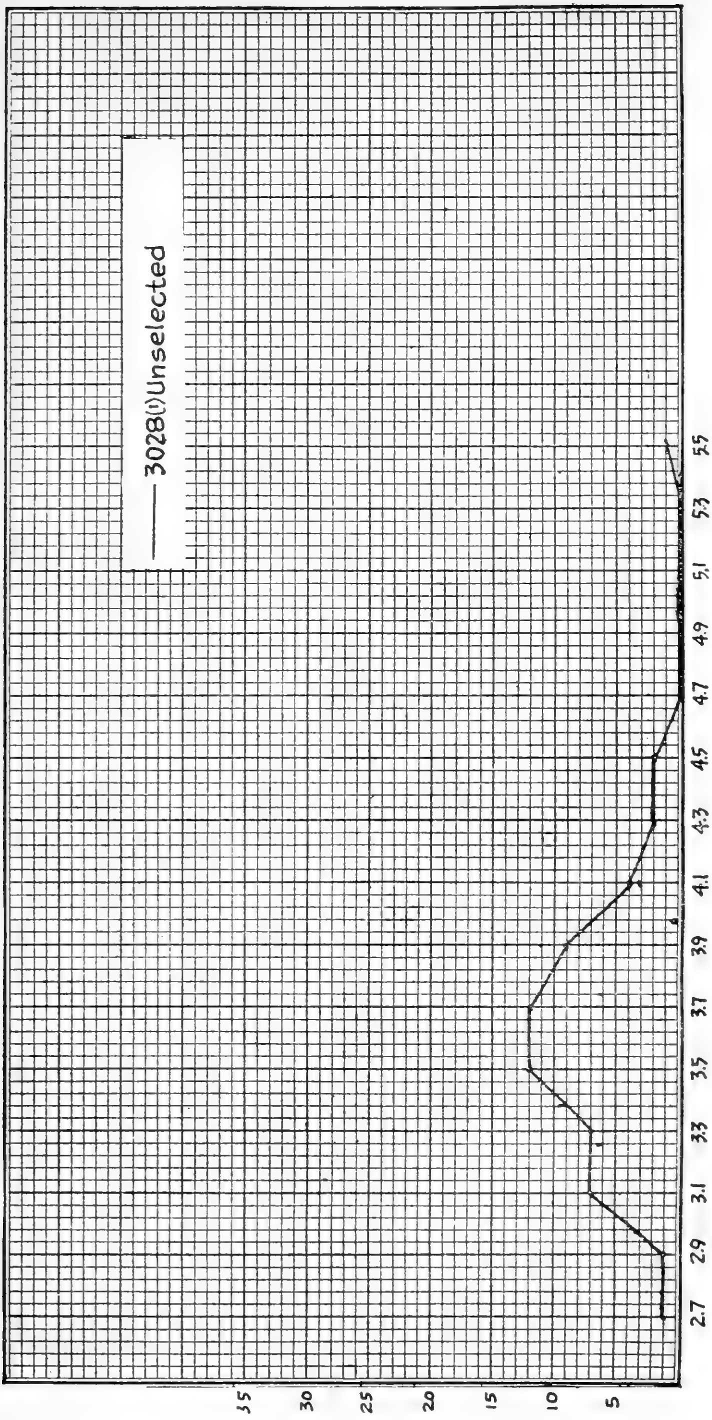
A parthenogenetic female (3027) was selected to start the first (3028)[1] generation. A brood is produced about every other day. The stock is kept in fingerbowls under greenhouse conditions, and temperature, food and other environmental conditions kept as nearly uniform as possible. The food consists of a coccus (Chlamyda monas) which causes the water to look green. Successive broods are termed A, B and C, and broods A, B and C are used as a basis for all the mathematical calculation. From brood A of 3028[1] an individual was selected to start the minus strain, and another to start the plus strain of 3029[2]. The difference in length of spine between the two was not great and was taken without measuring. After this the length of body, divided by the length of spine and called "Index", was made the basis of all calculations. The plus or long spine strain will therefore have a smaller index than the minus or short spine strain.

Selection was made from the A brood of ±3029[2] for the ±3030[3] generation, the indices being respectively .3 and .4.

In order to have better proof of the hereditary quality of the character, the A broods of ±3030[3] were measured alive and the five most favorable animals respectively were used to start five plus lines and five minus lines of 3031[4]. It was then thought best to use the method of selecting in each generation five individuals of the plus strain and five from the minus strain of the B brood belonging to the most favorable A brood. This was done to start generation 3032[5]. The curves of this generation


+ 3036 + ——— Frequency Curves
− - - - -
2.7
2.9
3.1
3.3
3.5
3.7
3.9
4.1
4.3
4.5
4.7
4.9
5.1
5.3
50
45
40
35
30
25
20
15
10
5


+3033 (6)+ —— Frequency Curves
— - - -
2.7 2.9 3.1 3.3 3.5 3.7 3.9 4.1 4.3 4.5 4.7 4.9 5.1 5.3 5.5 5.7 5.9 6.1
40 35 30 25 20 15 10 5 0


3028(1) Unselected
2.7
2.9
3.1
3.3
3.5
3.7
3.9
4.1
4.3
4.5
4.7
4.9
5.1
5.3
5.5
5
10
15
20
25
30
35

3031[4] are based on the five lines of ± strain A brood and the ± B brood from which selection was made.

However, the A brood is often small, sometimes only four or five individuals, and therefore not so good to base selection upon. The method was changed again so as to average together the A and B broods of each of the five plus lines and of each of the five minus, and select five individuals from the ± C brood of the most favorable average. This was done to start generation 3033[6] and has been continued to date (generation 3037 included). Calculations for all curves from 3032 to 3037 are based therefore on ±(5A's + 5B's + C) used for selection.

The results are shown in the table of Means and Differences each with their probable errors. It shows that the least positive results are a difference which is still three times the probable error, and two times as great as the difference between the first selected individuals. In one case the difference is twenty times the probable error. The frequency curves are interesting. They seem to show that whereas at the beginning the difference is often due partly to odd individuals at the extremes, later these are more or less eliminated and the population more even. The mode of the plus curve seems to be moving to the right of that of the minus curve.

Environmental conditions have important bearing on the results and probably explain the fluctuations of the difference. When the food water becomes concentrated other algae get the upper hand, one occurring particularly on which Daphnia could not subsist and in the long strings of which it became entangled. A sudden rise in temperature kills them rapidly, such as is caused by the sun shining on the bowls. The food must be replenished continually or they do not thrive. The writer has looked for indications that size of brood or size and vigor of animal causes a difference, but has been unable to find any signs of this. The vigorous animal is larger both ± but the length of spine has the same relation to body length. All individuals were measured at about seven days old. One cannot tell exact date of birth unless material is under constant surveillance. The size at the same age varies considerably, but not so the index.

The work was done entirely with parthenogenetic females, no males appearing; hence the results are entirely in a pure line. Whether similar results will continue or whether the difference will persist when selection is discontinued remains to be seen. The full significance of the experiment can not be gauged in so early and preliminary a stage.

What the causes are which may produce selection in a pure line if such should prove possible in the long run, is still an open question. A. M. Banta in his interesting work on "Selections in Cladecera on the Basis of a Physiological Character" takes up the question. He was slightly successful in selecting Daphnia longispina for its reaction to light. In one line he got a difference 4.05 times the probable error. He thinks selection may be due to (1) general physiological changes or (2) direct genetic changes. The first consists of materials carried over by cyloptasm, lide bacteria or protozoa or dye, which fed to fowls appears in egg yolk (Riddle 1908). But if the genetic basis be assumed, then he thinks that selection in a pure line altho it cannot cause genetic changes "may seize upon modifications of the character used in selection as they occur and in the case of plural genetic changes may build up differences between selected strains" and may be "the means of utilizing the variations in accomplishing the end sought." There is no way in Daphnia by which there could be any recombination of nuclear material, since there is only one maturation division without reduction in the parthenogentic egg.

Banta also discusses the mutation theory. In connection with such small genetic changes he would not call them mutations, but calls the point immaterial. He would not call them segregations or larger mutations because they occur too often and because there is no chromatic reduction involved. Sturtevant, in his work on Dichaet flies, was able to select plus and minus strain for a number of bristles. Dichaets vary more in bristle number than non Dichaets. In his final discussion he raises three questions.

1. "Does selection use germinal differences already present or such as arise during experiment, or both?" He thinks that, assuming the factors are Mendelian, selection in a group heterozygous for many minor factors will be effective in isolating favorable combinations of such modifying genes or multiple factors. Since mutations take place at all times, selection may make use of variations arising during the experiment.

2. "In case it uses new differences does it cause them to occur more frequently and does it influence their directions?" He finds nothing to show that favorable variations occur oftener on account of selection.

3. "Are differences new or otherwise more likely to occur in the locus of the gene under observation or in other loci?" He thinks variations appear more often in other factors since there are so many, but only in one that is responsible for the difference under observation.

TABLE OF MEANS AND DIFFERENCES WITH P. E.

Generation	— Means	+ Means	Difference
3029 (2)	4.6 ± .098	3.7 ± .13	.9 ± .016
3030 (3)	3.76 ± .046	3.6 ± .04	.11 ± .062
3031 (4)	4.7 ± .094	4.1 ± .074	.6 ± .011
3032 (5)	4.6 ± .034	4.0 ± .042	.6 ± .054
3033 (6)	4.8 ± .056	3.6 ± .035	1.2 ± .066
3034 (7)	4.2 ± .05	3.98 ± .051	.22 ± .055
3035 (8)	3.8 ± .039	3.3 ± .011	.5 ± .05
3036 (9)	3.8 ± .02	3.3 ± .017	.5 ± .025
3037 (10)	3.6 ± .028	3.1 ± .018	.5 ± .02

REGENERATION IN BRYOPHYLLUM CRENATUM

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In Vol. 60 (1915) of the Botanical Gazette, appeared an article by Jacques Loeb entitled "Rules and Mechanism of Inhibition and Correlation in the Regeneration of Bryophyllum Calycinum." This article was followed by several others from the same author in later numbers of the Gazette, in Science and in the Journal of General Physiology.

As there was available in the Botany Greenhouse at the University of Illinois a number of plants of Bryophyllum crenatum, the experiments given in Loeb's first article were repeated using this species. While many of the results obtained by Loeb with B. calycinum applied to B. crenatum, several differences were found sufficiently great to warrant noting. Since the plants of B. crenatum used in the experiments differed from those of Loeb in that they were mature and in flower, the differences were thought at first to be due to maturity or to the physiological state of the respective species. Subsequently it was found that very young plants of B. crenatum gave essentially the same results as the mature ones. In the cases where the results with B. crenatum differed from those obtained by Loeb with B. calycinum, the experiments were repeated using B. calycinum.

One difference between the two species should be noted here. With B calycinum, whenever growth appeared in the notches of leaves separated from the plants, roots developed before the shoots. The reverse order of development was always true with B. crenatum.

Since the study was to be a comparative one, the methods used by Loeb were followed as nearly as possible. The work was done in the greenhouse during the winter months and at a temperature of approximately 70° F. The numbers used in referring to the leaves correspond to those used by Loeb.

In the first experiment, 3 leaves of B. calycinum and of B. crenatum were prepared as follows:—leaf 1 was separated entirely from the plant, leaf 2 had a portion of the stem, leaf 3 had a portion of the stem and also the opposite leaf attached. These leaves were suspended by means of threads from the top of an aquarium in a saturated atmosphere in such a manner that their tips were submerged in water.

After 10 days the results obtained with B. calycinum were essentially those obtained by Loeb. After 16 days, however, roots had developed at the base of the petiole in 2 of the completely isolated leaves suspended in saturated air, and by the end of 5 weeks shoots had appeared also. These results are contrary to those obtained by Loeb who says, "The advantage of this plant for the study of the problem of regeneration lies in the fact that shoots can grow out only from definitely located buds in the stem and in the notches of the leaf."[1] In another place he states, "The stalk of an isolated leaf without any piece of stem is not capable of giving rise to any regeneration. Such a leaf will form adventitious roots and shoots in its notches very rapidly."

B. crenatum gave several results different from those obtained by Loeb with B. calycinum. After 10 days, growth had occurred in leaf 1 on the aerial as well as on the submersed portion of the leaf, and in mature flowering plants the growth from the aerial was more vigorous than that from the submersed portion of the leaf. In leaf 2 from mature plants the bud grew out from the opposite axil as stated by Loeb. In many cases, however, shoots appeared in both axils. In the leaves from very young plants, only the bud from the adjacent axil had developed. With B. calycinum, Loeb reports no development of the axilliary buds in leaf 3. In B. crenatum shoots appeared from both axils in all the specimens. There was also some notch growth on most of the leaves.

Plate I shows these leaves at the end of 5 weeks. Leaf 1 with the best notch growth had developed a large shoot at the end of the petiole. The shoots and roots in both axils of leaf 3 were as large as those in leaf 2 and the growth from many notches was nearly as vigorous as that in leaf 1. Leaf 2 showed considerable notch growth. All the drawings given in this article were made from photographs of the specimens.

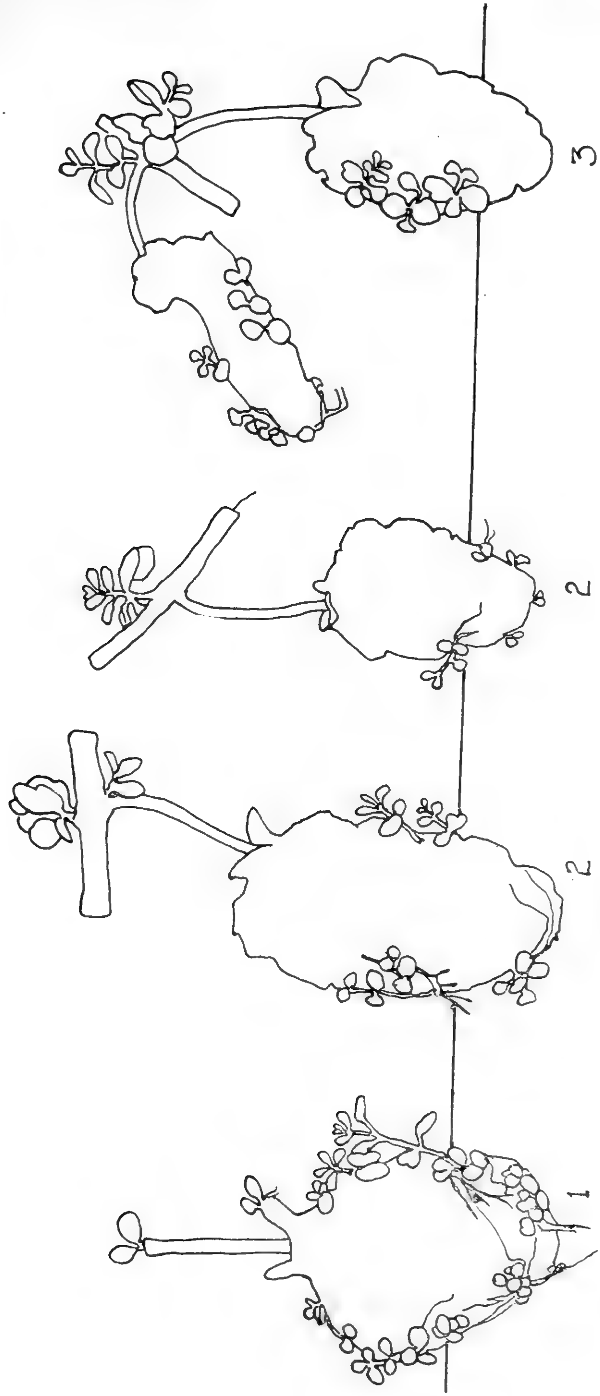


PLATE I

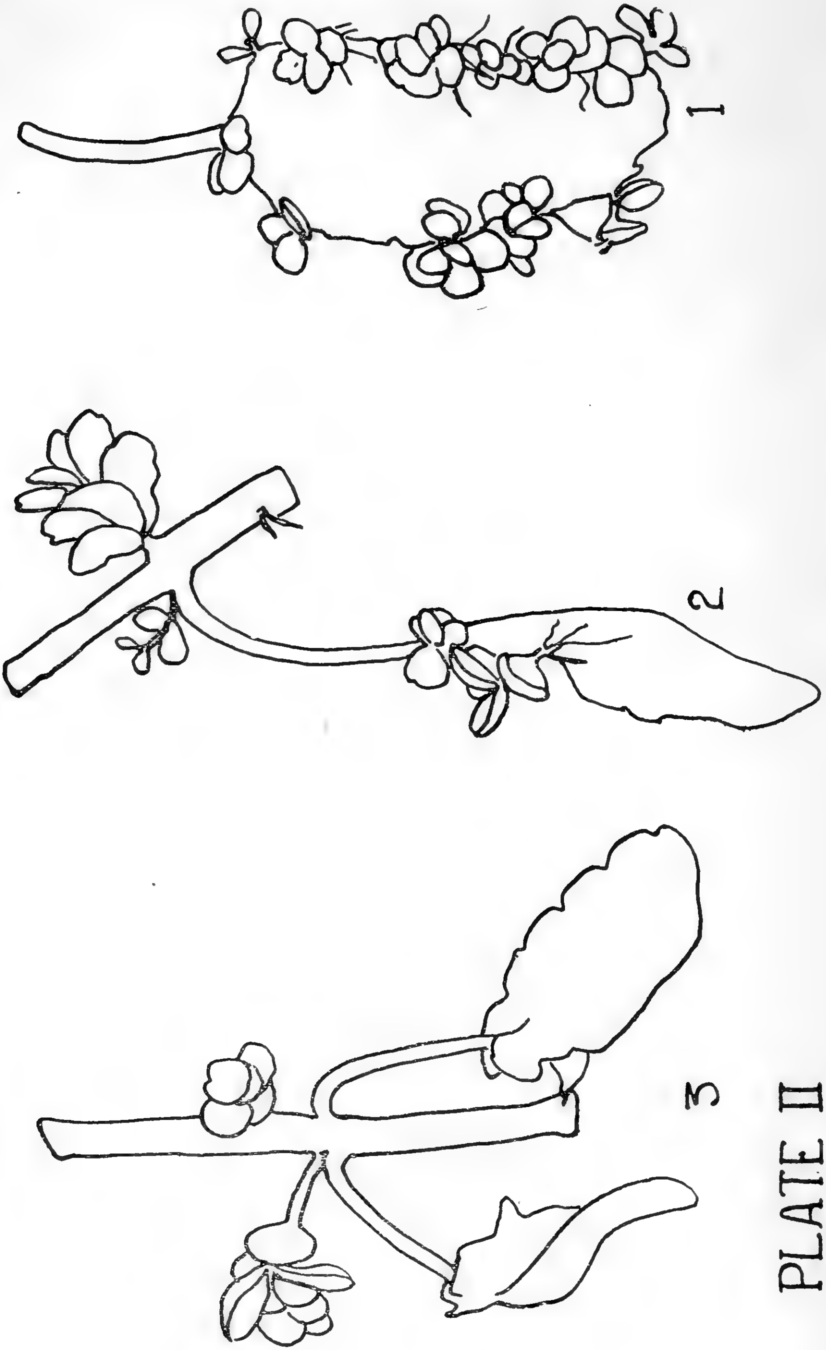


PLATE II

This same experiment was repeated suspending the leaves in a saturated atmosphere but not allowing their tips to touch the water. Plate II shows the results after 5 weeks. The growth was the same as that just described but the leaves were less turgid.

Experiment II was designed to show the inhibiting influence of the axillary buds on the growth in the notches of the leaves. Leaf 6, similar to leaf 1, was separated entirely from the plant; leaves 7, 8 and 9 had a portion of the stem attached. Both axillary buds were removed from leaf 7, the opposite axillary bud was removed from leaf 8, and no bud was removed from leaf 9. In this experiment B. crenatum gave results different from those obtained by Loeb with B. calycinum. Leaves 6 and 9 agreed with leaves 1 and 2 described in experiment I. After 4 weeks, 2 specimens of leaf 7 showed no growth. 3 specimens had developed a shoot from the petiole above the cut. In each of the latter, there was some notch growth although it was much smaller than in leaf 6. Leaf 8 had a shoot from each adjacent axillary bud and also some notch growth. Plate III shows these leaves after 5 weeks.

Concerning the inhibiting influence of the growth of the axillary buds on the notch growth Loeb states, "It is, therefore, obvious first, that a stem whose buds are removed has still an inhibiting influence upon the formation of roots in the notches of a leaf; and second, that if the buds of the stem are not removed, the growth of the bud opposite the leaf enhances this inhibiting effect of the stem upon the leaf considerably. Since the growth of this bud of the stem is as a rule also inhibited when the opposite leaf is not removed, as in figure 3, we understand why the non-removal of this leaf favors the growth of the adventitious roots from the notches of the other leaf." In B. crenatum the removal of the buds from the stem did inhibit the notch growth and the inhibiting effect was enhanced by the growth of the bud which was not removed, but the growth of this bud of the stem was not inhibited when the opposite leaf was not removed as was shown by leaf 3.

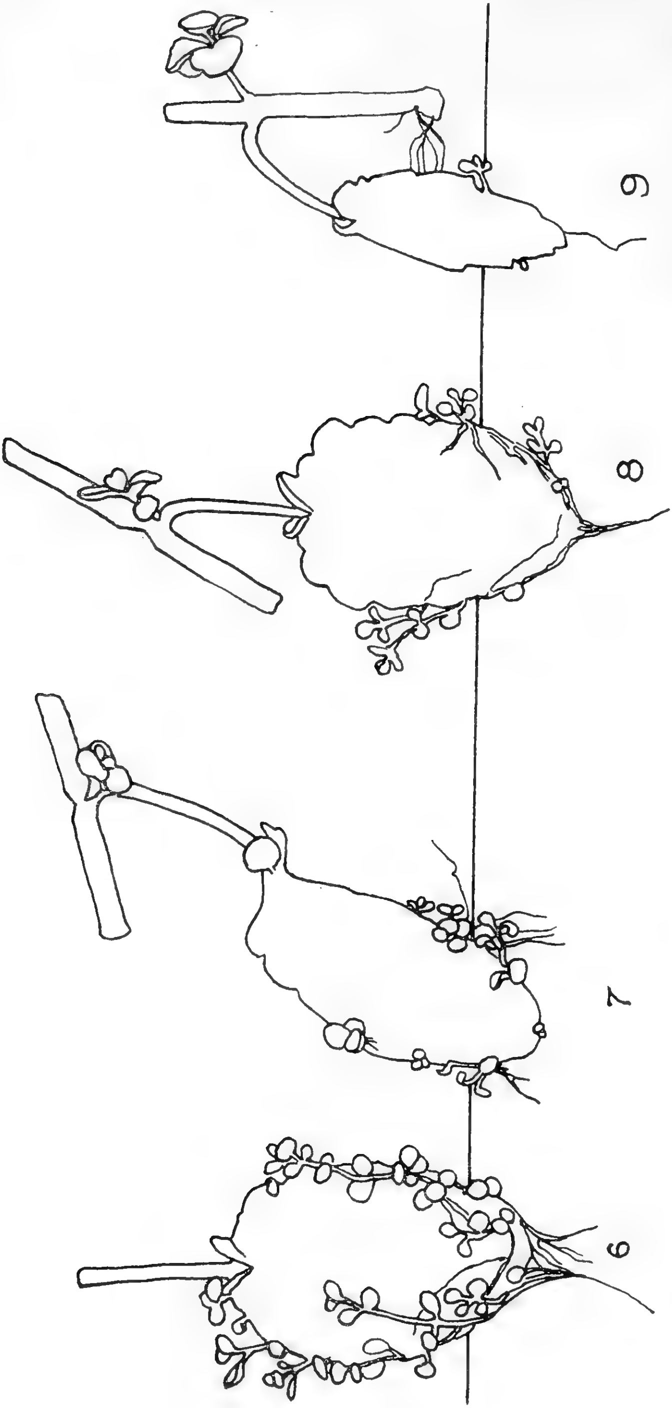
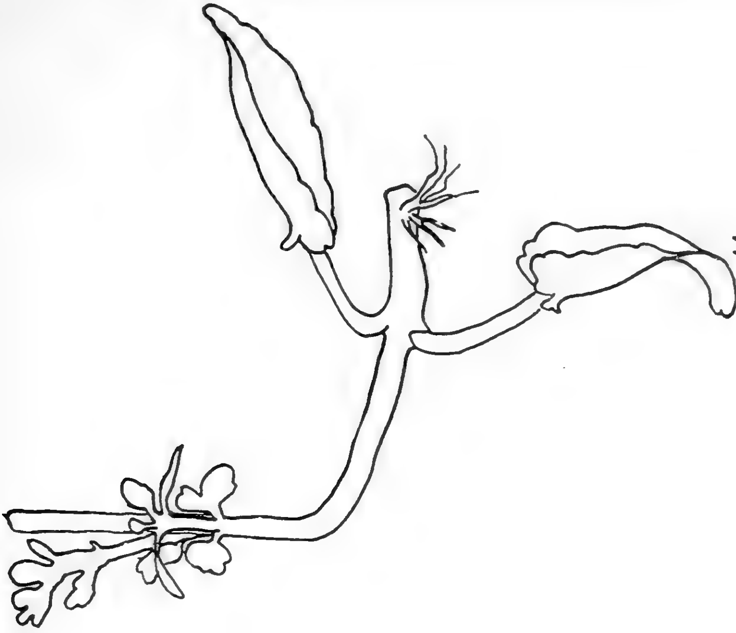


PLATE III



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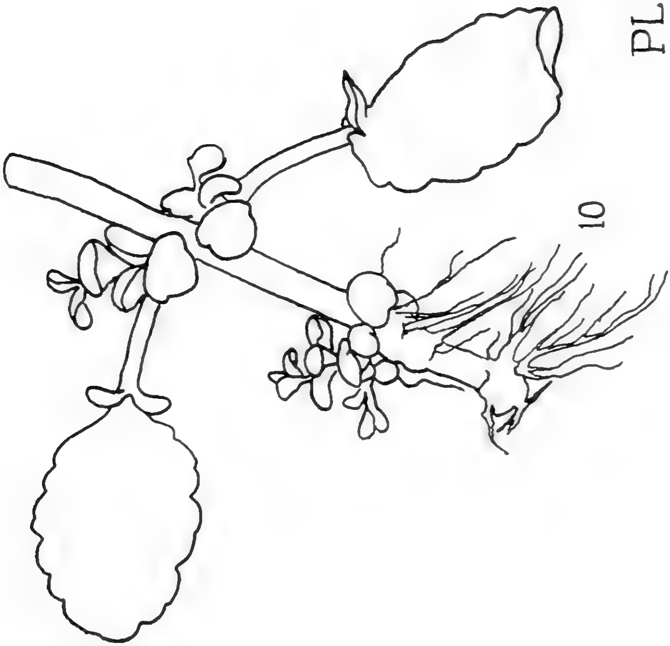

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PLATE IV

In experiment III, several nodes of a stem were used. On some stems, leaf 10, the leaves of the apical node and on others, leaf 11, those of the basal node were retained. The results with B. crenatum were quite different from those obtained by Loeb with B. calycinum. In 5 days, in leaf 10, four out of five specimens had developed basal node shoots and the fifth had both basal and apical node shoots. In leaf 11, there were two apical node shoots in each specimen and also a basal node shoot in one. In 20 days, in leaf 11, there were two shoots from the basal node of one specimen and some notch growth on 2 leaves. After 4 weeks, leaf 10 had developed 2 shoots from the basal node of each specimen. Four of the specimens had developed 2 apical node shoots and also some notch growth. The fifth had but 1 apical node shoot. Plate IV. shows leaves 10 and 11 after 5 weeks. The growth of the buds on the stem may have inhibited a vigorous notch growth as stated by Loeb, but the shoots developed rapidly at those nodes from which the leaves had been removed, regardless of whether those nodes were apical or basal. From the under side of one leaf, a shoot had developed near the mid-vein. Here again we have regeneration other than that from the notches of the leaf or from a definite place on the stem.

Loeb found that in B. calycinum the development of the bud on the stem was inhibited or retarded if only a piece of the petiole of the opposite leaf was left on the stem. This was not true for B. crenatum. In 14 days, in the leaves whose opposite leaf blade had been removed, leaf 14, a shoot grew from the opposite axillary bud in each specimen and there was a slight notch growth on most of the leaves. The petioles were still intact when the shoots developed. Plate V. shows 2 specimens of leaf 14 after 1 month. At this time the petiole had withered and fallen from one stem and a shoot was growing in the adjacent leaf axil in this specimen.

Leaf 20 on Plate V. shows the effect of cutting the stem lengthwise leaving a leaf attached to each half. In 5 days the adjacent buds appeared on 3 out of the 6 specimens. The other 3 showed notch growth. In 21 days there was an adjacent shoot in each and a slight notch

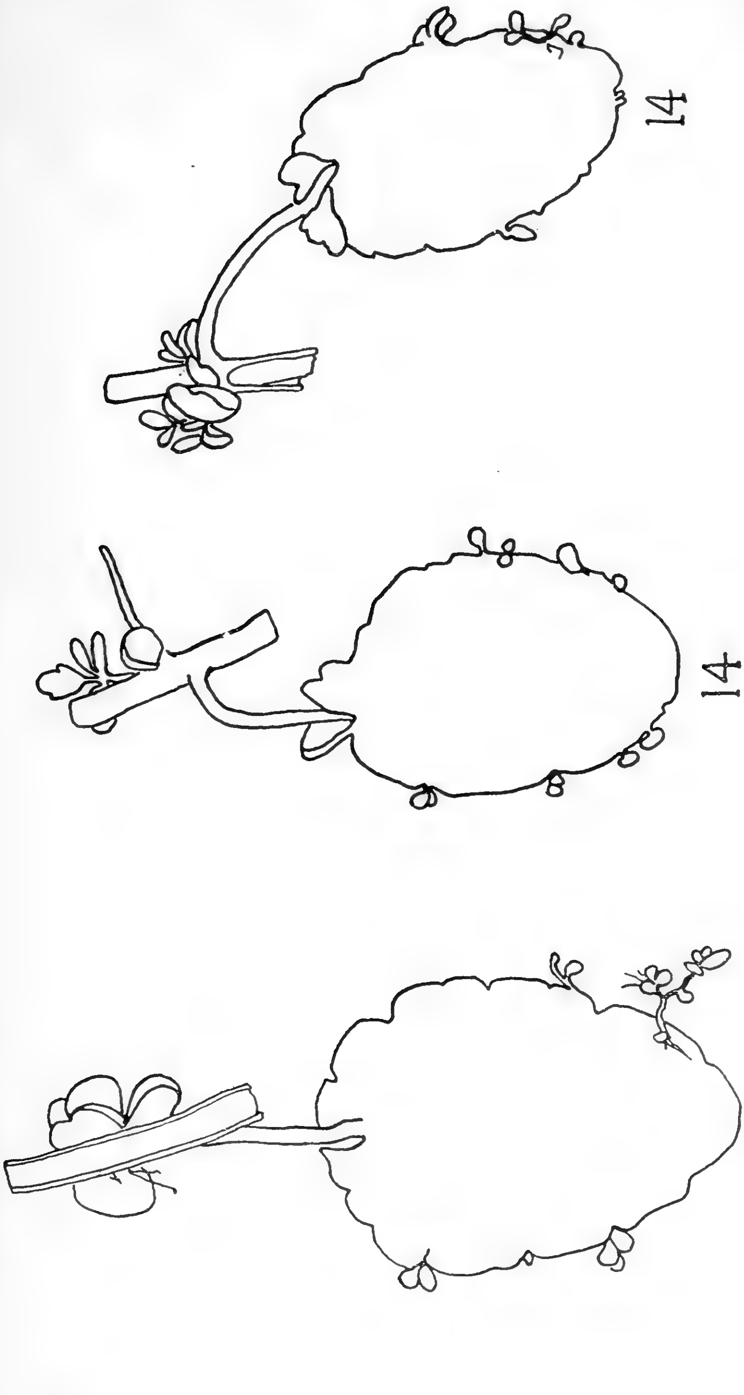


PLATE V

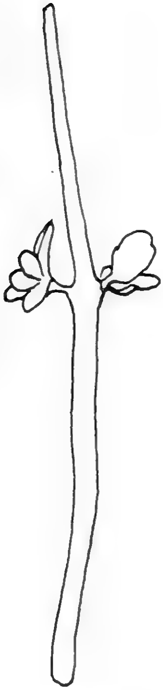
growth in 4 specimens. The rate of development here was about the same as in leaf 3 where both leaves were left on the stem.

In following Loeb's experiments to show that root pressure and not the roots themselves inhibited the notch growth, few, if any, roots developed in B. crenatum. In 10 days shoots from the opposite buds developed in 2 specimens. In 12 days, there were shoots from both buds in 4 cases. After 17 days, only one stem had formed roots. There was no notch growth in the mature plants, but in 14 days most of the leaves from very young plants had some notch growth. That is, with B. crenatum, the leaves with a piece of stem attached when placed in a Petri dish with a small amount of water behaved similar to leaf 2.

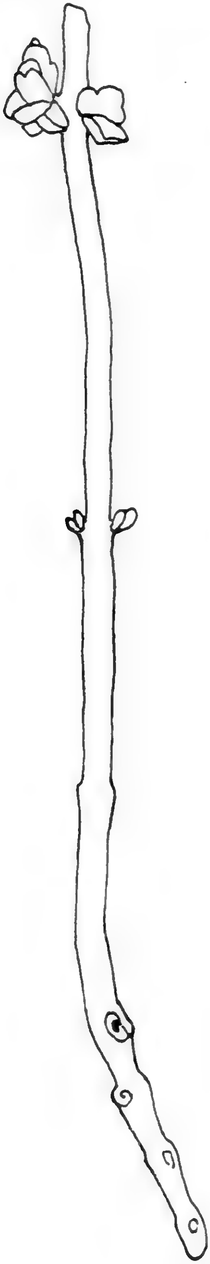
In the seventh experiment, the stem of B. crenatum, consisting of several nodes stripped of all its leaves, was suspended in moist air, number 23. In 3 days apical node buds had appeared from 2 out of 5 specimens. In 12 days, 2 shoots had developed at each apical node and in two specimens, from the second node also. After 20 days, 2 shoots had appeared from the third node of 1 stem. Although the shoots of the apical node developed most rapidly their development did not inhibit the growth of the shoots at the lower nodes. This is shown in Plate VI. The photograph was taken after 4 weeks.

This plate also shows a single node, number 28, from which the leaves were removed. When single nodes from near the top of the main stem were used, buds appeared on all the specimens in 3 days. In 12 days, 2 shoots were growing from each node. This shows that in B. crenatum the development in the single apical node was as rapid, in some cases more rapid, than when, as in leaf 2, a leaf was left on the stem. The presence of the leaf did not accelerate the growth of the axillary bud.

In experiment VIII, lateral incisions were made through the mid-vein of leaves of B. crenatum. In 7 days the smallest isolated leaf, leaf 38, showed notch growth. 3 of the 5 specimens of a leaf with a portion of the stem, leaf 39, had developed both axillary buds, and the adjacent bud of the other 2 just showed. In 9 days, there was



28



23

23

PLATE VI

notch growth in each of the 5 isolated leaves. 4 leaves with stems had both axillary shoots; the fifth had just the opposite shoot. These leaves are shown in Plate VII. The notch growth on the leaves having a portion of the stem attached was as abundant in the 4 specimens having both axillary shoots as it was in the isolated leaves. The axillary shoot had lost its inhibiting effect.

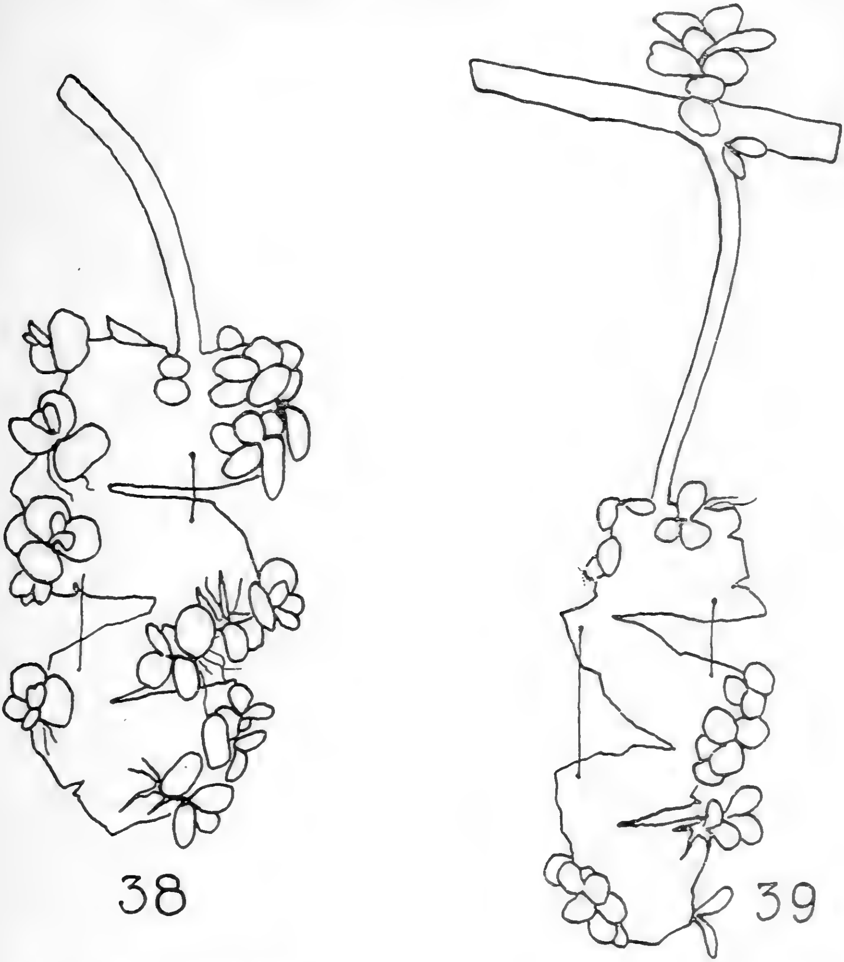
When leaf 1 of B. crenatum was suspended in moist air and deprived of light, the buds developed in most of the notches within 7 days. In 5 weeks the shoots were fully an inch long.

The purpose of these experiments was not to discover the cause of regeneration, but rather to determine whether the rules given by Loeb for B. calycinum could be applied to B. crenatum.

Loeb assumed that the cause of regeneration was the prevention of the flow of material from the notches of the leaf, and he was supported in this view by his experiments on B. calycinum. No such simple explanation can be given for B. crenatum. If a piece of stem was left attached to the leaf, leaf 2, one or both axillary buds developed. A comparison of this leaf with the isolated node from near the apex of the plant shows the growth of the buds about the same in leaf 2, altho in the latter case there were no leaves from which the buds could get this flow of material.

In a later experiment,[2] Loeb finds that an apical leaf influences the lower buds of its side of the stem. He states, in this connection, that the inhibiting influence of the leaf upon shoot formation is due to an inhibiting substance which is secreted by the leaf and carried with the sap toward the lower part of the stem. No such substance seems to be produced in B. crenatum.

Although the development of the axillary buds and notch growth is hastened by the separation of leaf or stem from the plant, Goebel[3] found in his experiments with B. crenatum that the development of the notch growth on leaves attached to the plant could be brought about by cutting squarely across the middle vein near the base of the leaf. If a longitudinal cut was made near the edge of the leaf no growth occurred. He attributed this lack of growth to the fact that by the longitudinal cut the vascular bundles were not sufficiently injured, Wakker[3] said that the growth of adventitious buds on B. calycinum could be brought about by injuring or disturbing the water passages of the leaf.



38 39

PLATE VII

Child and Bellamy[4] found that cooling a portion of the petiole of a B. calycinum leaf to a temperature from 2.5 to 4° C. for a few days was a very effective means of inducing notch growth.

That even these injuries and disturbances are not necessary in order that shoots may develop was discovered in the plants at hand. In the Botany Greenhouse, notch growth appeared on the leaves of several plants which apparently were in normal condition. This development has been found on the leaves of B. calycinum as well as on those of B. crenatum and on both old and young plants. An interesting feature noted in the species calycinum was that, while in the notch growth on leaves separated from the plant roots appeared before the shoot, the reverse order of development was true on leaves attached to the plant.

For more ready comparison, the results with B. calycinum obtained by Loeb and those with B. crenatum obtained by the author are given in the following table. Unless otherwise stated, the results given for B. calycinum are those obtained by Loeb; those given for B. crenatum were obtained by the author. Where no time is given for calycinum it was the same as for crenatum.

Leaf	Time	B. crenatum	Time	B. calycinum
1	10 da.	Much notch growth, aerial and submersed.		Roots and then shoots on submersed portion.
	5 wk.	Shoot on petiole in one.		Shoot on petiole of 2. (Author's results)
2	10 da.	Shoot from opposite or both axils in all mature leaves. In very young, shoot from adjacent axil in each.		Opposite axillary shoots.
	5 wk.	A few notch shoots and roots.		No notch growth.
3	10 da.	Shoot from each axil.		Roots and shoots on submersed portion. Not quite as quickly as in leaf 1.
		Notch growth on most leaves.		
	5 wk.	Shoots and roots as large as in leaf 2. Notch growth as vigorous as in leaf 1.		4 shoots from submersed portion. Adjacent axillary bud.
6	10 da.	Abundant notch growth the same as in leaf 1.		Roots and shoots under water, similar to leaf 1.
7	10 da.	No growth.		Roots on many submersed portions. Shoot on one.
	4 wk.	2—no growth. 3—shoot on petiole and some notch growth.		
8	10 da.	4 out of 6 no growth. 1—adjacent shoot. 1—adjacent shoot and notch growth.		A few had some roots and shoots on submersed portion.
	4 wk.	Adjacent shoots in each. Some notch growth.		
9		Same as leaf 3.		Same as leaf 3.
10	5 da.	4—basal shoots; 1—basal and apical node shoots.		Notch roots and shoots, no axillary shoots.

Leaf	Time	B. crenatum	Time	B. calycinum
	20 da.	2 basal shoots in each, 2 apical in 4, 1 apical in 1.	17 da.	Notch roots under water.
	4 wk.	Some notch growth.		
11	5 da.	2 apical node shoots in each, 1 basal in one.	A few days.	2 apical shoots in each.
	20 da.	2 basal in one and some notch growth in 2 leaves.	17 da.	No notch growth.
14	14 da.	Opposite axillary shoot, slight notch growth in most leaves, petiole intact.		A few notch roots and shoots.
	4 wk.	Adjacent shoot in one.	10 wk.	Petiole fallen off, axillary shoot growing.
20	5 da.	Adjacent buds in 3 out of 6. Notch growth in others.	6 wk.	Adjacent axillary shoots
	21 da.	Adjacent shoots in all, slight notch growth in 4.	14 da.	In very young plants—a few roots on base of stem, and in 6 wks. much notch growth under water. No adjacent buds. (Author's results)
23	12 da.	2 shoots from each apical node. 2 from second node in two cases.		Apical node shoots only
	20 da.	2 shoots from 3rd node in 1.		
28	3 da.	Buds in all 5 cases.		No growth.
	12 da.	2 shoots from each node.		
38	7 da.	3 out of 5 had both axillary buds, 2 had adjacent bud growing.		Opposite shoot, no notch growth.
	9 da.	4—both axillary shoots, 1—opposite shoot. No notch growth in 4 with both buds.		
1	7 da.	Most notches had growth.		No growth.
(In dark)	5 wk.	Shoots about 1 inch long but not sturdy.		Many small roots. Shoot from base of petiole. (Author's result)
		In all notch growth, shoots developed first, then roots.		Roots develop first, then shoots, when leaves are separated from plant.

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BARBERY ERADICATION IN ILLINOIS.[1]

F. E. Kempton, Pathologist in Charge, G. C. Curran, State Leader, Illinois, E. D. Griffin, Asst. State Leader, Illinois

INTRODUCTION

The barberry eradication campaign in Illinois was begun in the spring of 1918 as a part of the campaign organized by the United States Department of Agriculture in cooperation with 13 north-central wheat-growing States, namely, Colorado, Illinois, Indiana, Iowa, Michigan, Minnesota, Montana, Nebraska, North Dakota, Ohio, South Dakota, Wisconsin, and Wyoming.

This campaign in the United States followed the severe black rust epidemic in 1916 which produced a shortage of wheat that seriously affected the nation's flour supply during the period of the world war. Through the agitation of scientists and the results of preliminary surveys in Minnesota and Iowa, conferences were held in 1917

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[1] Office of Cereal Investigations, Bureau of Plant Industry, U. S. Department of Agriculture, and the Illinois University, College of Agriculture, cooperating.

[2] Thanks are due to S. P. Harter, field assistant, who made observations, counts, and germinations of aeciospores on the exposed slides,

and 1918 which brought about the organization of the present barberry eradication campaign by the Office of Cereal Investigations of the United States Department of Agriculture in March, 1918. Field work was begun in April, 1918, under an emergency appropriation for stimulating agriculture. An annual appropriation of approximately $150,000 was provided by Congress from July 1, 1918, to June 30, 1921, after which it was increased to $350,000. During this time, practically all cities and towns were surveyed for barberry bushes and a farm-to-farm survey was begun in 1919. By December 31, 1922, all properties in 472 counties had been surveyed.

Because of the desire of interested commercial and agricultural organizations to further the campaign and shorten the time necessary to complete the survey, a conference was called by them at Minneapolis in March, 1922, to consider further measures that might be adopted as a means of rust control. Representatives of commercial interests, the farm bureaus, the State departments of agriculture, and the State experiment stations formed a permanent organization, and indorsed the barberry eradication campaign as the feasible measure to be used in rust control. Largely through effective presentation by this organization Congress increased the appropriations for barberry eradication, and some of the States likewise provided extra funds.

PROGRESS OF ERADICATION

The entire State of Illinois is included in the eradication area. Due to a wide range of temperature and latitude within the State there is a marked difference in the type and variety of cereals and grasses in the northern and southern areas. Experimental data show that spring wheat is subject to greater damage from stem rust than winter wheat, and, as spring wheat is grown successfully only in northern Illinois, it was decided to begin barberry eradication in that section.

From April 1, 1918, to December 31, 1922, 762 cities and towns were surveyed for barberry and 15 counties were covered in the farm-to-farm survey with the result that 142, 882 bushes were located, and, in most instances, eradicated. Owing to a large increase in the Federal appropriation more men were employed for survey and eradication during the summer of 1922 than in previous years. As a result six counties were completed in 1922 alone, in addition to a considerable portion of the city of Chicago.

More properties infested with common barberries have been found in Illinois than in any of the other twelve States within the barberry eradication area. During the five-year campaign, 9,478 properties on which barberry was growing have been located. Iowa ranks second with 8,390 and Michigan third with 8,325. Although Illinois has the highest number of properties with barberry, in the total number of bushes found the State ranks fifth.

Thus far about twice as many bushes have been found in the towns as in the country, probably due to the fact that the urban survey has been nearly State-wide while the farm-to-farm survey has been confined to fifteen counties in northern Illinois.

At the rate of progress in Illinois during 1922, the best year of the campaign, at least five more years will be necessary to complete the original survey. Illinois received $20,000 of the Congressional appropriation of $350,000 in 1922. To date less than a quarter of the total area of the State has been covered in the farm-to-farm survey. Either the annual Federal allotment will have to be increased considerably or the State will have to give generous financial aid to the movement if Illinois is to be cleared of barberry by the time the other 12 States are covered.

PROBLEM OF ESCAPED BARBERRIES

One of the difficult problems encountered in the eradication campaign in Illinois is the widespread occurrence of escaped bushes that have grown from seeds scattered from cultivated bushes. Of the bushes found in the country, 27,463 were escaped bushes on 458 properties distributed in every county of the surveyed area.

Because of the large number of escaped bushes, eradication has been retarded considerably. Usually these bushes were found growing in timber land, brushy pas-

Fig. 1. Escaped barberry bushes growing in the Galena area. The soil is extremely rocky and eradication by digging is impossible.

tures or on rocky hillsides, often of rugged topography. Survey of these areas made on foot and covering every square rod is a slow process. Three outstanding areas of escaped bushes have been found in the surveyed territory, namely, at Gurnee, Lake County; Galena, Jo Daviess County; and Chana, Ogle County. They are widely separated and possess different characteristics.

THE GURNEE AREA

The Gurnee area is located in Lake County and has the largest number of bushes. The number of bushes is estimated at 5,000 and there is a wide variation in size and age. Most of these bushes were growing in a 40-acre woodlot on the farm of a Mr. Lake. Other scattered plantings were found along highways, hedges, and fences for several miles around. Seedlings, sprouts, and large mature bushes were all growing together in timber forming a dense growth of underbrush. Unlike most areas, the escaped bushes were not closely associated with streams. The original source of these bushes was a hedge near the old homestead on the Lake farm. This hedge had been eradicated some years ago.

THE GALENA AREA

The Galena area was found during the summer of 1922 and is located about the city of Galena in Jo Daviess County. The topography is extremely rough due to its being unglaciated, and many difficulties were encountered by the field men. It was necessary to survey twelve sections on foot and considerable time was thus consumed. Unoccupied property offered another stumbling block to the efficient destruction of the barberry. There were approximately 1,500 bushes found within a radius of about two miles from the original planting. Many were growing against rocky cliffs (Fig. 1) and in ravines that were almost inaccessible to the scouts. Digging was a difficult process and sprouts invariably appeared after digging because the roots could not be entirely removed.

This area originated from a large hedge planted in Galena in 1844. In general the escapes are scattered along hillsides on both banks of the Galena river. Birds probably were the principal disseminating agent, with water as a second factor.

THE OGLE COUNTY AREA

Three separate areas of escaped barberry were found in Ogle County during the summer of 1922. The total number of bushes in these areas was about 250 and in each instance they were associated with streams in timber lands. The topography is somewhat rough but not as rugged as that in the vicinity of Galena. Although the number of bushes in the Ogle County area would indicate that it was comparatively unimportant, there are several characteristics peculiar to it.

In the territory about the town of Chana, twenty bushes all about the same size were estimated to be 70 years old. One of the largest bushes found in Illinois was in this area (Fig. 2). Another unusual characteristic was that the escaped bushes grew separately, only a few on each farm.

In the area about Mt. Morris, the bushes were of all sizes and were widely scattered in small groups. The area is about six miles across and includes about 100 bushes originating from a single source. In the Polo area many of the bushes were found growing on the sides of rocky bluffs and eradication necessarily will be difficult.

CHEMICAL ERADICATION[1]

The common barberry (*Berberis vulgaris* L.) when well established is a very difficult plant to kill. This is the conclusion reached after five years of effort to eradicate the common barberries from 13 of the North-Central States.

When the bushes are dug, even small fragments of roots left in the ground usually will sprout. This means that where the digging is difficult, as in rocky ground or around trees or stumps or when unusual care is not taken to remove all fragments of roots, sprouts are almost sure to develop. In lawns or gardens where a careful watch can be kept, the problem is not so serious,

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[1] Noel F. Thompson. Kill the Common Barberry with Chemicals, U. S. Dept. of Agriculture, Cir. 268, 4 p., 3 fig. March, 1923.

Fig. 2. Immense escaped barberry bush found in Ogle County. This is one of the largest bushes found in Illinois and is typical of the twenty large and widely separated bushes found in one escaped area.

Fig. 3. Barberry sprouts near Galena, Illinois, treated with crushed rock salt. The character of the soil makes chemical eradication necessary.

for in a year or two all roots left at the first digging will have sprouted and can be removed. With bushes growing wild in pastures and woodlots and along fences at a distance from the house, the situation is different, and other means of killing the bush are desirable.

In the past two years experiments have been carried on at Gurnee in Lake County in an effort to find some suitable chemical that would kill barberry bushes. A large area of escaped barberry was found at Gurnee in June, 1921, and the chemical experiments were begun in the autumn of the same year. Noel F. Thompson, who is now in charge of the experiments, has found that rock salt and a commercial compound containing sodium arsenite are the most effective compounds for killing the bushes.

Dr. W. W. Robbins conducted a series of experiments to determine a satisfactory method for killing barberry seedlings. He found that a number of chemicals are apparently equally toxic to barberry seedlings. Sodium arsenite was the most economical and effective compound used. A spring application was more effective than a fall application. Apparently the seedlings gain in reserve strength as the season advances. This fact suggests the advisability of spraying the young plants as soon as possible after the germination of the barberry seeds in the spring and summer.

Because of the danger to livestock resulting from the use of sodium arsenite, it has become necessary to discontinue using this chemical and to rely entirely upon salt.

There are many localities in Illinois where the soil is of such a character that effective digging of the bushes is impossible. An example of such a condition was encountered in the Galena district. The soil of the entire region is extremely rocky and where bushes were removed in July, sprouts appeared in September, thus demonstrating the absolute necessity of adopting the more efficient method of using chemicals in order to eradicate permanently every common barberry bush in the State (Fig. 3).

Even when the character of the soil would not interfere with eradication by digging, sprouts have been found in many instances. For example, the 1922 survey in Oak Park, Cook County, showed that fully fifty per cent of the bushes eradicated in previous years had sprouted. However, it is not likely that chemicals can be used conveniently on every planting because of the injurious effect on the soil, retarding plant growth one or two years.

Crushed rock salt has been applied to a number of bushes in Jo Daviess County (Fig. 4). About ten pounds is the recommended application for the average-sized bush. It should be distributed over the crown. The bush may be left standing or the top cut off before applying the salt. The average cost per plant for treatment with crushed rock salt was from five to fifteen cents, depending upon the character of the bush. This included the cost for salt and labor.

RUST EPIDEMIOLOGY STUDIES

In connection with the barberry eradication campaign in Illinois numerous observations have been made in the spread of black stem rust from infected barberries. Several outstanding cases have been noted; one at Minooka, Grundy County, probably is best known because it was the first to be brought prominently to the attention of farmers. It was discovered in 1919 and showed the relationship so clearly that it was mapped and described in the annual report of the barberry eradication campaign of that year.

Much of the rust around Minooka originated in a large hedge of common barberry comprising some six hundred bushes. Directly east of this hedge was a field of winter wheat sheltered by an intervening orchard. This protection, together with the earlier development of winter wheat, prevented serious damage to this field. About a quarter of a mile southeast of the hedge was a field of spring wheat with no protection other than distance. Intervening was a pasture extending from the hedge to the wheat. In this pasture was considerable wild barley. Rust spread from the barberries to the grass and then spread rapidly through the pasture to the grain where it produced a 90 per cent infection. Directly across the

Fig. 4. An area of escaped barberries in Jo Daviess County. The tops of of the bushes have been cut off and the crowns treated with salt.

road, about 70 feet from the hedge, was a field of oats. Not a single stalk escaped the rust. A mile farther away was another field of oats which showed an infection of about 75 to 80 per cent. The removal of the hedge has decreased stem-rust losses in this neighborhood in subsequent years.

During the summer of 1922, no serious outbreaks of black stem rust were reported. Weather conditions in June were very unfavorable for the levelopment of stem rust. The rainfall was light and the dry weather hindered the growth of the rust. However, the earliest infection of stem rust in northern Illinois in 1922 can be traced to barberry bushes, and, if weather conditions had favored stem-rust development, severe attacks with heavy losses might have occurred in that year.

The first spread of rust from barberries in 1922 was noticed in Lake, Livingston, and Will counties at about the same time. Mr. Thompson found quack grass and oats with a trace of infection near barberry bushes on June 10 in Lake County. In Livingston County on June 9, wild barley growing near a barberry hedge was found to be slightly infected. No rust could be found on this grass more than fifty yards away from the hedge. On June 23, barley growing near barberry in McHenry County was heavily rusted, while at a distance of fifty feet from the bushes the rust was extremely light. On the same date orchard grass and quack grass were found rusted near barberry in DuPage County. In almost every instance when infected barberry was found, stem rust was present on grasses or grains, and probably weather conditions alone were responsible for the absence of heavy infections.

AIRPLANE STUDIES OF THE DISSEMINATION OF STEM-RUST SPORES

Airplanes have been used in connection with studies of stem-rust spores in the air.

The purpose of these investigations was to determine general relations which might exist between height or distance from the infected material and the resulting dissemination of rust spores. It includes an attempt to find a correlation between distance from infected barberries in the direction of prevailing winds and the number of aeciospores or urediniospores which might be found.

METHOD USED IN COLLECTING AND EXAMINING THE SPORES

The work of collecting the spores was made possible through a cooperative agreement between the United States Department of Agriculture and the Air Service of the War Department. Slides were exposed from Army airplanes stationed at Chanute Field, Rantoul, Illinois. The airplanes, piloted by U. S. Army officers, flew from Rantoul to Gurnee, a distance of 150 miles each time spore collections were made. The bushes in the Gurnee area, previously described, were rusted heavily in the spring of 1922 and it was during the period of rust infection on the barberry that most of the flights were made over this area.

The apparatus as described in another paper[1] consisted of ordinary glass slides 3″x1″ in size coated with a very thin film of white vaseline or glycerine jelly. Each slide was fastened to a wooden handle and placed in a small glass bottle two inches in diameter and four inches high. With the use of a close-fitting cork stopper the bottle was made air tight. The glass slide was exposed by removing it from the bottle and holding the handle with the slide attached out in the air above the cockpit of the airplane for a definite time at definite altitudes. The microscopic examination of the slides and germination tests were made in the laboratory.

Four series of slides were exposed. Glycerine jelly, because it is quite transparent when examined under a microscope, was used in one series to determine its effectiveness in catching and holding spores. The time of exposure varied from three minutes in the first, second and fourth series to ten minutes in the third series.

In all cases the slides were examined under a microscope with a mechanical stage for the purpose of getting

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[1] Elvin C. Stakman, Arthur W. Henry, Gordon C. Curran, and Warren N. Christopher. Spores in the Upper Air. In Journal of Agricultural Research, Vol. 24, No. 6, May 12, 1923.

a close estimate of the spores present on each slide. To insure positive identification of all spores, they were measured by means of an ocular micrometer and were compared directly with type slides which contained the various forms. Only spores which were whole and uninjured were counted. In addition to aeciospores, urediniospores and teliospores of *Puccinia graminis* Pers., which were the only spores counted, there were, in many instances, large numbers of smut spores, spores of other rusts, pollen grains and spores of a considerable number of other fungi such as Alternaria.

RESULTS FROM SERIES 1 AND 2

The slides of this series were exposed on June 14, 1922, from an Army airplane over and near the 40-acre area of escaped barberries on the H. C. Lake farm near Gurnee, Illinois. The barberry bushes were infected severely on this date. The wind was blowing from the northeast and the observations were made directly over the area of bushes, at distances of 10, 15, and 25 miles south of the area. Each slide was exposed for three minutes. A vaseline-coated slide was placed on one side of the wooden paddle and a slide coated with glycerine jelly on the other; thus, when the paddle was exposed, two slides were in position to catch spores from the air. Observations show that aeciospores were present in the air over the Lake farm at altitudes from 100 to 12,000 feet. Urediniospores were found at altitudes of 1,000 to 7,000 feet. Ten miles south of this infected area, both aeciospores and urediniospores were found at an altitude of 2,000 feet. Fifteen miles south, aeciospores were found at an altitude of 2,000 feet. Twenty-five miles south, only one aeciospore was found and this at an altitude of 2,000 feet.

RESULTS OF SERIES 3

Slides of this series were exposed from an Army airplane over and near the 40-acre area of escaped barberries on the H. C. Lake farm near Gurnee, Illinois, on July 5, 1922. The length of the exposure was ten minutes. All the slides were coated with vaseline and two slides were exposed at the same time by attaching two slides to each paddle.

Observations made on this date show that approximately the same numbers of spores were present at elevations of 100 to 2,000 feet. At 6,000 feet there were about six-tenths as many spores as at 2,000 feet. At each elevation there were twice as many aeciospores as urediniospores and few teliospores were found from 100 to 2,000 feet.

RESULTS FROM SERIES 4

These slides were exposed on September 18, 1922, and the results are given to show the presence of the different spore forms late in the season. The exposure period was three minutes over an area free from any escaped barberries, and probably harboring few cultivated bushes. No aeciospores whatever were found on microscopic examination. A very large number of urediniospores were found and a decidedly increased number of teliospores, all of which is in direct keeping with the advanced season and the other conditions under which the exposures were made.

SUMMARY

The campaign for the eradication of the common barberry began in Illinois in the spring of 1918. Practically all of the cities and towns were surveyed during the first two years. The activities of the past three years have been devoted to the farm-to-farm survey of 15 counties in the northern part of the State and a resurvey of the city properties in these counties.

Illinois has an unusually large number of escaped barberries. In most cases, these escaped bushes are growing in timber land, brushy pastures, or on rocky hillsides which are of rough topography and present serious problems of successful eradication. The spread of escaped barberries is correlated with the type of soil and topography of the land over which they scatter. Results of experiments show that the most feasible method of killing barberry bushes in rocky situations is by the application of salt. An average-sized bush can be killed with 10 pounds of common crushed rock salt piled over the crown.

The cost per bush for the salt and application ranges from ten to fifteen cents.

Epidemiology studies show that barberry bushes are directly responsible for the early spread of black stem rust to fields of grain. The aecial stage of stem rust was found on barberry bushes in northern Illinois as early as June 10 in 1922.

Observations made by airplane flights show that in June and July aeciospores were present in the air over infected barberries. Also, these spores were caught in the direction of the prevailing winds from 15 to 20 miles from any known area of infected barberries. From flights made on September 12, 1922, no aeciospores were obtained in the air, but numerous teliospores were caught.

GROWTH STUDIES OF CERTAIN BOTTOMLAND SPECIES IN SOUTHERN ILLINOIS

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The study of tree growth has always had a certain scientific interest. Now since we know that the virgin stand of timber amounting to 138,000,000 acres out of an original stand of 822,000,000 acres will be cut out, in all probability, within the next 50 or 100 years and that we must turn to the cut over lands and to plantations as future sources of supply, growth studies assume greater economic importance.

The two great classes of lumber—hardwoods or broad leaved trees and softwoods or conifers—are graded according to different specifications. The hardwoods are graded largely upon appearance and beauty; the softwoods largely upon strength, which in their case can be secured from immature trees, but clear lengths can not, this having been well exemplified in the choice of Sitka spruce for aeroplane stock.

In general, hardwoods require better soil, produce fewer trees to the acre and have a slower rate of growth than conifers. They must be carried over a long interval to produce the desired grades and sell for but little more than softwoods in the market.

Among the hardwoods the growth rate varies widely as to species; within the species also the growth rate varies as to site, but the height growth rate for the same species on similar sites is remarkably uniform, so that it is used in site classification.

The fact that different species grow at different rates is so well known that it needs no proof. That the same species may have a very different growth rate upon upland than upon bottomland sites is brought out in the study of sycamore (Platanus occidentalis). At fifty years of age sycamore growing upon the uplands in Randolph county averages sixty feet in height as compared with ninety-two feet for the same age on the Mississippi bottomlands of Union County. The fifty year upland tree has an average diameter on the stump inside the bark of 8 inches and the bottomland tree of 24.2 inches.

That the growth rate in height for the same species on similar sites is very uniform is brought out by study of pin oak (Quercus palustris). Measurements were taken in Gallatin county on pin oak growing on gray clay subject to flooding from the Wabash, and in Union county for the same species on drab clay subject to flooding from the Mississippi. The height growth of the average tree for each at 50 years is 68 feet, and at no period between 5 and 65 years is there a variation of more than one foot in the height of the average tree for these widely separated stands.

Comparing the rate of growth in height for the common upland commercial species with that of the bottomland species of the state, the studies show that the upland species grow in height about 70% as fast as the bottomland species and in diameter about 55% as fast. Thus it is apparent that if the growing of hardwood timber crops is going to be profitable anywhere the bottomlands present the more favorable conditions.

Comparing the height growth of the eight bottomland species studied there is a noticeable grouping. The intolerant cottonwood (Populus deltoides) and sycamore (Platanus occidentalis) show an average annual height growth of more than two feet for the first 50 years. The honey locust (Gleditsia triacanthos), soft maple (Acer saccharinum), and pin oak (Quercus palustris) have an average height growth of 1.4 feet for the same period. The elm (Ulmus Americana), ash (Fraxinus Americana) and hackberry (Celtis Mississippiensis) average slightly less than 1 foot per year. Thus in rate of volume growth for average individual trees the listing would be in order of importance, cottonwood, sycamore, pin oak, honey locust, soft maple, ash, elm and hackberry.

Where these studies were made the soils are rich and moisture abundant. Thus the factor controlling both the occurrence of any one species in the mixture and its rate of volume growth is available sunlight. Abandoned river channels generally have seedlings in abundance of several species, but the rapid growth rate of cottonwood and sycamore soon places these above their competitors and results in a belt of these intolerant trees. But the more tolerant species, while not competing with the overwood of cottonwood and sycamore, will persist at a slower growth rate, or will seed in under the tolerant trees. With the removal of the latter the site will be occupied and held by the elm, maple, oak, hackberry, honey locust and ash.

Within this grouping of the more tolerant species there will be a sharp struggle for crown space, and the check in crown expansion will be reflected in a correspondingly poor diameter growth.

Thus, under the conditions which exist in these all-aged stands, the two species which show unusually rapid growth are the species which must have an abundance of sunlight; therefore they occur locally in the bottomland as an early stage in the transition from the new land to the ultimate forest, and where occurring, make a uniformly high rate of growth.

In attempting to grow either sycamore or cottonwood in pure even-aged stands the average diameter growth would probably be less than that of these same species growing in a mixed stand, for the reason that in the mixed forest the sycamore or cottonwood carry their crowns well up above the other species with consequently more leaf exposure to sunlight. The average diameter growth of the more tolerant species grown in pure even-aged stands probably would be increased, because at no period of their growth would there be an overwood with consequent suppression. In the management of such even-aged stands the suppression resulting from lateral crowding would be modified by thinnings in the plantation.

In the natural grouping of this all-aged virgin bottomland stand the average yield per acre is 15,000 B. F. The average age of the merchantable trees is slightly over 100 years. Cottonwood and sycamore made a diameter growth inside the bark on the stump of 20 inches in 40 years, pin oak in 58, honey locust in 57, soft maple in 59, hackberry in 125, elm in 127, and ash in 150 years.

In conclusion, it seems evident that the highest returns can be secured from a naturally stocked bottomland area by encouraging the sycamore, cottonwood, pin oak and maple. Probably the honey locust should be considered as a desirable species but hackberry and elm grow altogether too slowly and have no special merit. Ash has an extremely low rate of growth and its encouragement is justified only by the high market value of the wood. The highest returns from artificial plantations would probably be derived from cottonwood and sycamore, but such a plantation requires a cleared field and involves almost prohibitive initial investments except on land which is subject to overflow and is not liable to be for some years in an organized drainage project.

April 26, 1923.

BOGS OF NORTHERN ILLINOIS—II

W. G. Waterman, Northwestern University.

At the 1921 meeting of this academy the writer briefly described four bogs located in Lake County, Illinois, and mentioned several others which had been heard of or seen in the distance, but not visited. In the present paper five others are described and some data are added to the descriptions already reported. There is still certainly one and possibly several others which have not yet been visited. (Fig. 1.)

The new bogs, both those visited and those reported, are in the same general region, already described. That is, they are all within the limits of the late Wisconsin Drift of the Valparaiso moraine which is characterized by a soil consisting of clay or gravel, frequently containing a large percentage of calcium carbonate, and having an uneven topography, orginally with many knobs and kettle holes. Most of these depressions have been included in the drainage systems of the rivers of the region, but a section in western Lake and eastern McHenry Counties on the edges of the drainage basin of the Fox and DesPlaines Rivers still contain a few poorly drained or undrained depressions, and it is in these that the bogs are found.

For a thorough understanding of these formations attention should be called first to the present distinction between bog and swamp, which is based partly on the character of the habitat and partly on floristic content. A bog is characterized in general by a xerophytic vegetation and by the presence of such special forms as the pitcher plant, drosera, cranberry and sphagnum, which are accompanied usually by an acid condition of the substratum. In a swamp, on the other hand, the characteristic bog plants are absent and the substratum is alkaline or neutral. There are, to be sure, occasional anomalous communities in which a few bog species are present, although the conditions in general would seem to indicate a swamp. In the main, however, the distinction is fairly well marked, and in many cases it is so well defined that

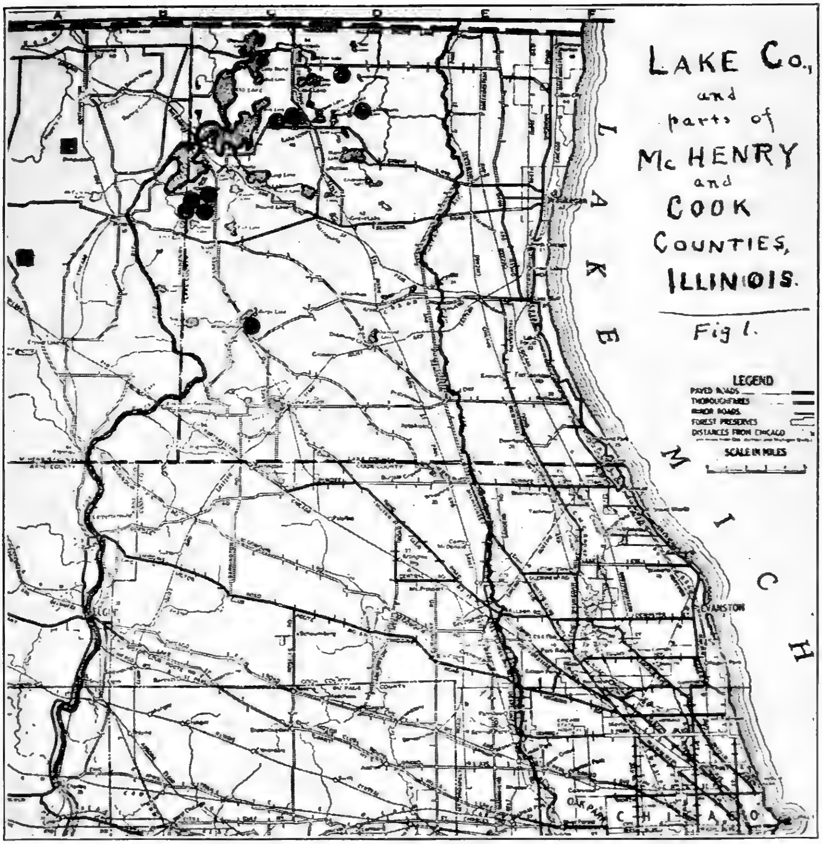

Fig. 1. Location of bogs in Lake and McHenry Counties. Black circles indicate bogs described; black squares, bogs reported but not yet visited.

swamp and bog zones may be distinguished clearly within the limits of the same depression.

The typical succession of communities in swamps include (1) free floating aquatics such as algae and pondweeds in deep water; (2) aquatics whose roots are in the soil of the bottom but their vegetative parts float on the surface, as the waterlilies; (3) plants which root in the bottom but have a large part of their vegetative parts above water, as bulrushes, cattails and pickerel-weed; (4) plants which grow in water or very wet soil, as sedges; (5) water-loving shrubs, chiefly willows; (6) swamp trees, as the ash and elm; and (7) the plants of the surrounding uplands when the substratum becomes solid and dry.

The first three stages of the bog succession are the same as those of the swamp, but at the fourth stage the characteristic bog plants begin to appear, usually on a floating mat made up of the roots and rhizomes of sedges and low woody plants with a filling of sphagnun. The characteristic shrubs are Chamaedaphne, Andromeda, Vacciniums and the dwarf birch, and the chief bog tree is the tamarack followed by the upland plants as in the case of the swamp.

By the identification of these stages, the progress of the succession and the consequent maturity of the bog or swamp may be determined.

CHARACTERISTICS OF HABITATS

The depressions in which these bogs are found are all similar in general features except in shape, as they vary all the way from small circular bowls or kettles 200 yards in diameter, to large oval or irregular basins half a mile or more in length. The most irregular is the group containing four bogs about a mile northwest of Volo, which will be found to be quite similar in general outline to the drained depression which contains the Fox-Pistakee group of lakes. The profiles of the larger depressions are similar also, usually including broad stretches of shallow, gently sloping plains which extend from the surrounding uplands to a deep pocket more or less centrally located. These bordering plains are wet and swampy at times of high water but may become quite dry in the late summer and fall. The line between these plains and the surrounding uplands is always clearly marked and shows evidences of shore erosion, as if it had marked the shore line of a lake which filled the whole depression at some time in the past.

The uplands show a marked alkalinity, and the glacial material of which they are composed contains many boulders and pebbles of lime-stone. The low flat borders are also alkaline, while the substratum under the bog vegetation is uniformly acid. The soil of the plains consists of black peat or muck, sometimes interbedded with sandy wash from the uplands, but this deposit is very shallow, not being more than six feet deep at the maximum. At the edge of the bog vegetation the bottom drops off rapidly and the character of the peat changes to a dark yellowish brown and contains fragments of bog plants. This kind of peat underlies all of the bog vegetation, and is everywhere over ten feet in thickness and probably much thicker in the central parts of the bogs. Many borings have been made in all of these bogs to a maximum depth of ten feet, and the data obtained confirm the finding of Burns (**1**) and indicate that the conditions he reports as to greater depths would hold good here also.

DESCRIPTIONS OF INDIVIDUAL BOGS

In many ways the most interesting bog is the one located on Cedar Lake and numbered 1 in the first report (**4**), as it is small in relation to the size of the lake and is evidently very immature. (Fig. 2.) On the open edge in the lake it is in the first bog stage, that of the quaking mat, and the shrub and tree stages are only beginning to appear. The bog mat is only about 100 yards wide, and between it and the shore is a swamp zone of about the same width. (Fig. 3.) The depth of the water gradually increases from the shore to the edge of the bog mat where it is about 6 feet, and from there it rapidly deepens, going beyond 10 feet in a short distance. Soundings beyond that depth have not yet been taken, but according to local opinion the lake is very deep just beyond the edge of the

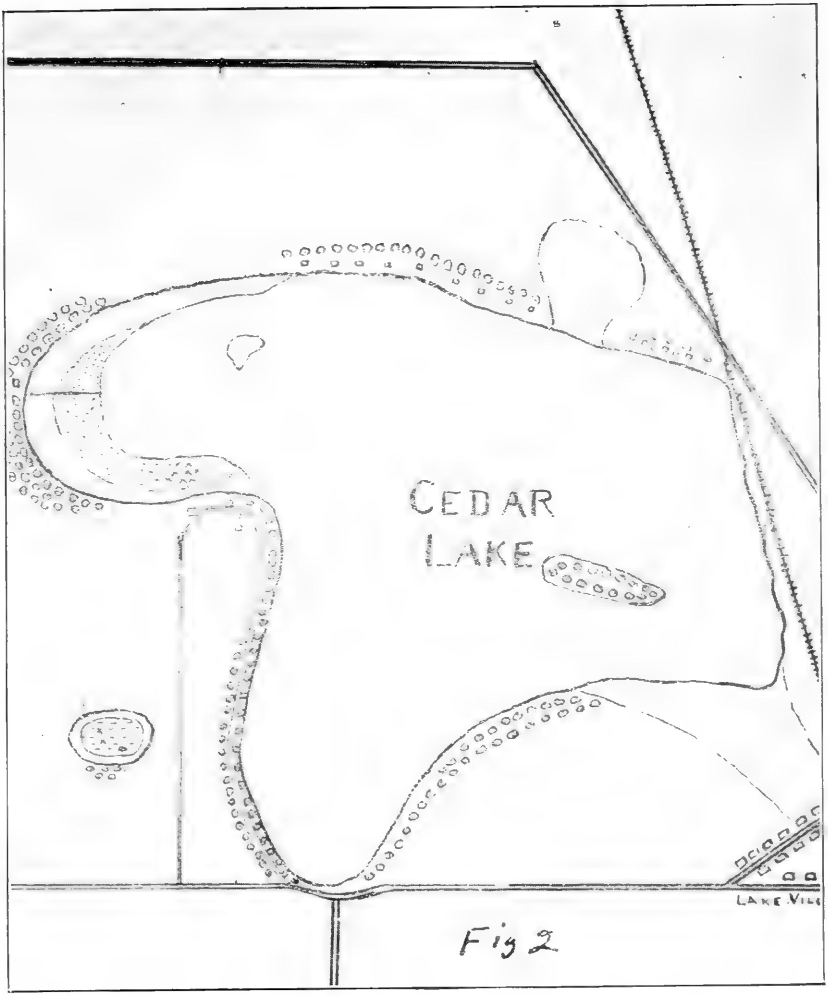

Fig. 2. Map of Cedar Lake showing location of immature bog.

bog while all other parts of the lake are relatively shallow.

Another feature of interest is a small island or patch of floating mat which is forming very rapidly about 300 yards off the center of the bog. It appeared about five years ago and was at first only a few yards across. In 1922 it was L shaped, each arm being about 20 yards long, but it is not yet solid enough to bear a man's weight. The plants are mostly sedges with some Decodon verticillatus, a very important mat-forming shrub. (Fig. 4.)

At the other extreme of maturity is the bog near Wauconda already described (4—No. 4) and one near Antioch in S. E. corner, Section 15, T. 46 N., R. 10 E., about three miles southeast of Antioch. The Antioch bog occupies a small, almost circular depression about 300 yards in diameter with a relatively narrow swamp zone on the north, east and west, but with a long flat valley on the south. The shrub zone is narrow, and consists chiefly of chokeberry and winterberry with some red ozier dogwood, swamp blueberry and elder. The tamarack forest is very mature with solid substratum and large trees, and there are also several upland specimens present, including a yellow birch 10 inches in diameter and several red or ellipsoid oaks, and occasionally choke cherries, trembling aspens and mountain ashes; and one service berry was noticed. (Fig. 5.)

The undergrowth is most mesophytic in the eastern half of the forest with few bog relicts, but including Maianthemum, Trientalis, Smilax, Geum, Onoclea sensibilis, Osmunda regalis, Asplenium sp., but in the western half there are fair sized patches of sphagnum, a few pitcher plants, and one specimen of menyanthes was observed. The east side is more open, many tamaracks have been overturned or cut, and there are few shrubs except red ozier dogwood which was abundant locally. There is a wide swamp zone on this side with quite abundant dwarf birch. Although the substratum is dry in autumn, the drift material in the bushes indicates temporary water levels of 2 to 3 feet above the surface in times of heavy precipitation, probably in the spring.

The Wauconda bog occupies a larger and more irregular depression with a broad shallow extension to the south east, apparently a large bay in the time of prehistoric high water, and a curving valley to the northeast which apparently connected the prehistoric lake with the depression now occupied by Bang's Lake. Both of these extensions are now occupied by swamp vegetation while the bog is confined to a rounded triangular depression to the west. The standing forest is similar to that of the Antioch bog, but the western half of the triangle was cut over about fifty years ago and is now a mixed secondary association containing scattered young tamaracks along the borders, a large number of dwarf birches, sedges and grasses, and among the stumps af the original trees, relicts of the undergrowth of the original forest, including Linnea, Cornus canadensis, with Leucobryum and other mosses. The central portion of the cut area is low, and apparently holds a small pond at times of high water as it contains vigorous colonies of Typha, Phragmites and other early-stage swamp plants.

The most mature bog found is in the small pocket near the Allandale farm already described (4—No. 2), and there is nothing to add to that description.

The most interesting group of bogs is found in two adjoining depressions northwest of the town of Volo, one of which was partly described as the Volo bog (4—No. 3), but it has been found to be surrounded by three other bogs which are quite as interesting. From the map in Fig. 6, it will be seen that there are three contiguous depressions not actually connected with each other which contain four formations of very different character. The bog described as No. 3 in the preliminary report (4) adjoins the George Sayer Farm No. 3, and therefore will be known as the Sayer bog. This was treated fully in that report and little needs to be added to the description. It seems almost certain that a twig of ledum was brought in among other specimens at the time of the first visit to the bog, but the twig was not preserved as it was supposed that if it was found so easily in a preliminary reconnoissance, it would be located easily later. Careful search subsequently has failed to find any trace of this species

Fig. 3. View over immature bog on Cedar Lake with floating island in distance.

Fig. 4. Close view of floating island in Cedar Lake.

and, while it is possible that there may be one or more specimens in the heart of the forest, its presence has not as yet been confirmed. On the other hand, Andromeda polifolia, not included in the first report, has been found to be rather common. The winterberry (Ilex verticillata) is a prominent shrub on the west border of the forest and there are a few small specimens of yellow birch and oaks in the western part of the tamaracks. The inner edge of the swamp zone, especially in the west and north, carries a dense growth of Bidens and other ruderals, which grow so luxuriantly to a height of five feet or more as to make passage through them rather disagreeable.

The pond in the center of the forest was found to be oval in shape and about 100 yards in length by fifty in width, and surrounded by a quaking mat of from 50 to 100 yards in width. Old inhabitants say that the pond occupied the whole of the open area when first visited about fifty years ago, and that the quaking mat has increased to its present width since that time, reducing the pond to its present size (Fig. 7). The open mat is made up of sedges, sphagnum, buckbean (Menyanthes trifoliata), marsh fern (Aspidium thelypteris), and large colonies of cattail on the edge of the pond itself. The clear water in the pond is not over a foot or two in depth and its bottom is apparently composed of soft peat.

Northeast of the Sayer bog but separated from it by a low ridge about 200 yards wide, traversed by an east and west road, is an oval depression about one quarter of a mile long by one eighth wide extending northeast and southwest, which formerly carried a tamarack forest growing on a sphagnum mat. The tamaracks were cut some time ago and their stumps are buried a foot or more by a thick growth of chamaedaphne and of sphagnum, which is climbing vigorously among the stems of the chamaedaphne. There are several small colonies of pitcher plant and occasional patches of sedges with cranberry and some blueberries. There are scattered specimens of dwarf birch, one large dead tamarack and five or six very young living trees near the center of the bog, and eight or ten others at the northwest corner. On the east side of the bog is a long belt of dense dwarf birch, and beyond that a swamp zone with swamp fern and sedges and some iris and swamp cinquefoil along a small drainage ditch. The edges of the bog are now being drained toward the center, but the draining of the whole bog would be an expensive matter owing to the height of the surrounding ridges. The surface has been burned repeatedly and the swamp zone is now occupied by a scanty growth of ruderals.

About one half a mile to the west of these two bogs is a long L-shaped depression which contains two separate tamarack groves indicated on the map (Fig. 6) and originally referred to as No. 7 and 8. One is long and L shaped, running north and south, and the other, approximately round, at the end of the western arm of the depression. The north end of the depression is large and rounded and the tamarack grove occupies only the western half of this enlargement, while the eastern half contains a crescent shaped pond which narrows rapidly toward the south and disappears about the middle of the tamarack forest.

The substratum is fairly solid under the tamaracks, and its upper surface consists largely of tamarack needles but below it is composed of dark brown peat. Both at the surface and below to a depth of six feet it gives a neutral or alkaline reaction. On the east side of the tamaracks between the forest and the small lake is a small morainic knoll covered with oaks, and beyond this knoll the substratum becomes a quaking mat which contains no characteristic bog plants and is underlain by a soft muck which is strongly alkaline and contains many small, white, calcareous fragments apparently of gastropod shells. This swamp mat surrounds the southern pointed end of the lake and in that locality contains dense colonies of cattail, bulrush and reed grass (Phragmites). The main body of the mat consists of grasses and sedge and swamp mosses with some swamp cinquefoil, St. John's wort and several colonies of fringed gentian.

The tamarack forest has been cut in places, but where relatively untouched the growth is dense and contains many trees up to 10 and 12 inches in diameter, with at least one of twenty inches. A 4-inch stump showed 40 or

Fig. 5. Yellow birch with slender stems and large tamarack in mature forest in Antioch Bog.

50 very narrow rings while one of 10 inches showed 75 rings divided into zones which varied considerably in the thickness of their rings. On account, perhaps, of the dense shade and the carpet of needles the undergrowth in the center of the forest was scanty but contained much minium, some patches of marchantia, one species of aster and some fungi, especially several specimens of Helvella. The southern portion of this forest and the western grove are less dense and the trees are smaller.

The swamp zone is narrow along the west side and on the east side below the northern basin which contains the lake, but the western depression has wide extensions both to north and south, which are filled with grass hummocks with occasional specimens of dwarf birch. The shrub zone is narrow and scanty toward the north, the chief species being Cornus paniculata and saplings of balsam poplar. From the center south and west it consists of an almost pure stand of swamp sumach which, taken with the specimens on the Sayer bog, constitute much the largest display of this plant to be found in the State. The topography of the bottom of the original depression is similar apparently to those of the other depressions,—shallow in the swamp zones but much deeper under the tamaracks. Where the swamp zone is narrow, the bottom drops away rapidly, but in the broad bay-like extensions the slope is very gentle.

The last bog of those so far studied is located in the N. W. corner of Section 35, T. 46 N., R. 10, E. about a mile west of the village of Millburn. In many respects it resembles the one located northeast of the Sayer bog, but it has some distinctive features of its own. There are no tamaracks visible and no sign of their former presence although, as there was no ditching going on, there was nothing to show whether or not a former forest had been cut in the past.

The depression is a broad oval extending northeast and southwest and measures about 500 yards by 300, bordered by the usual swamp zone which is narrow on the north and east, but with broad extensions to the south and southwest. Within this swamp zone the substratum is covered by a thick mat of sphagnum with much cranberry and many colonies of pitcher plants. A peculiar feature of this bog is the tendency of several species to form dense local colonies of almost pure stand. Among such species were noted dwarf birch, andromeda, dewberry, marsh fern, and violet; and cattail in the swamp zone on the northwest. Less common species were cotton grass, swamp cinquefoil, and the mosses Polytrichum and Leucobryum, a few saplings of trembling aspen, two willows, and one specimen each of winterberry and mountain ash.

A very dense belt of shrubs, almost as long as the bog mat and ranging from 15 to 30 feet wide, runs parallel with the southeast side of the oval and about 20 feet within it. 50 to 75% of the specimens are dwarf birch which grows there very dense and 5-7 feet high. There were also much winterberry, chokeberry, some elder, five or six oaks 10 feet high, and many trembling aspen saplings. The ground occupied by this shrub belt seemed to be a low sand bar rising a foot or two above the level of the mat, but as no borings were taken at this bog, the underground topography can only be guessed at.

DISCUSSION AND CONCLUSIONS

The chief interest in these bogs lies in the fact that they are the only examples remaining in Illinois of a type of plant formation common in most of our northeastern states and very abundant farther north. The distribution of deep peat deposits as shown by the soil map of Illinois would indicate that these bogs were much more common in Illinois in fairly recent geological times, though a careful examination of the peat would be necessary to determine whether it was formed in a bog or in a swamp.

The correlation between chemical condition and depth of the substratum and the character of the vegetation is important on account of its bearing on the theories of the causes of xerophytism in bog plants. In these bogs the substratum on which the bog plants grow is found to be of considerable depth and acid in character, while the swamp plants are found on a shallow substratum which gives a neutral or alkaline reaction.

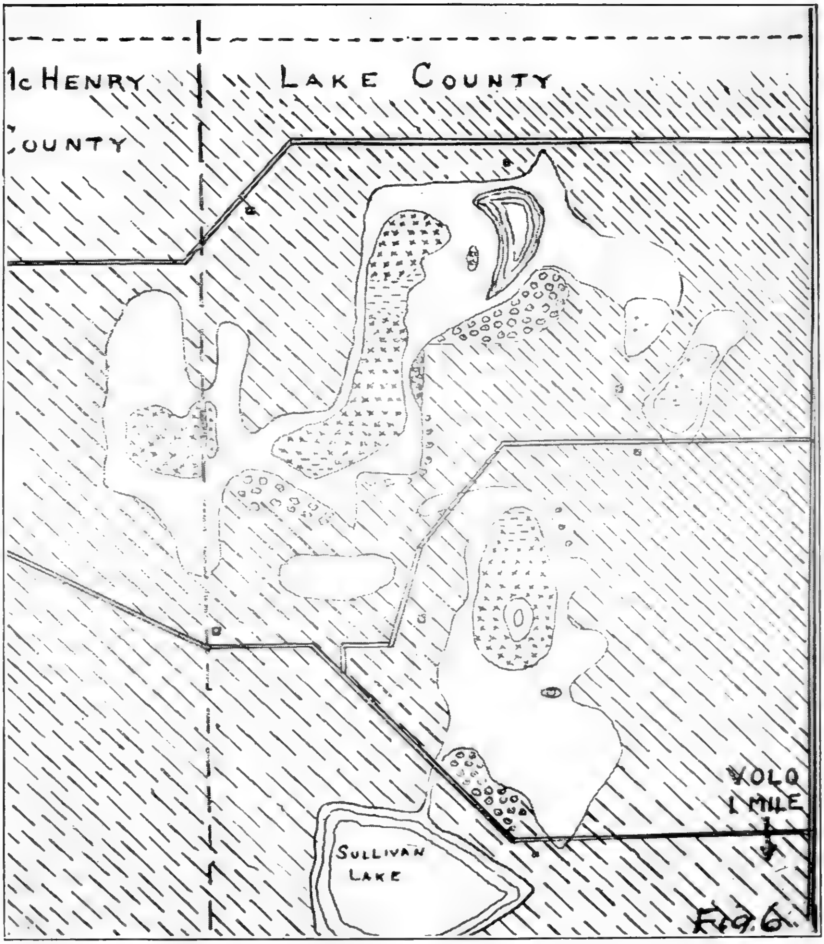

Fig. 6. Map of group of bogs northwest of Volo.

In summarizing the various theories of bog xerophytism, Rigg (**2**) regards four as of chief importance, and considers that these are; acidity, difference between air and soil temperature, lack of aeration of the substratum, and toxic substances in the substratum. It will be seen that the conditions in these four theories fit in with the observed relation between the distribution of bog plants and the depth of the substratum. In the broad shallow portions of the depressions the water is stirred up continually by the wind and mixed with finely divided matter from the uplands, thus insuring aeration, neutralization of acids, absorption of toxic substances, and a temperature more nearly the same as that of the air. The situation in the deep substratum would be just the opposite and would favor the development of conditions which would permit the growth only of plants with a structure more or less xerophytic in character.

The absence of sphagnum and other bog plants from depressions with an alkaline substratum has been reported before, but the experiments of Transeau (**3**) who succeeded in growing sphagnum in the laboratory in water containing 100 parts of calcium carbonate to the million, have usually been interpreted as overthrowing the theory that presence of calcium salts is the reason for the absence of sphagnum. This experimental evidence does not seem to the writer to be conclusive, for either conditions in the field might be different in other important respects from those in the laboratory, or the conditions governing the germination and establishment of sphagnum might be different from those affecting the mature plant.

In the bogs under consideration all other conditions except the acidity or alkalinity of the substratum seem to be the same in Nos. 7 and 8 as in the remaining bogs, so it would seem as if the presence or absence of calcium must be the limiting factor for the sphagnum. Experiments in transferring sphagnum and other bog plants to parts of bogs from which they are now absent are in preparation, and it is hoped they may throw some light on this question.

Complete lists of the species found in the different bogs have not as yet been completed, but an examination of the lists of the dominant species (Fig. 8) shows interesting anomalies. Apart from the absence of the usual bog plants in 7 and 8, the dominance of chamaedaphne in 5 and of andromeda in 2 is the most striking. These two bogs are very similar in all other respects and there is no obvious explanation of this marked difference in the presence of two species so closely related both taxonomically and ecologically.

Another point of great interest is the maturity and the rate of development of the bog mat in the different depressions. Bogs 1, 4, 7, 8, and 9 (Fig. 8) show by the condition of the substratum and the presence of members of the upland forest that they have reached a condition of considerable maturity, while 6 is intermediate and 3 is very young. Furthermore, the evidence, both from the formations themselves and from human testimony, shows that there has been a very rapid increase of bog mat formation within the memory of man. If these bogs have been in existence since the glacial period, as has been the generally accepted view, it is necessary to account for the sudden speeding up of their development in recent years. If, on the other hand, No. 3 is of recent origin, it is equally difficult to explain how the conditions which prevented its origin for a very long period became changed so as to permit its start in recent years. From observations of these bogs and also of similar formations in Benzie County, Michigan, (5, p. 27) it is the opinion of the writer that a recent lowering of the water levels in all of these depressions may have caused the change in conditions which made possible a recent increase in bog mat formation. Further study will be necessary before any final decision can be reached on this question.

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Fig. 7. Pond in center of Sayer Bog.

DISTRIBUTION OF SPECIES--ILLINOIS BOGS.

	1	2	3	4	5	6	7	8	9
Larix laricina	III		III	III	III	III	III	III	III
Quercus spp and other Climax trees.	I	I		II		I	I	I	II
Ilex verticillata	I	I		II		II			I
Rhus vernix						III	III	III	
Cornus stolonifera	I					I			I
Betula pumila	I	II	II	I	II	III			III
Chamaedaphne calyculata			II		III	II			
Andromeda glaucophylla		III	I			I			
Sphagnum sp.	I	III	III	I	III	II			I
Sarracenia purpurea	I	III	III		I	II			I
Vaccinium macrocarpon		III	III		II	II			I
Maianthemum canadense	I			I			I	?	I
MATURITY OF FORMATION	M	?	Y	M	R	Int.	M	M	M

Fig. 8. Table of distribution of plant species in bogs.

TITLES FOR ILLUSTRATIONS.

FARM WOODLOTS IN ILLINOIS

W. F. Schreeder, Natural History Survey, Urbana

The acreage of farm woodlots in Illinois as given by the 1920 Census amounts to 3,102,579 acres, and the value of woodlot products was $6,259,000.. Taking into consideration the value of this asset it seems that a brief discussion of the farm woodlot in Illinois would not be out of place at this meeting.

Some studies had been made as to the value of farm woodlot products as they contribute to the farmer's living (Funk '14) and the use of wood for fuel (Bulletin No. 753, U. S. Department of Agriculture, Office of Forest Investigations), but not until recently have studies been made as to the economic value and possibilities of the farm woodlot. Perhaps the most recent information on this subject is contained in an unpublished manuscript in the files of the Forest Service, by Mr. E. F. Hodgson, on "Farm Woodland Economics".

The results which are presented in preliminary form in this paper have been derived from a study made of farm woodlots in Illinois, partly by personal visitation to farmers in certain townships and partly through the questionnaire method. It is a part of the whole subject of forest economics of the state, for the study of which Professor H. H. Chapman, professor of Forest Management in the Yale School of Forestry, was employed part time last summer by the Natural History Survey and upon which he will later present a detailed report.

During the year 1922 questionnaires were sent out to 1,600 farmers in every county in the state. Lists of farmers from various counties were sent in by the county farm advisers and contained the names of those most likely to have farm woodlots or to be interested in the same, although many were "corn-belt farmers". Questions were asked not only concerning the acreage of the farm in woods and the amount of timberland grazed, but also regarding the amount of wood and coal burned, the number of fence posts used and the amounts of various products cut from farm woodlands for the last five year period with the prices received for the same, as well as local prices for lumber, fence posts and shingles. One question dealt with the durability of various species for fence posts and another with the attitude of the farmer towards annually burning over the woods. About 440 of these questionnaires, completely or partially filled out on these various points, were returned to the Natural History Survey and the figures resulting from averaging the data may be of interest.

GENERAL FACTS

The average farm contained 354 acres. Fifty acres, or about 14 per cent of the average farm, was woodland. Compilation of results on clearing for farming and pasturage showed that within the next few years this 50 acres is to be reduced to 34 acres, or there will be a reduction of 31 per cent of our present timber stand for the farms represented. The 16 acres which is slated for clearing will be about equally used for farm and pasture land. Inquiry as to the amount of land which might be planted or reforested showed that an average of five acres should be planted, being considered more valuable for forestry than for farming. The average amount of forest plantation for each farm was only one acre.

The value of the woodlot to the farmer as revealed by the answers is considerable. From his woodland he secures on the average 223 posts, or nine more wooden posts than he needs to keep his fences in repair.

Besides furnishing him with fence posts, this same woodlot yields 15.5 cords of wood annually to its owner, and during the last five year period has supplied him annually with 2,863 board feet of lumber, about two-thirds of his total needs in this line. While as a rule the farmer takes less care of his woodlot than of his other crops, in addition to the pasture it yields him, his average annual return from it, according to our figures, is as follows:

Amount or number of pieces	Price per piece cord or M. feet	Total yield per farm per annum
223 fence posts	.22 cents each	$ 49.06
15.5 cords of wood	$1.95 per cord	30.22
2863 board feet of lumber	$31.30 per M. feet	89.61
Total		$168.89

INDIVIDUAL EXAMPLES OF PROFIT

Some examples of individual profit from farm woodlots stand out conspicuously. The answer on one in particular, where the farmer said "that there was not enough timber around here to bother with" shows that he obtained from 17 acres 60 to 70 cords of wood for himself and tenant, valued at $247.50, 125 fence posts and 600 feet of farm lumber.

Besides, on eleven acres of the same woods he had pastured three head of cattle, four horses, and 250 hogs from May to November. When we consider that a fair price for pasturing stock is about $2.00 per head per month we must conclude that this 17 acres of woodland yielded a return fully equal to some of the owner's farm land.

DURABILITY OF FENCE POSTS

The figures given on durability of native timber for fence posts, while, of course, a matter of opinion by the farmers who have answered, agree very well with figures on the durability of untreated fence posts given by the Forest Products Laboratory at Madison, Wisconsin, by the Ohio Agricultural Experiment Station, and by the Iowa State College. Soft maple stood lowest in the list with a durability of 2.4 years; white oak, which is taken usually as a standard in service tests, was rated at 9 years, catalpa was rated at 15 years, cedar at 13, black locust and mulberry at 17 years each, while osage orange or "hedge" had an average rating of 36 years. We have seen specimens of osage orange posts which had been in the ground 35 years, so that we can rely on the latter figure as being not far from correct. Black locust and red mulberry are next to osage in order of durability.

WOODLOT MANAGEMENT

The three principal factors influencing successful woodlot management in Illinois are *grazing, fire* and *taxes,* and these will be considered in order.

(a.) *Grazing.* This is a state-wide practice. Results from the questionnaires show that 84.5 per cent of all the woodland owned by 212 farmers who replied to that particular question is subject to grazing.

Definite figures have not been obtained as to the amount of woodland pasture required to support a single head of stock, but most farmers agree that grass under the shade of trees has much less nourishment in it for stock than that grown in full sunlight. Farmers in southern Illinois place its value for forage at about one-fifth of that of good bottomland pasture. Hodgson estimates the value of woodland pasture at 24 acres required for 10 head of stock or 2.4 acres required per head.

DAMAGE DUE TO GRAZING

It is very easy to see the damage done by grazing, first to the trees and reproduction, and second to the soil. The bark of the mature trees is damaged by rubbing, the tender shoots forming the young growth are eaten off, and seedlings are trampled out and killed.

Forest soil which is normally moist and porous and ideal for the growth and reproduction of trees is packed hard, and growth is either retarded or completely stopped. The soil, where packed by the hoofs of grazing animals, becomes dry and dusty and the rain instead of soaking into the ground runs off rapidly, leading finally along paths to the formation of gullies.

In LaSalle county Dr. George D. Fuller states that not over 5 per cent of the grazed woodlands show any reproduction; that in the last 25 years there has been but little change in the timber; and that grazing has produced woodlots which had better be called "wooded pastures", so scattering are the trees.

The need of shade for cattle is advanced as an excuse for grazing the woodlands, and this is perhaps quite as important as the forage which the cattle obtain. Shade for stock can be provided by fencing off a portion of the woods sufficient to supply shade, thus shutting out the stock from the more valuable woodland. The numerous photographs which have been taken by the Forest Survey party show very forcibly the effects of grazing, leading us to say that good timber and good grazing are impossible on the same tract.

(b.) *Fire.* Fire, the second problem of the landowner, varies greatly with the region. The woodland tracts of northern Illinois are sufficiently isolated to confine fires to relatively small areas. The tracts in southern Illinois, however, are more continuous and public sentiment against burning is not so well developed. Results compiled from the questionnaires show that out of 217 farmers 80 per cent were against and 20 per cent in favor of annual burning. Out of 296 answers, causes for fires were assigned to the following:

Campers and hunters	103
Carelessness	54
Burning to kill insects	37
Brush and grass burning	32
Railroads	26
Smoking	25
Lightning	6
Incendiary	3
Total answering	296

It can be seen from this list of causes that about 89 per cent of the fires are due to man and are preventable. One fourth of this 89 per cent are set by farmers themselves under the pretext of killing insects or benefiting grazing. Burning over the entire woodland to kill chinch bugs is inexcusable (Flint '22) since investigations on the edges of woods have shown that at a distance of 50 feet about 90 per cent of the bugs are left behind, as they seek the sunny edges of the woods, being found mostly on the south and west sides. The burning of a narrow strip around the timber would not only kill the greater per cent of them but make a satisfactory fire guard to prevent the entrance of fires. As to benefiting grazing, the idea is prevalent that the ashes of the burned grass act as a fertilizer, but this is probably more than counterbalanced by damage to the roots of the grass. Wherever there is a rail or "worm fence" around the woods we usually find that fires are kept out, as farmers do not like to rebuild their fences, and this is true especially in southern Illinois.

(c.) *Taxes.* In spite of answers from farmers in certain sections showing that taxes were excessive on timberland and tended to its conversion into use for farming or pasturage, there was considerable opposition from farmers themselves, if we can believe newspaper reports, to the proposed clause on that subject in the new constitution which read thus: "Areas devoted to forests and forest culture shall be classified for or exempted from taxation".

The main objection stated was that "owners of fine landed estates would escape taxes by listing their grounds as woodland, thus adding to the tax burden of the dirt farmer". The object of the clause was simply to allow some kind of classification of forest land, with exemption perhaps of young timber not yielding any revenue, and the interests of the "dirt farmer" could have been amply safeguarded in the tax law by prescribing that land to be classed as forest must have a certain number of trees per acre, thus avoiding any chance of the wealthy owner of an estate having his few ornamental trees listed as a forest.

Over against such hastily formed conclusions as the above opposing some sort of forest land classification, are such statements as these from farmer's questionnaires: "The average landowner cannot afford to maintain forest land as taxes, and lack of income on the investment will put him in the County Home". "All of this sandy land is now taxed far beyond its worth. My tax last year on 300 acres was $158.90. My largest income from this 300 acres was $275, with 700 rods of fence to keep up". These statements certainly look as if some tax reform was needed, but of course they are only isolated examples.

As it is at present, matters are largely in the hands of the local assessor as to how much tax is paid upon a piece of timber. So far as we know, no consideration is taken of the age of the timber, its yield per acre, or the nearness to the time for cutting.

There is not time here to discuss the admitted failure of the general property tax. It may be said, however, to be defective when applied to immature timber "because by taxing the total value of the land and the trees upon it, it imposed an excessive burden upon the growing forest and it placed on the owner the inconvenient obligation to pay annual taxes for years before any income was realized'' (Fairchild '22). The Committee on forest taxation of the National Tax Association suggests as a remedy the paying of a products tax of about 5 per cent on timber when it is cut, this applying to mature forests; and an exemption from taxation for immature and young timber, assessing these lands no higher than similar bare lands in the neighborhood. The main difficulties lie in the determination of what is ''mature timber'', and the irregularity of revenue resulting from the yield tax. It is along these lines, however, that the most satisfactory adjustment of our forestry taxation problem is to be looked for.

Fairchild, Fred R., 1922. Finding the Solution of the Forest Taxation Problem. Report of the Committee on forest taxation, National Tax Association, Minneapolis, Minnesota, American Lumberman, September 30, 1922. Pages 54-55.

Funk, W. C., 1914. What the Farm Contributes directly to the Farmer's living. Farmer's Bulletin 635. U. S. Dept. Agr. December 24, 1914.

Flint, W. P., 1922. Burn the Chinch-Bug. Circular 265, Univ. of Ill. Agr. Exp. Sta., Urbana, Illinois, October, 1922.

WOOD CONSUMPTION AND WOOD PRODUCTION IN ILLINOIS AND THEIR RELATION TO THE FUTURE PROSPERITY OF THE STATE

R. B. MILLER, STATE FORESTER, URBANA

In order to form an economic back ground for forestry in Illinois the Natural History Survey has been making a study, largely by the questionnaire method, of the amount of wood consumed in the state. The amount of wood produced by growth and the extent to which this total can be increased by better methods of handling existing stands of timber or replacing them with more rapidly growing species form the other side of the problem.

This economic aspect of the question strikes us as the one lying at the root of the whole forestry question in this state. No matter how much we may expand our forest areas by an appeal to the sentimentalist and to the recreationist, we all realize that wood will be grown as a crop only when we can convince people that it is a basic substance, essential to industry, lacking which we shall be forced to lower our present standard of living to that which prevails today in some of the European countries.

This paper deals with some preliminary points which have been found out in following up various sources of information about our present consumption of wood to be elaborated more fully later in a bulletin of the Natural History Survey.

CONSUMPTION OF WOOD BY RAILROADS

Franklin B. Hough, who may be styled the first United States forester, sounded in 1882 a first note of warning about a scarcity of timber for railway ties when he said that at the existing rate of increase in railroad mileage there would come a time in 1893 when a total of 10 million ties would be needed annually by American railroads. What if Mr. Hough should return now? He would find that the American railroads use 125,000,000 ties annually and that the electric and trolley lines use 10,000,000 more, just the amount of his original estimate.

There is located some little distance out from the city of Galesburg a plant which the Academy of Science members will visit as one of the points of interest. I refer to the tie-treating plant of the C. B. & Q. Railway Company, one of the twelve located in this state, which is seeking by preservative treatment to prolong the life of timber, thus contributing their part to forest conservation. The Burlington railroad not only maintains this plant and buys treated ties and timber from commercial treating plants elsewhere in the state, but it has been foremost in maintaining experimental tracks where the durability of untreated ties and those treated by various methods can be studied. It has demonstrated that the average annual renewal of untreated ties in a track of 15 per cent can be reduced by using preservative processes to about 6 per cent. Other roads assure us that where now it requires on an average 250 to 275 ties per mile for renewals this figure can be cut, when all ties are treated, to something like 100 per mile. We can not yet give a figure for the total consumption of cross, switch and bridge ties required on the 25,000 miles of railroad in Illinois but we do have data on many of them and know that the normal consumption of one road alone in Illinois is 20,000 ties per month. On the production side we have definite records showing that 980,000 ties were secured in Illinois in 1921, and believe that this figure could be raised safely to 1,000,000 ties. Perhaps 500,000 of these come from southern Illinois.

CONSUMPTION BY COAL MINES IN ILLINOIS

Perhaps some persons have not thought of wood as an essential in coal production in Illinois but this problem is giving mining engineers some concern. Our own results compiled from answers to questionnaires from 27 large coal companies in this state, combined with material secured by the U. S. Bureau of Mines (Tufft '23)[1], show that on the average close to one-quarter of a cubic foot of timber is required to mine one ton of coal and that the

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[1] Tufft, Harry E., 1923. Mine Timbers in Illinois Coal Mines. Reports of Investigations, Bureau of Mines, April, 1923. Department of the Interior. Serial No. 2465.

cost to the operator is not far from 5 cents per ton. Take one-fourth of our coal production, then, and you get almost 20,000,000 cubic feet of wood required yearly for coal mining, costing delivered at the mine almost $4,000,000. Furthermore, the ordinary mine prop has an average length of life of about two years. Only a few companies in Illinois have begun to apply preservative treatment to mine timbers or to think seriously of perpetuating the supply of mine timbers. Both of these lines of work present worth-while problems in practical forestry for mining companies.

This shortage of timber for mining purposes seems to be rather general. The U. S. Bureau of Mines (Hornor and Hunt '22)[2] under date of February, 1923, says that in the East and Middle West, the Lake Superior region and the metal mining regions of the West, the sources of mine timber are becoming more remote from points of consumption, the timbers are getting more difficult to obtain and, naturally, more costly. Moreover, the better and more durable varieties are being exhausted rapidly; consequently the less durable varieties must be used in their place.

CHARCOAL

It takes almost 2,000,000 kegs of powder for blasting purposes in Illinois in connection with mining operations. Leaving out smokeless powder, which is made from gun cotton, charcoal is a very important constituent of powder used for blasting and sporting purposes. Some of the facts which we have learned about this industry of charcoal making in Illinois may be of interest.

We have found that in a limited region of southern Illinois near to a supply of second growth bottomland hardwoods over 15,500 cords of wood are reduced annually in brick kilns in the making of charcoal, most of which finds a market in Illinois. Some of the powder companies have their own kilns, one large company getting over 6,000 cords of charcoal wood annually from islands of the Illinois and Mississippi rivers.

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[2] Hornor and Hunt, 1922. "Mine timber preservation". Reports of Investigations, Bureau of Mines, Serial No. 2321, February, 1922. Reprinted in Coal Trades Bulletin, April 17, 1922.

Other powder companies buy their charcoal in other states, the amount used being shown by the fact that one Illinois company in normal times imports over 5,000 bushels per month from Pennsylvania. This is explained doubtless by the fact that operators of retorts and ovens in the East can undersell the men operating brick kilns here because the former secure in the distillation process not only charcoal as a by-product but also wood alcohol and lime acetate for which there is a good demand in the market.

FURNITURE AND WOOD-USING INDUSTRIES

According to the Secretary of the American Walnut Manufacturer's Association, the city of Rockford ranks first in the United States as a consumer of walnut lumber, with Chicago second by a very fair margin. At Rockford most of the walnut goes into the manufacture of furniture but in Chicago it is used by a wide range of industries, among which furniture is the leading one. The total of all kinds of lumber and logs used by the Rockford furniture manufacturers has not yet been compiled, but present figures stand at 11,500,000 board feet annually. The leading species used consist of cedar and mahogany, oak, walnut, gum, birch and basswood, with considerable quantities of rock and red elm, used for crating. A very large amount of this lumber comes from the southern states, the local supply cutting very little figure.

The consumption by wood-using industries in Chicago in the year 1910 was 1,116,855,120 board feet, out of a total of about 2,500,000,000 board feet of lumber shipped into that city. This large amount used by factories of various sorts did not include material used for cross ties, telegraph and telephone poles, mine timbers, shingles, lath, or rough lumber used in construction. Rock Island also used about 30,000,000 feet of lumber in her factories outside of that sold by local lumber yards, while factories in Peoria, Quincy, Aurora, Kankakee, Bloomington and other cities are yet to be heard from.

VENEERS

With the growing scarcity and high prices of logs of the larger sizes in this country, we are coming gradually to the use of veneered panels for furniture and interior finish where large surfaces must be exposed. The success during the war with waterproof casein glues has led to a marked increase in the manufacture of built-up material, commonly known as "ply-wood" for trunks, automobile tops, shoe findings, airplane propellers, and many other articles requiring both strength and durability. The fact that the fibres of the constituent pieces run in several different directions insures strength, while the waterproof glue makes the built-up piece proof against moisture changes.

Outside of the large amount of wood used for the above, the scarcity of elm and other slack cooperage woods has increased the price of barrels so that there have been introduced into the fruit shipping industry a number of "veneered packages" which are made from wood by slicing vertically or cutting in a rotary direction logs which have been steamed previously to soften the fiber. Egg cases are made also in large quantities from cottonwood and gum by a similar process.

In the face of increasing demand, the amount of wood used for veneers in Illinois has fallen from 22,650,000 board feet to 19,538,000 board feet, a decrease of over 3 million feet or 13.7 per cent in the last ten years. Visits to veneer plants in a limited portion of southern Illinois covered by a recent bulletin show that about 4,000,000 board feet of logs are consumed for veneers in that immediate region, and that some of the mills will be forced to move to Arkansas or Missouri nearer a larger source of supply within five years. Thousands of dollars are paid out in one limited region of southern Illinois for fruit and vegetable containers, and some are imported from other states, especially ladders for fruit-picking. Indications are that larger and larger quantities of both logs and manufactured products will have to be shipped into this region which is in some parts 30 per cent timbered.

TIMBER IN THE ROUND

Large quantities of wood are used in the round for telegraph and telephone poles, piling, and fence posts, which it is almost impossible to estimate. The Illinois farmer uses a considerable quantity of lumber for farm buildings, and the amount of wood produced and consumed on farms has been made the subject of a special study, some of the results of which will be given in the paper on farm woodlots. This leaves a long list of special uses to be investigated, such as in the manufacture of refrigerators, school equipment, handles, wagons and farm implements, cabs and other vehicles.

If you saw the frame of a certain make of popular cab you would understand better why the "thinking fellow" calls that variety—— the frame is built in Chicago or Detroit of second growth Argansas ash, every piece of which is tested carefully for strength before being used. In connection with the use of ash for sporting goods you may be interested in knowing that the American record for the javelin throw of 203 feet, 9½ inches was won by Milton Angier of the University of Illinois at the Drake relay carnival, and that these javelins are manufactured in Urbana of Indiana and Illinois ash, under the supervision of Coach Harry Gill. This same firm turns out the discus, the maple for which comes largely from Wisconsin and Michigan.

Thus wood is a material with which we can not well dispense. We can not afford to reduce our standards of living in this country by dwarfing our use of wood to the 125 board feet per capita of Europe. In spite of substitution for wood along many lines we are constantly going to need more of this basic commodity. The only way to insure against a shortage is to grow more of it now, on our three million acres of farm woodlots in Illinois, on our undrained bottomlands and on our other idle and waste land. The whole question centers back in the right use of land, the devotion of a lot of it, which is just on the margin between profit and loss, to *timber growing.*

April 27, 1923.

LEGUMES AS A SOURCE OF NITRATE FOR FARM CROPS

H. J. Snider, University of Illinois

The maintenance of an adequate supply of available nitrogen is probably the most important practical soil problem with which the farmer of today has to deal. This problem is not limited to any particular area or to any one country, for the production of agricultural products the world over is limited by an insufficient supply of nitrogen. This is by no means a difficulty of recent origin, because there are records showing that a shortage of nitrogen caused some apprehension among the old Roman farmers.

The peculiarity of the nitrogen supply is that there is a superabundance of free nitrogen in the atmosphere which must be combined with other elements before it may be utilized for growing crops. It is said that there is in the atmosphere 5.8 tons of free nitrogen for each square yard of earth surface, and it is estimated that there is less than one ounce of combined nitrogen per square yard of earth surface in the service of man. The supply of free nitrogen is almost inexhaustible, and in comparison the supply of combined nitrogen now in use seems insignificant.

Converting free atmospheric nitrogen into combined nitrogen is a process which is of vital importance to all classes of people. There are several practical methods for manufacturing combined nitrogen, but at present these processes are not sufficiently developed to furnish economically any considerable amount of available nitrogen which might be used on a large scale as a soil fertilizer. In the production of our grain crops at the present time, it is necessary to look to some other source for a supply of combined nitrogen. The most economical and practical means of securing this nitrogen supply for farm crops at present is by the utilization of the various leguminous plants.

It has long been known that leguminous plants have the power of enriching the soil, but it was not until comparatively recent years that the process has been well understood. The old Roman farmers (Ill. Bul. 179, p. 472) knew that beans possessed the power of enriching the land, and these early farmers followed the practice of plowing under lupines as a means of adding nitrogen and enriching their cultivated lands. There are many early writings which indicate that legume plants were considered valuable for soil enrichment, but it was not until after 1886 that Hellriegel first announced the discovery that bacteria living in symbiotic relationship with leguminous plants have the power to fix free atmospheric nitrogen. From the time of Hellriegel's discovery down to the present day there has been much experimental work done looking toward the utilization of legumes as a means of furnishing a supply of combined nitrogen sufficient to meet the requirements of crops in general farm practice.

After the fact was thoroughly established that legumes do have the power to fix free atmospheric nitrogen, there have been efforts made to determine the approximate amount fixed by these plants. The amount of nitrogen fixed is influenced by different soil conditions and other factors. It is apparent that when legumes properly inoculated are grown in a soil rich in available nitrogen they will utilize the supply in the soil rather than make use of the free atmospheric nitrogen. On the other hand, if legumes properly inoculated are grown in a sandy soil or other soil low in nitrogen they will at once fix comparatively large amounts of free nitrogen in order to make proper growth.

Some experimental work conducted by the late Dr. Hopkins(Ill. Bul. 76) shows a comparison of inoculated and uninoculated alfalfa when grown on common corn belt prairie land. The results of this test show that the alfalfa when properly inoculated fixed about 40 lbs. more nitrogen per acre than did the uninoculated alfalfa. The amount of nitrogen fixed as indicated by this experiment might vary with different soil conditions; however, this test serves to show the possibilities of the utilization of free atmospheric nitrogen by legumes under field conditions.

There are many legume plants which adapt themselves to general farm practice, and some of these are particularly desirable for furnishing on a large scale a part at least of the available nitrogen needed in producing farm crops. One of the most outstanding of these legumes at the present time is sweet clover (Mellilotus Alba). There are many interesting and valuable facts regarding the influence of sweet clover as a soil enriching crop under the various soil and climatic conditions found in Illinois. In 1905 the Illinois Experiment Station began the use of sweet clover for soil improvement on the Odin Experiment Field (Marion county). The object of this experiment as stated in the field records was "to test the value of sweet clover as a leguminous green manure crop." Starting with this test the Experiment Station has made practical use of sweet clover for soil improvement purposes in many parts of the state. Sweet clover has been very successful under field conditions as a means of securing available nitrogen for the production of general farm crops.

Some very valuable facts have been brought out by the Illinois Experiment Station regarding the available nitrogen created in the soil when sweet clover is plowed under as a green manure crop. (Ill. Bul. 233.) The following table gives some results obtained on the Minonk Experiment Field (Woodford county) during the season of 1919. The land on this field is typical of the common prairie corn belt soil. In this test a spring growth of sweet clover was plowed under late in April and the land planted to corn. The figures represent pounds per acre of available nitrogen found in the surface soil at various dates on treated and untreated land.

Soil treatment	April 26	May 30	July 1	Aug. 12
Sweet clover turned under..........	38.7	76.8	67.2	143.6
No soil treatment..................	10.1	8.1	11.8	11.8

Limestone and rock phosphate had been applied to the land where the sweet clover was turned under. Limestone is usually essential to the successful growing of sweet clover on average corn belt land. The above results show that as compared with the untreated land the decomposition of the green sweet clover when plowed under does greatly increase the supply of available nitrogen. It requires about 1½ pounds of nitrogen to produce one bushel of corn, and on August 12 there was sufficient available nitrogen in the soil to produce about 95 bushels of corn. Comparing the untreated land with the treated land it may be seen that the sweet clover contained about 3½ to 12 times as much available nitrogen as when no sweet clover was turned under.

The farm lands in southern Illinois are very different in composition and productiveness from those in the central and northern parts of the state. On these lighter soils of the south part of the state clovers cannot be grown successfully without the judicious use of limestone. When limestone and sweet clover as a green manure are used on these lands the supply of available nitrogen is greatly increased.

The following table gives results obtained on the Newton Experiment Field (Jasper county) during the season of 1919. (Bul. 233.) The land on this field is typical of the light prairie soils of southern Illinois. The figures represent pounds per acre of available nitrogen in the surface soil at various dates.

Soil treatment	May 12	June 18	July 4	Aug. 19
Sweet clover turned under..........	18.6	36.8	30.6	78.2
No soil treatment..................	14.0	22.6	9.2	25.9

Limestone and rock phosphate were used in addition to the sweet clover. The decomposition of the sweet clover furnished available nitrogen far in excess of that on the untreated land. On August 19, the available nitrogen on the treated land was sufficient to produce 50 bushels of corn while on the untreated land there was enough for about 16 bushels of corn.

The data above cited show that legume crops when worked into the soil do increase greatly the supply of available nitrogen. This plan of soil management is practical and fits into the scheme of general farm practice, and there is no question regarding its economy when compared with the cost of commercial nitrogen as sold on the market today.

It has been demonstrated clearly that sweet clover as a green manure crop may add large amounts of available nitrogen to the soil; now it is well to look at actual crop yields and note the influence of this treatment. The

Experiment Station has followed the plan of locating soil experiment fields at various points in the state, and thru the operation of these fields by the University much reliable information is secured from year to year regarding the permanent improvement of Illinois soils. In the following tables some twelve experiment fields are considered upon which sweet clover has been used as a green manure crop during the past eight years. These fields are distributed widely so that they represent in general the predominating soil types of the state, and are located in regions of varying climatic conditions.

The following table gives corn yields obtained from three experiment fields located in northern Illinois and representing the Brown Silt Loam soil which is the predominating soil type of that region.

CORN YIELDS 8 YEAR AVERAGE (1915-22) BUSHELS PER ACRE.

Soil Treatment	Dixon	Mt. Morris	LaMoille	Average
Crop residues and limestone—sweet clover.	56.5	60.7	53.4	56.9
Crop residues only.....	49.1	49.1	50.0	49.4
Gain for lime — sweet clover	7.4	11.6	3.4	7.5

The average of these three fields gives an eight year average increase of 7.5 bushels of corn per acre for the use of the lime-sweet clover treatment. This is a very substantial increase on land which is maintaining an average corn yield of almost 50 bushels per acre.

The following table gives the corn yields obtained from three experiment fields located in the central part of the state and also representing the Brown Silt Loam soil which is the common corn belt prairie farm land.

CORN YIELDS 8 YEAR AVERAGE (1915-22) BUSHELS PER ACRE.

Soil treatment	Urbana	Carthage	Clayton	Average
Crop residues and limestone—sweet clover.	68.7	51.6	52.2	57.5
Crop residues only......	57.5	43.2	43.3	48.0
Gain for lime — sweet clover	11.2	8.4	8.9	9.5

The average gain for the lime-sweet clover treatment on these three fields on corn belt soil is 9.5 bushels of corn per acre. This type of soil has often been referred to as inexhaustible, and yet these experiments demonstrate that the corn yields may be increased greatly by the addition of nitrogenous organic matter and limestone.

The following table shows the corn yields obtained on three experiment fields located in southern Illinois. These fields are on a soil type known as Gray Silt Loam On Tight Clay, and this type predominates over a large area of the southern part of the state.

CORN YIELDS 8 YEAR AVERAGE (1915-22) BUSHELS PER ACRE.

Soil treatment	Ewing	Oblong	Toledo	Average
Crop residues and limestone—sweet clover.	31.7	36.8	27.7	32.0
Crop residues only......	12.9	26.6	17.3	18.9
Gain for lime — sweet clover	18.8	10.2	10.4	13.1

The average gain for the lime-sweet clover treatment on these three fields is 13.1 bushels of corn per acre. This type of soil is much less fertile than that of the corn belt, as indicated by the corn yields, but these experiments show that the productiveness of this soil may in some cases be almost doubled by the application of the soil treatment indicated.

The following table shows the corn yields obtained from three experiment fields located in the extreme part of southern Illinois. These fields are on a type of soil known as Yellow Gray Silt Loam. This land was formerly timbered, and is the predominating type over a large area of the southern part of the state.

CORN YIELDS 8 YEAR AVERAGE (1915-22) BUSHELS PER ACRE.

Soil treatment	Raleigh	Unionville	Enfield	Average
Crop residues and limestone—sweet clover.	38.8	39.2	40.8	39.6
Crop residues only......	20.8	22.6	29.7	24.4
Gain for lime — sweet clover	18.0	16.6	11.1	15.2

The average gain for the lime-sweet clover treatment on these three fields is 15.2 bushels of corn per acre. This is the largest increase on any of the types of soil mentioned, and indicates to what extent corn yields may be increased on these less fertile soils of southern Illinois.

The corn yields on the twelve experiment fields named show an increase of 11.3 bushels per acre as an average of the past eight years. It would seem from the distribution of these fields that this figure is fairly representative of what might be accomplished under average farm conditions throughout the state. As an average of the past eight years the state has grown annually approximately 9,500,000 acres of corn, and on the basis of the 11.3 bushel increase this would add over 107,350,000 bushels of corn to the total annual production of the state. This increase would amount to almost 1/3 of the present annual corn production of the state, and would add much to the agricultural wealth of Illinois for the corn crop alone. The experimental evidence obtained shows that not only is the corn yield increased by the addition of legume nitrogen, but the yields of wheat, oats, clovers and other crops have been increased materially by the lime-sweet clover treatment.

These experimental results show that our agricultural production may be increased greatly by the proper utilization of the common legume crops which may be grown successfully on every Illinois farm. This also indicates that science has made much advancement toward the solution of practical soil problems.

A SUMMARY OF THE PLANT DISEASE SITUATION IN 1922 WITH RESPECT TO THE CROPS OF ILLINOIS

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Plant diseases are factors of extreme importance in crop production. Each year crop reductions are attributed to them which, if translated into terms of dollars, would appear amazingly large. All are not equally severe every year, but vary according to climatological conditions and the abundance of infectious materials. Observations of plant disease from year to year are useful in that they tend to indicate what may be expected under specific conditions subsequently, and their publication is justified as forming a concise and permanent record for future reference.

A year ago the writer prepared a statement of the purposes of a plant disease survey of the state, conducted as a part of the activities of the State Natural History Survey Division, and included a number of observations on plant disease conditions during 1921.

This paper proposes to summarize briefly the disease situation with respect to the crops of the state for the year 1922. In securing the material upon which the summary is based a force of four men was placed in the field from about the first of June until the last day of August. Their reports and observations are substantiated by representative specimens of disease deposited in the Survey Herbarium. A considerable amount of additional material has been obtained from other sources.

WEATHER CONDITIONS

The abundance and severity of plant infection is always influenced extensively by climatological conditions. As a whole these conditions were not conducive to the development of severe infections during 1922. The year was the warmest, with the exception of 1921, in the climatological history of Illinois. The precipitation was below normal throughout the state, while during the crop growing period the precipitation was 15 per cent less than normal for that period.

The rather warm winter of 1921-22 allowed certain ot the rusts to overwinter and probably was helpful in providing an unusual amount of viable infectious material. Frequent showers with excessive precipitation during early spirng was productive of certain early fruit disease infections and of rust epidemics. On late maturing crops, and on crops not planted until the wet period had passed, these diseases were held in check by the subsequent dry and hot weather.

CEREALS

Barley: Loose smut (Ustilago nuda (Jens.) K. & S.) was about the same in severity as in the average year. Our estimates indicate 0.2 per cent of the plants of the state affected, with a crop loss probably not large enough to be estimated.

Stem rust (Puccinia graminis Pers.) was generally prevalent in small amounts, and resulted in only very slight losses.

Corn: Bacterial wilt (Pseudomonas stewarti E. F. S.) was locally important, but was not an important factor in reducing the yield of the state.

Brown spot (Physoderma zeae-maydis Shaw) was less severe than usual. Reports and specimens collected through the state indicate that it has extended its range northward to Lee county.

Rosen's disease (Pseudomonas dissolvens Rosen), hitherto noted in two counties, made its appearance in Union County. Here a field of 10 acres showed 1 per cent of the stalks diseased. The characteristic twisting at the base of the stalk was present throughout the infected area. Later examination of material from the infected field by Dr. Rosen positively identified the disease.

Rust (Puccinia sorghi Schw.) appeared later, and was less abundant in the state, than usual. Undoubtedly, the dry hot weather during the usual infection period served to minimize the infection.

Smut (Ustilago zeae (Beckm.) Ung.) was apparent in about the same amount as during average years. A reduction in yield for the entire state of 2.5 per cent is estimated.

Oats: Blast (cause unknown) appeared throughout the state, but was met with most frequently in the east-central part. A loss of 5 per cent of the crop of the entire state is estimated.

Crown rust (Puccinia coronata Cda.) appeared in rather more than its usual abundance. A mild winter, through which a large quantity of severely infected volunteer oats lived, provided an abundance of infective material for the year's crop. A loss of 4 per cent is estimated.

Smut (Ustilago avenae (Pers.) Jens.) was common everywhere and is estimated to have reduced the crop by 5 per cent.

Stem rust (Puccinia graminis, Pers.) was rare in the southern part of the state, and only slightly more frequent in the north. Nowhere was it severe. The wet spring, with its consequent late seeding, was probably instrumental in reducing the early infections, and the dry hot periods that followed prevented further serious development.

Rye: Ergot (Claviceps purpurea (Fr.) Tul.) was not abundant. We have estimated that less than 0.2 per cent of the plants of the state were infected. Damage to the crop was so slight as to be incapable of estimation.

Smut (Ustilago sp.). An undetermined species of Ustilago was found in a rye field near Mitchell in Madison County by Dr. R. D. Rands.

Leaf rust (Puccinia dispersa Eriks.) was prevalent and is estimated to have reduced the crop of the state by 2 per cent.

Stem rust (Puccinia graminis Pers.) was common everywhere, but the total infection was slight indeed, and resulted in very little crop loss.

Wheat: Bunt (Tilletia laevis Kuhn) was especially important in some northern counties. One county estimates a cash dockage at the mill or elevator of not less than $2000. The reduction in yield for the entire state is estimated at 2 per cent.

Flag smut (Urocystis tritici Koern). A special survey made during April, May and June increased the area of known infection from 75 square miles in Madison and St.

Clair counties to an area of about 500 square miles including parts of two additional counties, Jersey on the north, and Monroe on the south. A few fields located within the original infested area showed spots where the infection ran as high as 30 per cent.

Foot rot, rosette, etc. (Helminthosporium spp.) was of local occurrence and of local importance only.

Leaf rust (Puccinia triticina Eriks.) appeared southward in epidemic form. Probably every field of winter wheat in the state was infected. The most serious losses occurred in the spring wheat region in southwestern Illinois where twelve counties report an average crop reduction of 1.51 bushels per acre or a total loss of 1,233,400 bushels from an approximate acreage of 822,000. A total reduction of 10 per cent of the winter wheat crop of the state appears to be a conservative estimate.

Loose smut (Ustilago tritici (Pers.) Rostr.) appeared in its usual abundance throughout the state, but the losses sustained appear to have been much more severe northward. It is estimated that this disease is responsible for a 4 per cent reduction in the yield of the state.

Stem rust (Puccinia graminis Pers.) was prevalent throughout the state, but the infection was slight and the loss not estimable. It is noteworthy that no instance has yet been found where the presence of the common barberry has been responsible for epidemics of any considerable extent or importance.

FORAGE CROPS

Alfalfa: Leaf spot (Pseudopeziza medicaginis (Lib.) Sacc.) was of common occurrence but was not responsible for important losses except locally.

Rust (Uromyces striatus Schr.) was found in one field in Edgar county. This is the first known occurrence of this disease in Illinois.

Wilt (Fusarium sp.) made its appearance in Randolph county during April. This disease seems not to have been described in pathological literature. Young plants only appear to be attacked, the disease showing first as a wilt on the lower leaves. The crown of the plant and the stems arising from it are cankered and blackened, and covered with a pinkish cushion of mycelium which bears the spores in abundance.

Clover: Powdery mildew (Erysiphe polygoni DC.) appeared over the entire state in great abundance. Probably the mild winter allowed a considerable quantity of infectious material to live over from the epidemic of the previous fall, and certainly the spring weather was conducive to its early and general development. Although considerable apprehension was apparent among farmers lest the presence of the mildew might materially damage the crop or impair its value for feeding purposes, there was little loss to be attributed to the disease.

Rust (Uromyces trifolii (Hedw.) Lev.) was not of frequent occurrence. It was observed chiefly in the northern half of the state, and caused no appreciable loss.

Cow Pea: Leaf spot (Cercospora cruenta Sacc.) was found in the state for the first time, near Makanda in Jackson county. The increased planting of cow peas, soy beans and other leguminosaeous crops within the state furnishes an economic importance for many diseases hitherto regarded as important merely from a mycological standpoint.

Sweet Clover: Anthracnose (Colletotrichum trifolii Bain) was reported generally from the northern part of the state, but appears to have been serious only locally. No appreciable loss can be attributed to it.

Anthracnose (Gloeosporium caulivorum Kirch.) was reported from Kankakee county, but was not severe.

FRUIT CROPS

Apple: Bitter rot (Glomerella cingulata (Stonem.) S. & v. S.) was of little importance. It was found once in Saline, once in Massac, and once in Pulaski county. The earliest date of appearance reported was at Stonefort, July 22.

Black rot (Physalospora cydoniae, Arn.) was somewhat less abundant than usual. A crop reduction of 2 per cent may be attributed to it.

Blister canker (Nummularia discreta Tul.) appears to be increasing in abundance and occurs throughout the state. It is estimated to have caused damage to trees equivalent to a crop loss of 1 per cent.

Blotch (Phyllosticta solitaria E. & E.) appears commonly as far north as Champaign county. Year by year it is migrating northward. A crop reduction of at least 5 per cent is attributed to it.

Brown rot (Sclerotinia cinerea (Bon.) Schroet.) was found July 13, near Francis, in Saline county, and was found later in Jackson, Monroe and Randolph counties. It occurred only sparingly, and caused little if any reduction of the crop.

Rust (Gymnosporangium juniperi-virginianae Schw.) was less abundant than usual, and appeared chiefly on the leaves. It occurred throughout the southern half of the state. It was reported to be severe on the Mississippi bluffs in Whiteside county, and near Martinsville in Clark county. The crop reduction is estimated as 1.5 per cent. There appears to be a general correlation between the range of cedar infection in the state and the range of the rust on the apple.

Crown gall (Pseudomonas tumefaciens E. F. S.) was reported from Williamson county.

Fire blight (Bacillus amylovorus (Burr.) Trev.) occurred in every county in the state. It was more abundant than last season, but occurred chiefly as leaf and twig blight. The crop reduction is estimated to have been not more than 1 per cent.

Fly speck (Leptothyrium pomi (Mont. & Fr.) Sacc.) was generally distributed. A few instances of severe infection with consequent serious defacement of the fruit appeared in the extreme south.

Leaf spot (Septoria pyricola Desm.) was found in Jackson, Saline, Union and Pulaski counties. Two reports show 100 per cent and 40 per cent respectively of infected leaves on the trees. So far as we can determine, this appears to be the first report of the occurrence of this disease in Illinois.

Powdery mildew (Podosphaera leucotricha (E. & E.) Salm.) was not abundant and caused very little damage.

Scab (Venturia inaequalis (Cke.) Wint.) was severe locally and was present in its usual abundance throughout the entire state. It is estimated to have caused a reduction in the crop of 4 per cent.

Sooty blotch (Gloeodes pomigena (Schw.) Colby) was practically coexistent with fly speck, and caused no damage.

Apricot: Leaf blight (Pseudomonas pruni E. F. S.) was found twice in southern Illinois. One collection is from Massac county and one from Saline county. This is the first report of occurrence on this host in Illinois.

Cherry: Bacterial shot hole (Pseudomonas pruni E. F. S.) was reported from Galatia, Saline county, July 13. Subsequent reports came in from scattered localities throughout the state. The infection was slight in all cases. This is the first report of occurrence on this host in Illinois.

Brown rot (Sclerotinia cinerea (Bon.) Schroet). Two collections were made, one in Jackson and one in Edwards county. Neither was severe.

Powdery mildew (Podosphaera oxyacanthae (Fr.) deBary) was abundant over the state, and in most cases appeared to be rather severe. A crop reduction of 1.5 per cent has been attributed to it. The earliest collection was made near Whittington, in Franklin county, June 24.

Shot hole (Coccomyces hiemalis Higg.) was slightly more severe than usual. It occurred uniformly over the state and was the cause of some slight reduction in the crop.

Peach: Bacterial shot hole (Pseudomonas pruni E. F. S.) appeared in its usual abundance. There was considerable leaf injury with serious defoliation locally. It is estimated that 90 per cent of the peach trees of the state suffer from the attack of this disease annually. The probable crop reduction for 1922 is estimated at 2 per cent.

Brown rot (Sclerotinia cinerea (Bon.) Schroet.) appeared generally over the state. The moist spring weather gave opportunity for an early development of blossom and twig blight which was first reported early in April from Madison county. Extremely dry and hot weather later in the season held the fruit infection in check. The first fruit rot was reported June 26 from

Hoodville, Hamilton county. A crop reduction of 1 per cent probably occurred.

Leaf curl (Exoascus deformans (Berk.) Fckl.) was slightly more abundant than usual and occurred throughout the state. It is estimated to have had an injurious effect equivalent to a 2.5 per cent crop reduction.

Scab (Cladosporium carpophilum Thuem.) was responsible for a slight injury to the crop. Our first report came from Jefferson county where it was found June 22.

Pear: Black rot (Physalospora cydoniae Arn.) was found only in Randolph and Jackson counties. The first report came from DeSoto, August 19.

Fire blight (Bacillus amylovorus (Burr.) Trev.) was somewhat less severe than usual. A reduction of 5 per cent in the yield of the state is estimated.

Leaf blight (Fabraea maculata (Lev.) Atk.) was severe locally but did not materially affect the crop. Our first report came from near McLeansboro in Hamilton county June 26. It was reported as far north as Morrison in Whiteside county.

Leaf spot (Mycosphaerella sentina (Fr.) Schr.) was not commonly found. The first report was from Coles county, August 29.

Scab (Venturia pyrina Aderh.) was found in Jackson, Coles and Edgar counties. The earliest collection was made near Makanda, July 19.

Plum: Bacterial shot-hole (Pseudomonas pruni E. F. S.) appeared throughout the state and resulted in a slight crop reduction.

Black knot (Plowrightia morbosa (Schw.) Sacc.) appears to be common only in the eastern and southern part of the state.

Brown rot (Sclerotinia cinerea (Bon.) Schroet.) was rather less severe than usual. It probably caused a crop reduction of 5 per cent.

Leaf blight (Coccomyces prunophorae Higg.) appeared to be slightly more abundant than usual throughout the state, although no appreciable damage can be attributed to it.

Leaf curl (Exoascus mirabilis atk.) was more abundant than last year, especially southward. The continual blighting and killing of terminal buds that occur each year justify an estimate of damage done equivalent to a yearly crop reduction of at least 1 per cent.

Quince: Fire blight (Bacillus amylovorus (Burr.) Trev.) occurred occasionally on twigs and fruit but was not generally important.

Leaf blight (Fabraea maculata (Lev.) Atk.) was as common as usual and resulted generally in slight defoliation. It was collected in seven counties, the earliest collection being made July 5 at Mt. Carmel.

Powdery mildew (Podosphaera oxyacanthae (D. C.) deBary) was found in Coles and Edgar counties. The date of collection was August 29. This is the first report of the presence of this disease on this host in Illinois.

SMALL FRUITS

Blackberry: Anthracnose (Plectodiscella veneta Burk.) is the most important blackberry disease in the state. It occurs throughout the state, and is especially abundant northward. We have estimated a crop loss from this source of at least 3 per cent.

Cane blight (Leptosphaeria coniothyrium (Fckl.) Sacc.) occurs throughout the state. It is probably more severe southward.

Leaf spot (Septoria rubi West) was abundant everywhere and is believed to have been responsible for a crop reduction of at least 1 per cent.

Leaf spot (Cercospora bliti Tharp) was found twice in southern Illinois. This disease is reported to be severe in Texas. This is the first report of its presence in Illinois.

Orange rust (Gymnoconia interstitialis (Schlecht.) Lagerh.) was locally abundant and severe.

Gooseberry: Anthracnose (Pseudopeziza ribis Kleb.) caused serious defoliation locally, and occurred as a mild infection generally over the state.

Leaf spot (Septoria ribis Desm.) was common throughout the state, and was sufficiently injurious to be estimated as equivalent to a 1 per cent crop reduction.

Powdery mildew (Sphaerotheca mors-uvae (Schw.) B. & C.) was collected near Ridgway in Gallatin county July 15.

Grape: Black rot (Guignardia bidwellii (Ell.) V. & R.) appeared to be rather more severe than usual. An estimated loss of 5 per cent of the crop was not so evident, although really larger in proportion, to the grape grower on account of the unusually favorable weather conditions and a consequent excellence and abundance of crop.

Downey mildew (Plasmopara viticola (B. & C.) B. & deT.) was slightly less severe than usual and occurred throughout the state. A loss of 1 per cent is estimated. It was first reported June 9 near Lebanon in St. Clair county.

Powdery mildew (Uncinula necator (Schw.) Burr.) was probably as abundant as usual. The earliest collection was from Alexander county, August 17.

Strawberry: Leaf blight (Dendrophoma obscurans (E. & E.) Anderson) was noted to be more abundant than heretofore.

Leaf spot (Mycosphaerella fragariae (Schw.) Lind.) was very abundant and is estimated to have taken its usual 10 per cent toll of the crop of the state.

TRUCK AND GARDEN CROPS

Asparagus: Rust (Puccinia asparagi DC.) was common throughout the state. The first collection was made near Geff in Wayne county, July 1.

Anthracnose (Colletotrichum sp.) was collected August 26, near Polo in Ogle county. It was collected later in Champaign county. This is the first report of this disease in Illinois.

Bean: Anthracnose (Colletotrichum lindemuthianum (S. & M.) B. & C.) was generally distributed, but less severe than usual. The first collection was made in Jackson county, August 19.

Bacterial blight (Pseudomonas phaseoli E. F. S.) was of slight importance although of general occurrence. The first collection was made June 22 in Jefferson county.

Rust (Uromyces appendiculatus (Pers.) Lev.) was more abundant than usual, and was reported to be severe in some localities in the south. The first collection was made July 27 near Parker in Johnson county.

Beet: Leaf spot (Cercospora beticola Sacc.) occurred in almost every garden in the state. There was no apparent loss.

Cabbage: Black rot (Pseudomonas campestris (Pam.) E. F. S.) was serious in some localities and is estimated to have reduced the crop of the state by 1 per cent.

Yellows (Fusarium conglutinans Woll.) still continues to be the limiting factor in cabbage production. It is estimated to have caused a crop reduction of 5 per cent. Seed of resistant varieties is not commonly used. The chief method of control now practiced consists in a systematic change of crops on infected soil.

Cantaloupe: Bacterial wilt (Bacillus trachiephillus E. F. S.) was more serious than usual. In the Poag Station melon district in Madison county the infection was particularly bad.

Celery: Late blight (Septoria apii (Br. & Cav.) Chest.) was not common, but caused severe loss where the Skinner system of overhead irrigation was practiced.

Lettuce: Leaf spot (Septoria lactucae Pass.) was of some importance throughout the state. The earliest reported occurrence was June 30 in Wayne county.

Pea: Powdery mildew (Erysiphe communis Wallr.) was destructive on the late maturing varieties. Collections were made of this disease in five counties, the earliest of which was near Ryder in Jefferson county, June 23.

Pepper: Fruit rot (Alternaria sp.) was collected near Charleston in Coles county, August 28.

Potato: Early blight (Alternaria solani (E. & M.) J. & G.) was general and is estimated to have damaged the plants to an extent equivalent to a crop reduction of 1 per cent.

Rhizoctonia disease (Corticium vagum Burt.) was found once only. It was collected June 23 near Ryder in Jefferson county.

Scab (Actinomyces scabies (Thax.) Gussow) was common over the state.

Radish: Downey mildew (Peronospora parasitica (Pers.) deBary.) was collected once.

White rust (Albugo candida (Pers.) Rous.) occurred occasionally. The first collection was made July 10 near Carmi in White county.

Rhubarb: Crown and stalk rot (Phytopthora sp.) was still severe in Union county.

Leaf spot (Phyllocticta sp. and Cercospora (?) sp.) were common in all localities but caused little if any loss.

Sweet Potato: White rust (Albugo ipomoeae-panduranae (Schw.) Sw.) was generally distributed but less abundant than usual. The first collection was made July 31 in Hardin county.

Tomato: Blossom end rot (physiological) occurred throughout the state and is estimated to have reduced the crop by 1 per cent.

Early blight (Macrosporium sp.) was generally distributed over the state and was usually severe. It is estimated to have resulted in a crop reduction of 4 per cent.

Leaf spot (Septoria lycopersici Speg.) was prevalent, but reduced the crop less than 1 per cent.

Wilt (Fusarium lycopersici Sacc.) was abundant and severe generally. It is the most serious disease the commercial grower has to contend with. The crop reduction is estimated at 10 per cent.

Watermelon: Wilt (Fusarium vasinfectum Atk.) was unusually serious. Its distribution was general. Many fields were totally destroyed. The disease is estimated to have caused a crop reduction of not less than 25 per cent for the entire state.

ORNAMENTAL AND MISCELLANEOUS PLANTS

Carnation: Rust (Uromyces caryophillinus (Schw.) Wint.) was generally distributed. The first collection was made at Belleville, June 10.

Evonymus: Powdery mildew (Microsphaera alni (Wallr.) Salm.) was common late in the season, but did not greatly injure the appearance of the shrub.

Impatiens: Rust (Puccinia impatientis Arth.) was found in White, Hamilton, Edwards and Jefferson counties. The first collection was made at Texico, June 21.

Lilac: Powdery mildew (Microsphaera alni (Wallr.) Salm.) resulted in some defoliation. The earliest collection was made June 24 at Whittington.

Rose: Leaf spot (Diplocarpon rosae Wolf.) was common throughout the state on cultivated plants.

Powdery mildew (Sphaerotheca pannosa (Wallr.) Lev.) was present over the southern half of the state on cultivated roses in epidemic form. Considerable defoliation resulted later in the season when the hot, dry weather appeared.

Symphoricarpos: Powdery mildew (Microsphaera alni (Wallr.) Salm.) was abundant everywhere. The earliest collection was made July 3, in Edwards county.

Virginia Creeper: Leaf spot (Guignardia bidwellii (Ell.) V. & R.) was abundant throughout the state.

Zinnia: Powdery mildew (Erysiphe cichoracearum, DC.) was collected August 31 at Chrisman. This is the first report of this fungus on this host for Illinois.

SUMMARY

The outstanding features of the year appear to have had a direct connection with climatological conditions. The greater number of diseases were either about the same as in an average year or caused less than the usual crop reduction. Noteworthy conditions included the early appearance of brown rot as a blossom and twig blight on peaches, the widespread epidemic of powdery mildew on clover and cultivated roses, the serious losses occasioned by leaf rust in the winter wheat area, the abundance of crown rust on oats, and the unusual and destructive outbreak of the wilt diseases of cantaloupe and watermelon.

ORIGIN OF PRAIRIES IN ILLINOIS

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The work of other investigators has shown features common to all prairies regardless of where they are found. The dominant prairie species are xerophytic grasses. The evaporation rate is much higher in prairies than in the adjoining forests while the soil moisture content is much lower, often falling below the wilting point of plants during the summer. This evidently explains the xerophytism of the prairie vegetation, for these grasses can become dormant and remain alive during these unfavorable conditions which would destroy tree seedlings. After a prairie grass sod is formed, it tends to exclude tree seedlings. Trees can, however, invade prairies along the slopes of streams, gullies and morainal ridges where erosion has removed the sod and the irregular topography checks the wind velocity and thus reduces its dessicating action. A much slower invasion takes place along forest borders where the trees check the wind velocity and the shade destroys the prairie grasses.

As the Illinois prairies are in a region that was covered by glacial ice they must be post-glacial in origin. During the ice age there were several advances of the ice sheet separated by long interglacial periods, except for the period between the Early and Late Wisconsin glaciations, which was short. The Kansan ice sheet invaded northeast Kansas and extended into Missouri as far south as the Missouri river. The Illinoisan ice sheet invaded Illinois as far as the Ozark Hills in the southern part of the state. Just east of the Illinois-Indiana line, the border of this ice sheet bends to th northeast, continuing to central Indiana, then turns south to the Ohio river, then east to south central Ohio, and then north to central Ohio where it is buried by drift of the Wisconsin ice sheets. The Iowan ice covered northeast Iowa and possibly a small area in northwest Illinois. The Early Wisconsin glacier only entered the east side of Illinois, extending to Shelbyville and Mattoon, but covered most of the Illinoisan drift in eastern Indiana and in Ohio. A lobe of the Late Wisconsin entered western Iowa, extending south to Des Moines. Another lobe entered northeastern Illinois but did not extend as far to the west or south as the Early Wisconsin. In eastern Indiana and western Ohio, however, it covered nearly all of the Early Wisconsin drift while it overrode all earlier drift in northeastern Ohio. South of the glacial drift the country is badly dissected all the way from eastern Ohio to Missouri. In the Plains Region, however, the relief is moderate. The Late Wisconsin drift has many strong morainal ridges and depressions while the Early Wisconsin, although it has some strong moraines, is nearly level over large areas in east central Illinois. All the earlier glaciations left a comparatively plain surface, a large part of which has not been dissected up to the present time. Before the advance of the Late Wisconsin glacier, the Mississippi, the Illinois, and the Rock rivers had cut large valleys and had dissected the adjoining country to some extent. During the retreat of the last ice sheet, Lake Chicago was formed at the south end of Lake Michigan basin and Lake Maumee at the west end of the Erie basin. Both of these lakes found outlets to the southwest, the former emptying into the Illinois river and the latter through the Wabash valley into the Ohio river.

During the advance of each ice sheet, the timberline was depressed and the forest trees pushed farther and farther to the south. In hilly country the conifers probably occupied the hilltops and exposed slopes while the hardwoods were distributed along the protected slopes and in the valleys. Between the timberline and the ice front there was a tundra, whose width depended on the topography. At the time of the maximum advance of the last ice sheet the ice front was against rough hilly country in eastern Ohio, and the area of tundra in this place must have been small just as it is in mountainous Greenland today. In western Ohio and Indiana the tundra probably was wider but still rather narrow. Farther west, where the earlier glaciations left a comparatively flat surface, the tundra must have been very wide as it is in the flat country of north Siberia today. It seems probable that the tundra covered all the region between the ice front and the Ozark Hills in Illinois and the dissected bluffs of the Missouri river in Missouri. In the Plains Region the tundra probably was bordered by prairie. The dessicating action of the strong winds would not permit the growth of trees except along protected stream slopes and possibly in some depressions.

Each glacial advance probably represents a long period of years during which the annual snowfall was greater than the annual loss of ice by melting. On the other hand the glacial retreats probably represent periods during which the snowfall was less than the loss by melting. The changes, then, which accompanied both advance and retreat must have been gradual. As the ice retreated it left a bare area composed of ground up rock fragments. This bare area was invaded by the mosses and lichens of the tundra because they can grow on such a substratum and can endure the severe climatic conditions found immediately below the glacial ice. As the ice retreated farther and farther to the north, other plants invaded the tundra. The dessicating action of the wind prevented tree development in exposed situations, so the trees invaded the protected slopes along streams and morainal ridges while grasses occupied the intervening areas. Swamps grasses and sedges undoubtedly were pioneers but, as the higher ground dried out, it probably was occupied by xerophytic grasses and the pioneers were restricted to the depressions which remained wet throughout the summers. In the Plains Region xerophytic grasses invaded the tundra and then moved east as far as Ohio, occupying all the high ground except the protected places where trees were able to grow.

Two kinds of tree vegetation invaded the tundra; the bottomland vegetation along the flood plains of the larger streams and the upland vegetation along morainal slopes and stream bluffs. In the former the pioneers are the willows followed by the river maple, cottonwood, ash, the elms, linden, the walnut and butternut, and the pignut. The pioneers of the latter are pines or xerophytic shrubs, followed by oaks, then maples, and, in some places, the beech. Pines have undoubtedly advanced along some of the stream bluffs and some remain as relics along the Illinois and Rock rivers. It is probable also that they advanced along the steeper morainal ridges, especially those that are sandy or stony. Pines still remain on some of the sandy moraines in Ontario.

As streams and gullies cut back into the prairie, their slopes are invaded by shrubs and trees. Where the stream bluffs are low and but little dissected the timber belt is narrow but, where there is much erosion, the timber belt is correspondingly wider. Where streams cut through moraines, the forests have spread out along the morainal slopes. This is noticed along the Kaskaskia at Shelbyville and along the Embarrass at Charleston. The shores of small lakes probably have been invaded by bottomland forests from nearby streams. These forests gradually move inward as the lakes fill up or become drained. Some depressions develop into bogs which may be invaded by forests. Along the borders of forests, the prairie grasses are killed out by the shade and the wind velocity is checked so that tree seedlings are able to grow. In this way the forests enlarge at the expense of the prairie.

As already mentioned, most of Illinois is a region with low relief which probably was occupied by a tundra at the time of the Late Wisconsin glaciation. This region became a prairie at the close of the ice age and much of it still remains prairie because post-glacial time has been too short for the invasion of such large relatively flat areas by forests. The Late Wisconsin drift has more relief and can be invaded more rapidly by forests. Forests advancing up the Mississippi, the Rock, the Illinois, and the Wabash rivers invaded the Late Wisconsin drift and spread rapidly over its surface. Farther east the tundra belt was narrow and easily crossed by the forests so that invasion was rapid. These differences in topography and consequent differences in rate of forest invasion explain why Illinois still has large areas while the states to the north and east are almost completely timbered. It also explains why forests are found on the moraines in northern Illinois but only along the streams in southern Illinois.

The idea of Lesquereux "that all the prairies of the Mississippi Valley have been formed by the slow recess of sheets of water of various extent, first transformed into swamps and by and by drained and dried" is no longer tenable. It is true that glacial Lake Chicago and glacial Lake Maumee, as well as many smaller lakes, became swamps and later either prairies or forests, but there is no evidence that all of Illinois and the neighboring states, or even a large part of them, were ever covered by water since the ice age. The "prairie fire" theory has still less in its favor. Prairie fires may check the advance of the forests but it is not likely that forests destroyed by fire are ever replaced by prairies. Such areas usually are invaded by weeds followed by briers, then scrub, then forest.

Prairies are treeless because conditions, at the time of their origin, favored the invasion of a grass vegetation rather than a tree vegetation. The prairies of Illinois arose from a tundra which bordered the ice sheet and invaded the drift as the ice retreated. This tundra was invaded by prairie grasses except along streams and morainal ridges where the uneven topography checked the wind velocity and reduced evaporation so that tree seedlings could grow. Forests have been steadily invading the prairies since the ice age but the rate of advance is so slow on the relatively flat surface of Illinois that large areas still remain as prairies. In the states to the north and east invasion has been more rapid because of rougher topography and most of these states have been forested.

PAPERS ON CHEMISTRY AND PHYSICS

THE PROBLEM OF COLD LIGHT

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The exact nature of light is not understood, but our present conception of it is something of a compromise between the wave theory and the earlier corpuscular theory. From a consideration of the recent discoveries of Planck, Thompson and Einstein it is concluded that light consists of discrete particles or atoms of energy, each with a specific energy content $E=h\nu$, moving with velocity c, and having a mass e/c^2. (h is Planck's constant $=6.55\times10^{-27}$ ergs per sec. ;ν is the frequency of vibration.)

Light energy is emitted by matter when in an excited state. This excitation may be induced by various means, the most general being by increasing the temperature of the system. A black body is non-luminous up to 500° C. due to the limit of sensitivity of the human eye. If the eye were sensitive to longer wave lengths of the infra-red, lamp-black would appear highly luminescent among other bodies at the same temperature. All substances whose temperature is above absolute zero emit simple thermal radiation. The higher the temperature the more rapid the vibration of the atoms and electrons and therefore the shorter the wave length. At sufficiently high temperature the wave length of the emitted radiation corresponds to the range of the visible spectrum.

The total radiation of a body increases directly at the fourth power of the absolute temperature; as stated by Stefan's law $R=kT^4$. As the temperature rises the maximum-power radiation recedes to shorter wave lengths. The expression of this relation, known as Wien's law, is

$\lambda_c=kT^{-1}$ or $\lambda T=k$.

A body which is emitting light by purely thermal radiation, in agreement with the two laws just mentioned, is said to be *incandescent*. A body which is emitting a greater total radiation than can be accounted for by its temperature alone is said to be *luminescent*. It is light produced in this way, unaccompanied by the theoretical amount of heat, that is referred to as *cold light*. For example, the flame of carbon disulfide has a temperature of only 150° C. but it is luminiscent and can affect a photographic plate. Pure temperature radiation at 150° would be far in the infra-red and entirely devoid of any photochemical action.

Artificial illumination at present depends entirely upon the emission of light from incandescent solids or gases. Because of the high temperature required to maintain this condition, by far the greater proportion of the energy supplied is converted into heat and wasted rather than emitted as light. Heat, light and electricity are all forms of radiant energy; the essential distinction is a difference in wave length. The visible spectrum, comprised between the extreme violet and the extreme red, is but a small portion of the complete spectrum. *Chart I* shows the relation of the various forms of energy radiation and the distribution of the energy from several sources of radiation.

CHART I

Note that all wave lengths in the visible spectrum are not equally visible. There is a maximum of visibility nearly corresponding with the maximum of the sun's radiation. The visibility curve is indicated in the small rectangle.

The sun emits a practically continuous spectrum corresponding to that from a black body at a temperature of 6,000° K- which is therefore taken as the temperature of the sun. Its maximum-power radiation is at a wave length of 5,600 Å* which is in the yellow-green of the visible spectrum. About 25 per cent of the radiation of the sun is in the ultra-violet, although only about 3 per cent of it reaches us, the very short wave lengths being absorbed or dispersed by the atmosphere. Practically all the rays of wave length shorter than 3,000 Å are eliminated in this way.

The radiant energy of the fire-fly is entirely within the visible spectrum. This is an example of an ideal cold light. It has been impossible to detect the evolution of any heat from this source.

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* Å=Ångstrom unit=10^{-8} cm.

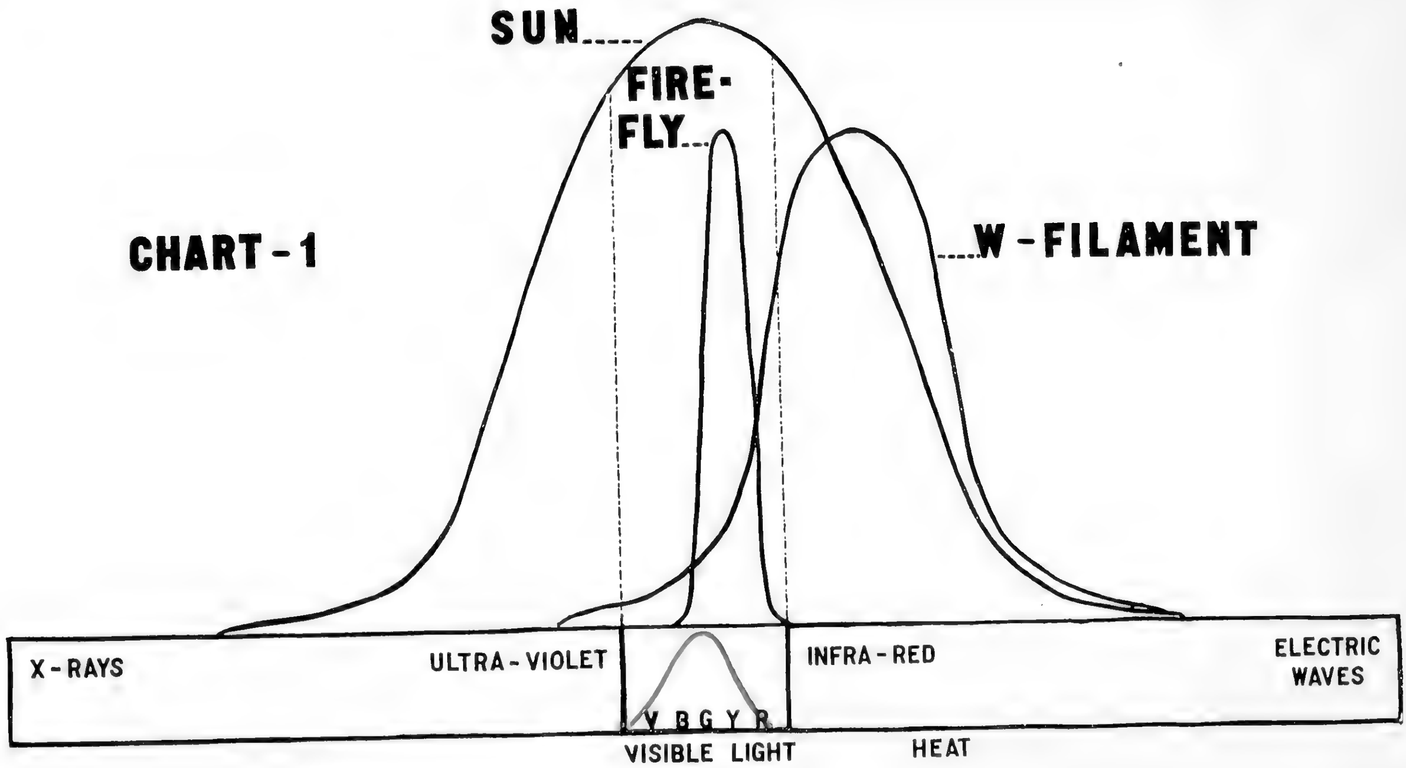
CHART - 1
SUN
FIRE-
FLY
W - FILAMENT
X - RAYS
ULTRA - VIOLET
V B G Y R
VISIBLE LIGHT
INFRA - RED
HEAT
ELECTRIC
WAVES

If the radiations of an ordinary carbon or tungsten filament could be converted into shorter wave lengths, it would produce a light as efficient as the fire-fly and of a more desirable quality. Electrical transformers are used to step-up voltage; if there were a radiant energy transformer to step-up vibration frequency, the infra-red rays could be converted into visible light. The curves illustrate the immense waste in producing light by present methods.

It is clear that for economic reasons research should be directed toward finding a more efficient means of producing light—that is, to reduce the amount of heat that is generated when a body is caused to become luminous, or to devise some method of producing light other than by purely thermal emission.

Electricity is by far the most convenient, safe, and satisfactory means of producing light yet devised; and it seems likely that the solution of the problem of efficient lighting, at least for a long time, will consist in some application of the electric current. A comparison of the relative efficiencies (or inefficiencies) of various means of illumination shows that, although electrical means are better than others, they are still extremely wasteful.

In measuring *quantity* of light, as in the case of electricity, there is an intensity factor and a capacity factor to consider, besides several other factors which determine the *quality* of the light. The unit of light intensity is the *candle-power*, the unit of quantity or flow of light is the *lumen*. In proper illumination a balance between the two must be attained. Efficiency calculations based upon the two factors separately and upon data from different sources agree only roughly, but all values point to the same conclusion—that our best sources are very poor when compared with ideal conversion of energy into light.

Coblentz[1] has determined the mechanical equivalent of light and has shown that the theoretical conversion of power into light of maximum visibility (yellow-green light) is 617 lumens per watt. The conversion of solar radiation is only 86.5 lumens per watt, so the sun, considered as a light producing source, is only 14 per cent efficient—though in this case we are grateful for the heat also. *Chart II* shows the efficiency of various light sources calculated on the basis of power consumption for light produced. A candle power of brightness should give a flux of 4π or 12.56 lumens but in practice a lower value is usually obtained.

CHART II

Tungsten at its melting point, 3670°K, would emit 57 lumens per watt (an efficiency of 9.24 per cent) but its rate of evaporation is considerable even below this temperature. Progress with incandescent filaments depends upon finding a material with a lower rate of evaporation and a higher melting point. Thus carbon, which has been displaced by tungsten as a filament material, may come back into use, since it has a much higher melting point, if certain of its disadvantages can be overcome.

Another possibility is to find a suitable gaseous envelope which will reduce the loss of material due to evaporation. Or it may be possible to control the emissive properties of matter to procure proper selective radiation. It has been pointed out that the maximum possible efficiency of selectively radiating rare-earth oxides in an ordinary Bunsen flame is thirteen times that of the incandescent mantle. It is known that most of the white refractory oxides, such as lime and magnesia, as well as the oxides of the rare earths are thermo-luminescent. That is, when heated they emit a greater amount of visible light than can be accounted for by their temperature

The luminosity of electrical discharge in gases must be considered. Incandescent solids emit continuous spectra while incandescent gases give selective emission. If this radiation happens to be in a part of the visible spectrum that is desirable as illumination, the luminous efficiency may be very high. Lamps are being operated on this princple in England at a consumption of 0.5 watt per candle power. Their development has just begun, and since a very high intensity has not been attained they are being used mainly as glow lamps and for advertising display. The Germans claim to have developed this method of light production to a still higher efficiency.

We are familiar with the use of the same principle in the spark-plug tester containing neon gas.

So far only luminescence produced by thermal or electrical means has been considered. Some other light-producing phenomena will now be indicated.

When light strikes a body it may be in part transmitted, reflected or absorbed. That which is absorbed may be re-radiated in longer wave lengths. This is called *fluorescence.* The light energy may actually be stored and emitted later—which is called *phosphorescence.* The only distinction between these two phenomena is that phosphorescence may continue after the incident beam is cut off while fluorescence does not. In some cases the incident beam is of longer wave length than the emitted beam. Here the vibration seems to have been stepped-up to a higher frequency. This phenomenon is known as *calorescence.*

Phosphorescence and fluorescence in substances is thought to be due to minute traces of impurities. Perfectly pure substances are incapable of phosphorescence. A certain proportion of the impurity gives a maximum effect. Thus phosphorescence is governed by the following conditions:

1. The amount of the impurity present.
2. The nature of the impurity.
3. The temperature of the substance.
4. The intensity and duraton of the light stimulus.

Ultra-violet light is more active in producing phosphorescence and fluorescence than is ordinary light. Ultra-violet light can thus be converted into visible light. The mercury arc and the magnetic arc give a light rich in ultra-violet. Quartz is used rather than glass for the mercury arc because its high melting point (1700° C.) allows a higher temperature for the arc and hence a better efficiency, and also because quartz allows a thousand times as much ultra violet light to filter through as does glass. All radiations of wave length less than 3300 Å are absorbed by glass. Quartz is permeable to light of wave length above 1850 Å.

The production of light in chemical reactions, or *chemiluminescence,* is fairly common. The crystallization or precipitation of certain salts may be accompanied by luminescence. Slow oxidation of organic matter, such as rotten wood, decayed fish and meat, and the oxidation of phosphorus are luminescent. The glow of phosphorus is often erroneously referred to as phosphorescence, but it has been found to be due to the second stage in the oxidation of phosphorus—that of P_2O_3 to P_2O_5. The *bioluminescence* of bacteria, the fire-fly and the glow-worm, is likewise produced by oxidation. The production of light by the fire-fly has been studied thoroughly by Prof. Harvey of Princeton[2]. He has been able to extract two substances from the fire-fly, luciferin, an oxidizable material, and luciferase, an enzyme which is a catalyst for its oxidation. When these substances are mixed in contact with air or an oxidizing agent, light is produced. Prof. Harvey points out that the heat of the reaction is extremely small and the product of the oxidation is oxyluciferin and not carbon dioxide and water. Hence the reversal of the reaction and regeneration of the luciferin should be easy.

The light of the fire-fly is of interest principally because it proves that an ideal cold light is not an impossibility. In this paper it has been endeavored to emphasize the extreme inefficiency of present methods of light production. A careful study of the natural phenomena outlined above may suggest means of improving luminous efficiency. If we follow the advice of Louis Agassiz and "study Nature, not books," some success in this direction will no doubt be attained.

CHART 2—LUMINOUS EFFICIENCY.

Source	C-P/W	L/W	Per Cent
Perfect	49.1	617	100
Sun	6.9	86.5	14
Mercury Arc	3.12	39	6.35
Flaming C Arc	2.08	26	4.24
W. in Argon (3,000° K)	1.66	20	3.4
W. in Vacuum	.8	9	1.45
Nernst Rare Earth Glower	.41	5	.8
C. Filament	.28	2.7	.57
Inc. Mantle (C_2H_2)	.2	2.5	.4

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STANDARDIZED TESTS

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Tests or examinations of some sort are a recognized part of the instruction in every serious course of study. If it is a standard course,—one in which the same topics, essentially, are given to large numbers of classes, the tests in the different classes will necessarily be somewhat alike. If a test covers materials commonly given in all schools, and if we *know,* not merely guess, what the average student should do on such a test,—better still, if we know what the best ten percent will do, the next best ten percent, and so on, we shall have a Standardized Test.

The preparation of a Standardized Test involves much more work than is given commonly to a set of ordinary examination questions. The subject matter of the test should cover not only what has just been studied but what we may reasonably except will be studied next year and every year in all schools. This will make a long examination, you may say. It is true, but not a long one for the pupil to answer, or for the teacher to score, as I shall show. Moreover, the Standardized Test parts company with the idea that any pupil shall answer all the questions. If the test is to be used in many different schools, in order to give every one a chance, it should contain from twenty-five to fifty questions, correct answers for sixty percent of which may, perhaps, be regarded as a high score.

Such a test as this is scored easily if the answers are very short. There are several types of questions admitting of such answers, and they need not be of the "yes or no" type either. First may be placed numerical problems, and the pupil should have been trained to indicate the process by which the answer was obtained; not the literal formula, but one containing all the numerical data, with the operations indicated. Perhaps the pupil is called upon to indicate, by underscoring, which of several answers given is the correct one. Perhaps certain statements are given, to be checked as true, false or uncertain. I think the "true-false" test, and especially the usually recommended method of summing up the scores (i. e. rights minus wrongs) is about discredited. Not only may guessing play too large a part in the student's performance, but the subtraction of the number of "wrongs" from "rights" may leave him with a minus score. Moreover, it can be proved that the subtraction of all or any part of the wrong answers from the number of right ones leaves the examinee with exactly the same relative rank in the class as when the usual method is followed,—counting up the correct answers only. But if a third type of statement be added, the truth or falsity of which it is impossible to determine from the data given, and if, moreover, both false and uncertain statements are so worded as to have a considerable air of plausibility, the possibility of getting a high score by guessing is probably no greater in this than in any other test. Still another type of easily scored question is that in which the one word which gives the correct meaning to a sentence is omitted. Considerable skill is needed here, if the missing word is not to be too obvious on the one hand, or the meaning of the sentence, on the other hand, too obscure even to those well acquainted with the subject. It is obvious that the wording of questions must be such that teachers cannot disagree on the scoring of any question.

The arrangement of the questions will depend upon two points of view; whether we wish to test the student's quickness to recall and use facts which should be thoroly known; or to determine his grasp of the subject,—his power. If the former, we will make the questions in any set uniformly difficult, and impose a sharp time limit, so that only the quickest will be able to finish; if the second, we will let the questions in each set increase sharply in difficulty, so that only those who have the greatest mental power will be able to answer all. Plenty of time should be allowed on this test, and in order that those who get through first shall not disturb the others, additional questions should be provided, the scores of which, however, should not be recorded with the others. At Crane Technical High School and Junior College, we have now in preparation physics tests in sets of twenty-five questions, with as many alternative sets as possible, of which the high school pupils are expected to answer the first twenty, and the college students the whole number. Not infrequently the self complacency of some careless collegian has received a severe jolt, when we have shown him that his score on a certain test is less than that of the average high school boy.

We are now ready to give the test for the first time. It is evident that the usual precautions to prevent copying and communication are more necessary when the answers are as short as in this sort of a test. There should be a printed or mimeographed sheet of the questions for each student. Distribute them face downward, not to be looked at until the signal to begin is given. I have not been able to discover that it makes any difference whether the answers are written on the same or another sheet of paper. If the questions are supposed to be of about equal difficulty, note the time of starting, and stop when the first few have finished. This gives an idea of the standard time to be fixed for the test.

Before scoring, prepare a key on a slip of stiff cardboard, with answers so placed that they correspond in position with the answers on the students' papers. If the test is answered by underlining words, or filling in blanks, the key may be made on a sheet of celluloid or transparent paper, or a cardboard with holes at the proper places to show the correct answers. With such devices as these, the drudgery of scoring the papers is reduced to a minimum, and it is very evident that more questions per tests, and more tests per year, can be handled without adding to the already heavy burden of the conscientious teacher. Add to this the moral satisfaction of knowing that you have eliminated from your grade book the influence of the famous "sweet smile and winning way", and you will be willing to take the extra trouble necessary in preparing the tests.

Although in assigning values to correct answers it is very easy to say that students should be marked as right or wrong only, in practice it is often very difficult to do. Suppose a pupil has worked a problem by the right method, but because of a mistake in arithmetic, or a mistake in copying, he puts down the wrong answer. Should he not get some credit for it? Many questions, again, can not be answered properly by the use of several words. Suppose the full answer is "Simple harmonic motion" and the student writes "Harmonic motion." It is neither completely right nor completely wrong. It has therefore been my custom to give *two* for correct answers, *one* those partly right. Elaborate methods have been worked out for giving weighted scores, the values of which are proportional to the percentage of pupils failing on each question. It is doubtful if such a scheme is worth the trouble it takes. Better recast the whole test if there is any great difference in the difficulty of the questions.

Having scored the papers, we must next study them for certain necessary information. To find whether the test is too hard or too easy, we plot a curve, using the scores as abscissas, and the number of pupils making each score as ordinates. An approximation to the normal probability curve shows that we have a test reasonably suited to the capacity of our class; if it is skewed to the right, it is too easy; if to the left, it is too hard.

We may next study the relative difficulty of the questions by recording the number of times each question has been missed. If any question has been missed by no one, it is too easy and should be dropped. On the contrary, if any question is missed by all, it is too hard; the form is ambiguous, or the content is too difficult for their comprehension, or the subject has not been taught properly. It should be dropped or reshaped. If the number of correct answers to each question runs ninety-five to five per cent, we may conclude that we have a good set.

The next step is to revise the questions, eliminating some, inserting others, restating some, and putting the harder questions toward the end. Another trial on the same or a similar class should be much more satisfactory; that is, it should give a nearly normal distribution in which the failures should be much more numerous in the latter part of the test than in the first part.

We are now ready to compare the grades on this particular set of questions with a criterion. About the only one we have is the teacher's judgment, as derived from his knowledge of their laboratory work, their written reports, their daily recitations and the average of all their previous tests to date. If in general the best students have made the best scores and vice-versa,—in other words if there is a high correlation, say 0.6 or more, between the class grades and the results of this test, we may conclude that we have a satisfactory test. Standardization may then proceed as fast as we can give the test to other classes in the same or other schools, accumulate and classify the scores, and establish norms.

What about the student's reaction to this type of tests? Uniformly satisfactory. They do not dread them; they are even eager for them. It is amusing to see them "get set" and "go" after a few experiences, and settle down to a good natured race to get every word possible written in the ten or fifteen minutes before "time" is called. They feel that the larger number of questions gives them a better chance of telling what they know, and there is never any chance for a difference of opinion as to what a certain answer is worth.

Finally, no claim is made that all the testing of a year's work can be done with this kind of tests. Even for the measurable results of our work, an occasional one or two hour test of the old type is desirable. And no scheme of "testing", no matter how perfected, should blind our eyes to the most important objectives of our work:—the appreciation and love of science, the habit of mental honesty, and of deferring judgment until all available evidence is weighed carefully; in a word, that attitude of mind that will make of the raw material that comes to us good citizens and reverent, obedient inhabitants of a Universe that is governed by Law. These are things that can not be measured by an examination nor expressed by grades in a class-book.

PHOTOELECTRIC EFFECT OF CAESIUM VAPOR AND A NEW DETERMINATION OF h, THE UNIVERSAL CONSTANT OF PLANCK

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The ionization potential V_1 is related to the convergence frequency n_1 of the principal series in the spectrum of the gas by the expression

$$V_1e=hn_1$$

where h is Planck's universal constant and e the charge of the electron.

In view of the results in the X-ray region, we may expect an interchangeability in the effect of electron collision and radiation, i. e., we may expect a gas to be ionized whether it is struck by an electron moving with the critical velocity corresponding to V_1 or illuminated by radiation of the corresponding wave length.

To test this, caesium vapor was illuminated by ultraviolet light. The result was that for light below a certain wave length, about 318$\mu\mu$, ionization was produced whereas above this value no effect could be detected. Substituting in the above equation the frequency corresponding to the wave length 318$\mu\mu$ and the known values of V_1 and e we obtain for h the value of $6.58.10^{-27}$ ergs while the accepted value determined by other methods is $6.55.10^{-27}$ergs.

A COMPARATIVE STUDY OF SOIL ACIDITY METHODS ON ILLINOIS SOILS

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INTRODUCTION

Much effort has been spent by agricultural investigators in determining the so-called lime-requirement or acidity of soils. That much of this effort is justified will be conceded, when it is recognized that the major portion of all agricultural land in the humid regions of the United States is "acid," and that on such lands the correction of this condition is fundamental to the establishment and maintenance of crop production at a reasonably high level.

Under humid weathering conditions the decomposition of soil minerals is accompanied by the liberation of basic elements in the form of soluble compounds, largely through the action of water and carbonic acid. The soluble bases are removed, partly in the ground-water and, in tilled soils, in the crops harvested from the land. The continual removal of basic elements at a more rapid rate than that at which the acidic elements are removed produces several conditions in the soil, which taken together, make it an unfavorable substrate for the growth of many of the most important farm crops. In soils which have developed a very high degree of acidity, practically all plants refuse to grow. Some of the more important factors of soil acidity may be enumerated as follows:

(a) The presence of hydrogen-ions, indicating true acidity in the chemical sense.

(b) Insoluble acids and acid salts.

(c) Colloids, both organic and inorganic, most of which absorb basic ions, rather than acid.

(d) Aluminum compounds which are either soluble or in a combination sufficiently "active" as to be rendered soluble by reaction with neutral salts, or to affect unfavorably the growth of plants.

Each of these factors taken separately may not be necessarily toxic to growing plants; indeed corn, wheat, rye and many other crops grow best in a soil containing a low concentration of hydrogen-ions. However, since these and other factors contribute in varying degrees to the results obtained by the application of various acidity methods to soils, these various methods can not be expected to give concordant results.

It is the purpose of this paper to record the results obtained in a comparative study of five different soil acidity methods, as applied to a number of Illinois soils which vary rather widely in type and in lime-requirement.

THE METHODS

Three of the methods used, those of Hopkins, Veitch and Jones, are recognized as *quantitative*. The Comber and Truog methods, which were designed primarily as *qualitative* tests for field use, furnish also a rough index of the degree of acidity.

The Hopkins method consists essentially in shaking 100 grams of soil continuously for three hours with 250 cc. of normal potassium nitrate solution. After settling has taken place, 125 cc. of the solution are decanted and titrated with standard alkali, after boiling to remove carbon dioxide. From the titration value and a factor proposed by Hopkins, the lime-requirement is computed in terms of calcium carbonate equivalent.

In the Veitch method, separate 10 gram samples of soil are treated with increasing amounts of standard calcium hydroxide solution and evaporated slowly to dryness. Then, after a short digestion on the steam bath with distilled water, a portion is filtered off and boiled down nearly to dryness and tested with phenolphthalein. From the amount of $Ca(OH)_2$ used in the sample which is neutralized, is computed the lime requirement.

The Jones method consists in grinding a small sample of soil, dry, in a mortar with a weighed quantity of calcium acetate. When thorough mixture is effected, distilled water is added, the whole stirred for one minute, filtered and titrated with standard alkali solution.

It will be noted that the Hopkins and Jones methods depend upon reaction with a neutral salt for liberation of acid-reacting compounds from the soil, while the Veitch method measures the absorption capacity of the soil for a free base.

In the Comber test, advantage is taken of the fact that iron and aluminum occur in acid soils in a combination that can be broken up by reaction with a salt, as KCNS, and it is essentially a test for ferric iron in such form. To 2 or 3 grams of soil in a test tube is added an excess of 4 per cent KCNS in 95 per cent alcohol. After shaking thoroly and allowing to settle, the supernatant liquid becomes red within 15 minutes if the soil is acid. The red color is due to the formation of ferric thio-cyanate.

The Truog test, like those of Jones and Hopkins, relies upon reaction with a neutral salt to liberate acid-reacting substances. The soil is mixed with zinc sulfide and barium chloride. Distilled water is then added and the mixture boiled. A strip of filter paper, saturated with lead acetate, is held over the flask and is blackened by the formation of PbS from the H_2S liberated from the flask. The intensity of blackening is presumably proportional to the acidity of the soil.

EXPERIMENTAL

Fifty-seven samples of surface soil (0″—6⅔″) were selected from the stock samples collected in various parts of the state, representing twenty-six soil types. These were selected to represent a wide range of lime-requirement as previously determined by the Hopkins method. For the presentation of data, these soils were classified into five groups, each group containing soils similar in physical and textural characteristics. These groups are as follows:

I. Sandy soils (8 types.)

II. Light colored silt loams (5 types).

III. Dark colored silt loams (4 types).

IV. Clay loams and clays (5 types).

V. Black soils, high in organic matter (4 types).

The results of the tests by each of the five methods are presented in Tables I to V inclusive, each value representing the average of closely agreeing duplicate determinations. The content of total organic carbon and of calcium are included also in the tables. For the sake of convenience in studying the relative values obtained, the soil numbers are arranged in order of increasing values as determined by the Hopkins method.

The results are graphically expressed in Figs. 1 to 5, inclusive.

TABLE I.

SANDY SOILS.

Lab. No.	Soil Type	Total Org. C. lbs. per 2,000,000	Total Ca lbs. per 2,000,000	$CaCO_3$ requirement lbs. per 2,000,000			Comber Number	Truog Number × 1.3
				Hopkins	Veitch	Jones		
36	Dune sand	....	7,160	40	210	300	4	5.07
38	Dune sand	9,780	3,920	40	210	400	5	8.45
60	Yellow gray sandy loam...	29,320	5,980	40	630	1,100	14	5.2
41	Brown sandy loam........	9,980	7,340	40	300	400	6	6.76
23	Yellow gray fine sandy silt loam	13,860	7,220	60	700	500	4	1.69
43	Brown sandy loam	10,160	8,700	60	210	400	5	11.83
30	Brown sandy loam........	44,040	7,500	100	1,260	1,700	11	10.14
26	Yellow sandy loam	....	11,140	120	500	320	21	13.52
44	Brown fine sandy loam....	39,480	9,540	120	400	1,400	10	16.9
48	Yellow sandy loam.......	17,860	3,980	300	1,260	800	8	13.5
11	Brown sandy loam........	50,140	14,720	320	120	100	15	1.69
33	Brown sandy loam........	18,700	4,680	360	630	800	8	16.9
34	Brown gray sandy loam on tight clay	47,670	10,280	400	1,260	1,100	8	5.07
31	Yellow gray sandy loam...	18,360	6,080	460	500	500	6	8.45
24	Gray sandy loam.........	16,880	6,280	800	300	800	15	16.9

TABLE II.

LIGHT COLORED SILT LOAM SOILS.

Lab. No.	Soil Type	Total Org. C. lbs. per 2,000,000	Total Ca lbs. per 2,000,000	$CaCO_3$ requirement lbs. per 2,000,000			Comber Number	Truog Number × 1.3
				Hopkins	Veitch	Jones		
19	Yellow gray silt loam.....	27,880	7,240	40	1,260	2,400	10	11.83
29	Yellow silt loam..........	14,320	5,040	120	420	600	5	6.76
17	Yellow silt loam..........	18,440	8,840	240	1,890	900	10	16.9
1	Yellow gray silt loam.....	....	7,900	260	900	300	7	10.14
32	Yellow gray silt loam.....	70,580	14,480	260	300	500	2	3.38
28	Light gray silt loam on tight clay	12,860	2,560	380	630	1,100	6	10.14
27	Yellow gray silt loam.....	19,460	4,340	500	1,890	1,350	10	10.14
15	Yellow silt loam..........	16,160	8,360	540	480	500	4	8.45
14	Yellow gray silt loam.....	26,780	10,380	580	1,890	1,200	9	10.14
22	Deep gray silt loam.......	18,680	4,220	1,020	2,940	1,400	12	18.59
2	Gray silt loam on tight clay	....	2,520	1,380	3,990	2,200	14	20.28
6	Light gray silt loam on tight	29,060	6,340	2,420	1,890	1,900	17	20.28
49	Yellow silt loam..........	15,640	3,580	3,600	5,250	2,300	14	22.10
4	Yellow silt loam..........	....	3,860	5,680	3,360	4,750	14	22.10
5	Yellow silt loam..........	9,560	4,480	4,000	3,570	2,100	10	15.2

TABLE III.

DARK SILT LOAMS.

Lab. No.	Soil Type	Total Org. C. lbs. per 2,000,000	Total Ca lbs. per 2,000,000	$CaCO_3$ requirement lbs. per 2,000,000			Comber Number	Truog Number × 1.3
				Hopkins	Veitch	Jones		
37	Brown silt loam..........	37,420	6,160	40	840	1,100	9	11.83
57	Brown silt loam..........	....	10,200	40	2,300	1,600	8	16.9
16	Brown silt loam..........	....	9,760	60	2,100	2,200	9	16.9
55	Brown silt loam..........	53,380	5,620	80	1,260	2,000	9	18.59
59	Brown silt loam..........	55,560	8,980	80	1,890	1,500	6	10.14
45	Brown silt loam..........	48,620	6,720	100	630	1,825	13	6.76
56	Brown silt loam..........	62,440	9,480	120	1,680	1,800	10	6.76
20	Brown silt loam..........	....	7,240	160	1,260	4,700	13	16.9
21	Brown silt loam..........	75,240	6,120	180	1,470	4,400	10	13.5
52	Brown silt loam..........	49,840	8,040	260	6,300	2,100	14	18.59
47	Brown gray silt loam on tight clay	36,680	4,700	400	1,420	1,750	16	18.59
35	Mixed loam	42,000	12,880	420	840	700	7	8.45
8	Brown silt loam..........	71,520	18,180	600	820	1,700	8	13.52
9	Brown silt loam..........	59,900	10,320	600	2,840	1,975	13	15.21
13	Brown gray silt loam on tight clay	50,900	12,110	960	1,260	1,200	8	11.83
3	Brown loam	90,500	3,940	3,540	6,310	3,200	17	21.97

TABLE IV.

CLAY LOAMS AND CLAYS.

Lab. No.	Soil Type	Total Org. C. lbs. per 2,000,000	Total Ca lbs. per 2,000,000	$CaCO_3$ requirement lbs. per 2,000,000			Comber Number	Truog Number × 1.3
				Hopkins	Veitch	Jones		
54	Black clay loam..........	64,300	19,120	20	420	400	2	1.69
39	Drab clay loam...........	39,020	10,820	40	420	700	8	6.76
53	Black clay loam..........	68,120	16,900	40	630	700	3	5.46
40	Drab clay	40,280	11,940	60	400	600	9	6.76
42	Sandy drab clay loam.....	53,740	12,240	60	1,260	3,750	7	13.52
10	Drab clay loam...........	51,000	14,220	400	630	1,200	8	6.76
7	Clayey muck	220,100	13,940	1,620	5,250	3,000	16	18.59

TABLE V.

BLACK SOILS, HIGH IN ORGANIC MATTER.

50	Peaty loam	229,760	25,560	40	1,050	1,100	3	8.45
46	Black silt loam..........	44,480	7,060	160	2,310	1,350	13	13.5
12	Black mixed loam.........	90,480	19,180	560	630	300	2	1.69
25	Medium peat	....	9,080	580	4,500	2,750	6	10.4

Sandy soils.

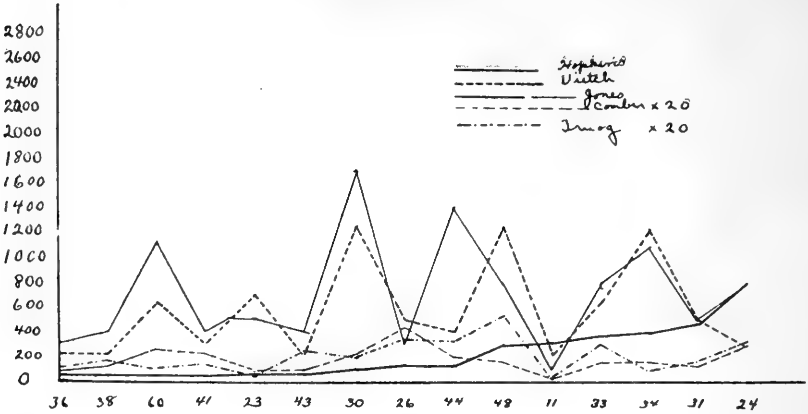

Fig. 1

Light silty soils.

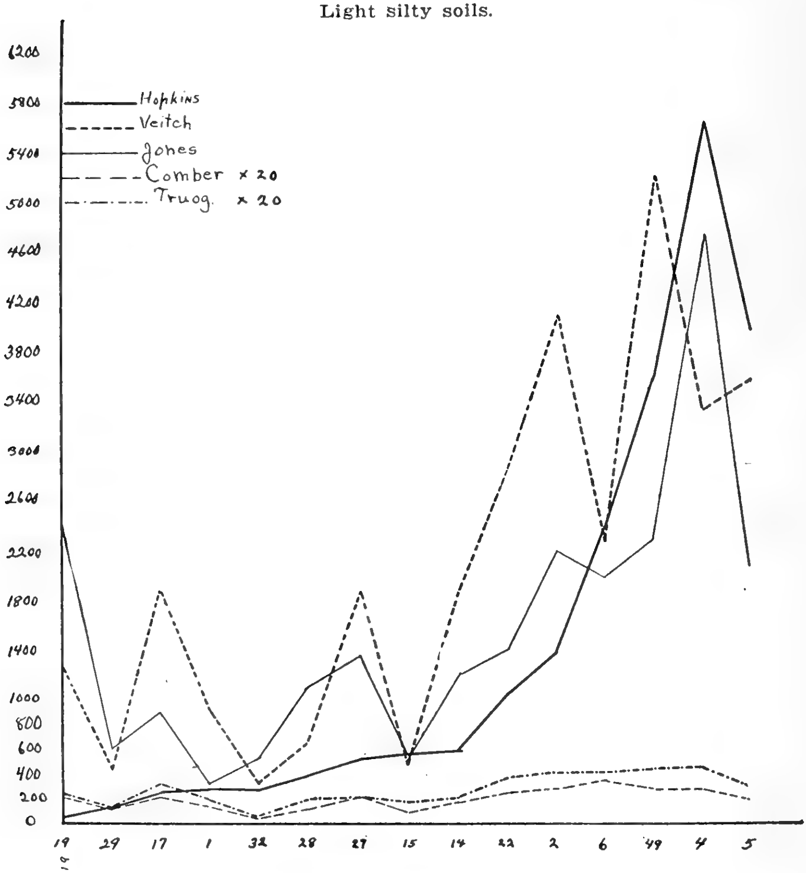

Fig. 2.

DISCUSSION OF RESULTS

The two outstanding results of this study are first, the lack of agreement of the three quantitative methods studied, and second, the low values obtained by the Hopkins method as compared with the other two. The only

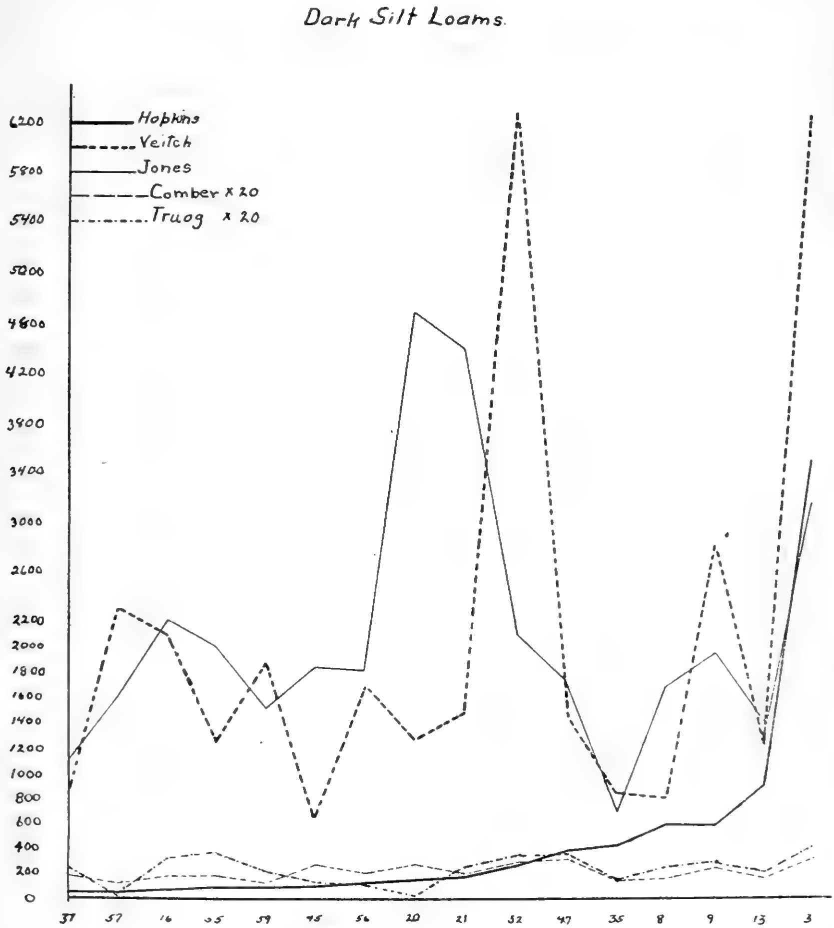

Fig. 3

semblance of a correlation is in the group of light colored silt loams. In only three cases are the results by the Hopkins method higher than by the Jones; in one case they are greater than the results by the Veitch method, and in three other cases they are higher than the results by both the Jones and Veitch methods. These seven soils showing relatively high Hopkins values are for the most part low in organic matter, being yellow silt loams or sandy soils, although one is classified as black mixed loam. There are six soils having a lime-requirement of more than 1000 pounds per acre by the Hopkins method and the other methods agree in showing these soils to be

Clay loams and clays. Soils very high in organic matter

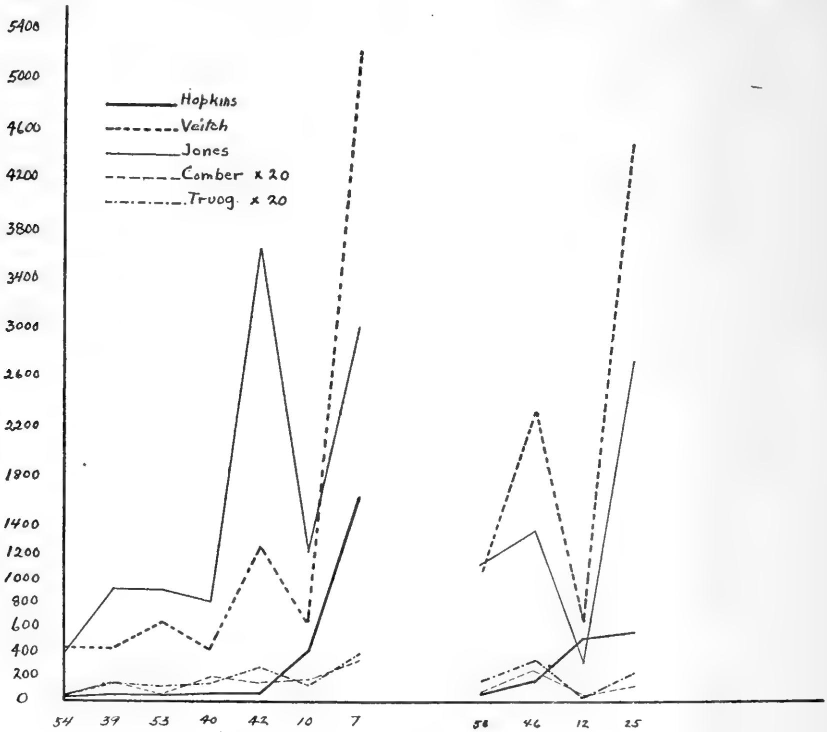

Fig. 4. Fig. 5

highly acid. They do not agree, however, in the degree of acidity. These soils, with one exception, are of types characteristically low in organic matter. It has been generally observed that the majority of Illinois soils actually need considerably larger applications of limestone in order to grow the more acid-density crops than are indicated by the results obtained by the Hopkins method.

A considerable number of soils which are high in organic carbon content were found to give high lime-requirements by the Veitch and Jones methods. On charting all the results in order of increasing content of organic carbon, however, no indication was observable of a causal relationship. When all the results were similarly charted in order of increasing total calcium content of soil, no relationship whatever was found between total calcium and lime-requirement as determined by any method.

The wide divergence between the Hopkins method on the one hand, and the Veitch and Jones methods on the other, is in accordance with what one might expect when the principles involved in the methods are considered. The Veitch method measures essentially the total absorbing power of the soil for the free base, since Ca $(OH)_2$ is the reagent used. The absorbing capacity of the soil is a lesser factor in the Jones calcium acetate method, the calcium ions being in equilibrium with those of a weak acid, while in the Hopkins method absorption phenomena are more largely excluded. Potassium ions, which under similar conditions are absorbed more readily by most soils than are calcium ions, are here combined with a strong acid into one of the most stable salts. It is altogether probable that absorption plays some part in the exchange of bases which occurs in this determination, as a result of which aluminum salts are brought into solution. These undergo hydrolysis, yielding an acid solution which may be titrated until all the aluminum is precipitated as the hydroxide. It is of interest to note that Dr. Veitch criticized the Hopkins method when it first appeared on the ground that it was essentially a method for the determination of soluble aluminum in soils. At that time aluminum was not recognized as a factor in the toxicity of acid soils to crops. The discovery of aluminum toxicity has converted this objection into an advantage for the method.

It may be observed that the divergence between the Hopkins, and the Veitch and Jones methods is slightly greater in the soils represented in Figs. 3, 4, and 5, than in those of Figs. 1 and 2. The former three groups consist of soil types which ordinarily contain a larger proportion of combined organic and inorganic colloidal constituents than the soils shown in the latter groups. This statement can be taken as no more than a mere indication of a possible relationship between colloidal content and high results by the Veitch and Jones methods.

An attempt was made to compare the Comber and Truog field tests with the quantitative methods discussed. In studying Comber's test, 17 shades of color were prepared as standards for comparison of the colors obtained with the various soils. These were prepared by adding increasing quantities of $FeCl_3$ to an alcoholic solution of KCNS. The shades obtained in the Truog test were classified into 13 groups and numbered from 1 to 13. In order to have these "Truog numbers" comparable with the "Comber numbers" they were each multiplied by the factor 17/13 or 1.3. Again in order to increase the scale so that these results could be charted along with those from the quantitative methods, the results of both tests were further multiplied by 20.

The results obtained in these two tests appear to agree rather closely, but show no correlation with the quantitative methods used. Field observations with the Comber test indicate that in general soils which give a red or pink color will not grow sweet clover or alfalfa and will not grow red clover satisfactorily without the application of limestone. Further than this, quantitative deductions can not safely be made.

In another series of nearly 200 tests, not reported here in detail, the Comber test was compared with the Hopkins method on soils covering a wide range of types and degrees of acidity and alkalinity. The Comber test consistently gave negative results on those soils reacting neutral or alkaline to the Hopkins test, while a red color was produced invariably with those soils having a lime-requirement of 40 or more pounds per two million pounds of soil. In these tests, the color intensity was of no significance from a quantitative point of view.

In a further study of the Comber test, samples of a very acid soil (No. 2009) were extracted with water and alcohol respectively. These extracts were both distinctly acid, showing a Ph value of 5.0 to 3.5 by the colorimetric method. They were free from ferric iron, since they failed to respond to KCNS additions, although a positive reaction was secured by adding Comber's solution to the soil itself. The intensity of the color is reduced greatly by substituting an aqueous solution of KCNS because of the excessive ionization of the colored ferric salt.

Since the intensity of the red color is dependent upon the amount of iron which can react, the iron content of the soil might be expected to affect the results. It has been found, in fact, that this is true. Five soils (numbers 1620, 1717, 2015, 4471, 8153), showing a faint pink color with KCNS, were moistened and treated with iron filings. After standing two days they were dried and then taken up with KCNS as usual. The color was intensified considerably in each case.

It has been observed frequently that this test is not applicable to peat or peaty soils, no color being produced even by very acid peats. This was conceived to be due to a possible iron deficiency. Accordingly several peat soils ranging from alkaline to acid by the Hopkins method were treated with the Comber solution, both with and without the addition of iron filings. All those without iron filings were colorless. In each case the samples with iron filings and having a lime-requirement by the Hopkins method showed a red color, while the neutral and alkaline samples remained colorless. The iron filings were added to the dry soil immediately before adding the KCNS. It is suggested that this test may be made applicable to iron-deficient soils by means of this slight modification.

SUMMARY

1. The Hopkins, Veitch and Jones quantitative methods, and the Comber and Truog field tests were studied on 57 soils representing a wide range of Illinois soil types and degrees of acidity.

2. The three quantitative methods failed to show any consistent agreement with each other from a quantitative point of view.

3. The Veitch and Jones methods gave consistently higher results than the Hopkins, particularly on those soil types which ordinarily contain fairly large proportions of colloidal material, including organic and inorganic.

4. The comparatively low results obtained by the Hopkins method are due probably to the failure of this method to measure fully the absorption capacity of soils for bases.

5. The Comber and Truog field tests agreed fairly closely with each other in the comparative intensity of their respective colors with the various soils, but these graduations of color intensity are considered of but little significance as quantitative indications of the lime needs of soils.

6. Both the Comber and Truog tests are reliable as qualitative tests.

7. In the Comber test the alcoholic KCNS solution must be brought in contact with the soil mass. Neither water nor alcohol extracted ferric iron from the acid soils used in these tests.

8. By the addition of iron filings to the soil previous to applying the Comber test, it may be used for soils very high in organic matter, such as peats and peaty loams.

ABBREVIATED LIST OF REFERENCES.

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PENETRATION TESTS IN WOOD-PRESERVATION

George T. Parker and H. A. Geauque, Lombard College

Wood-preservation has been carried on since the beginnings of history but only since 1657 have scientific methods been used. From 1657 to the present time the growing scarcity of timber and the difficulty of replacing decayed timbers have made it necessary to try in different ways to lengthen its life with preservatives. The first requisite for a preservative is that it be able to preserve the timber from the common fungi. The next is that it be in a form and of a price that renders it economical in application. It must be also of a nature so that plant solutions can be handled easily and their strengths easily controlled.

Cresote oil is the standard organic preservative and zinc chloride the standard inorganic preservative. Malenkowic seems to be the first man who used sodium fluoride. In 1887 he used it in connection with some organic compounds; tars, creosotes, nitrophenols, etc., and got very good results. In this country, tho, the chief use of sodium fluoride has been in mine timbers. Some of the mines in the anthracite region, Mr. L. W. Conrad states*, used it for two reasons: Zinc chloride was very hard to get at reasonable prices due to war conditions, and it was thought that creosoted material increased the fire hazard and rendered a fire harder to handle after it was started. He also states that the minds were getting about three years life from untreated mine timbers and mine props while those that were treated with sodium fluoride have given already five years life and are still in good condition. The American Wood-Preservers' Association in January, 1922, prescribed as future work** for their committee on preservatives the development of a volumetric and a gravimetric determination of sodium fluoride, the direct determination of sodium fluoride in treated wood, and if possible to develop a visual method for determining sodium fluoride in treated wood.

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* American Wood-Preservers' Association Proceedings, 1921, page 183.
** American Wood-Preservers' Association Proceedings, 1922, page 54.

The Baltimore and Ohio Railroad gives the results obtained from three hundred red oak ties treated with sodium fluoride and placed in track at Herrin Run*** in 1914. To date, two of these ties, or 0.6 per cent of the total number placed in track, have been removed because of decay, and five, or 1.7 per cent, because of other reasons. This makes a total of seven ties of the three hundred placed in 1914 that have been removed. These ties received 0.41 pounds of sodium fluoride per cubic foot.

In 1921 more than three-fourths of the timber preserving plants in the United States were in the hands of either commercial or private companies, while the rest were in the hands of the railroads. As the railroads use a large part of the treated wood of the country much of the treating is done by contract. Because of this it is necessary to have a penetration test for the preservative in order to prove the depth of the treatment.

At the present time nearly all of timber preserved is treated with either cresote or zinc chloride or a mixture of the two. Sodium fluoride is coming into more general favor because it seems to have as good preserving qualities and is much less corrosive than zinc chloride which gives a large overhead in plant equipment.

The progress of sodium fluoride treatment has been retarded by the lack of a satisfactory penetration test and a simple, accurate and rapid method of analysis. A test for sodium fluoride penetration was presented to the American Wood-Preservers' Association at their meeting in January, 1923, but this test has not proved to be entirely satisfactory as it calls for absolute alcohol, which is not a general laboratory reagent in a commercial laboratory. The solutions used are:

1. Three per cent solution of ferric chloride in absolute alcohol.

2. Three per cent solution of ammonium thiocyanate in absolute alcohol.

The surface of the wood to be tested is sprayed evenly with the solution of ferric chloride, and dried and then

*** Baltimore and Ohio Railroad, Report of Experimental Ties, 1922, page A2.

sprayed with the solution of ammonium thiocyanate and dried. It is a negative test producing a red stain on the untreated portion and not affecting the color of the treated portion. The red stain is ferric sulphocyanate, which is attacked by the phosphates in the wood and decomposed, leaving the natural wood color.

It was found that ferrous salts in an acid solution used in conjunction with ammonium thiocyanate solution produced a good test, but it was not permanent. It faded in a few hours. The method used was the same as that used above except that the solutions were made with water. The wood was sprayed first with a solution of ferrous ammonium sulphate and then dried. It was then sprayed with a solution of ammonium thiocyanate. The resulting color was red on the untreated parts and natural color on the treated parts.

As the water solutions of ferric salts are turned black by tannic acid, it is impossible to use them on any wood containing an appreciable amount of tannic acid. The method used on woods that did not contain tannic acid was the same as the above except that ferric chloride was substituted for ferrous ammonium sulphate. This test gave a good red stain on the untreated parts and did not affect the color of the wood that was treated. It lacked permanence as did the others.

The test that was found to be the most satisfactory in the laboratory was the one using the water solutions of potassium ferricyanide and iron ammonium chloride. First, the surface of the wood to be tested is sprayed with a five per cent solution of potassium ferricyanide and dried. Then it is sprayed with a five per cent solution of iron ammonium chloride, and as soon as the line dividing the treated and the untreated portions appears the surface of the wood is washed thoroughly with tap water. The test should be performed in ordinary daylight, not direct sunlight. The untreated part of the wood is colored a deep blue and the color of the treated portion is not changed. It generally takes about three or four seconds for the line to appear, and the test works equally well on pine, oak, or fir woods with widely divergent qualities.

The reasons that the test is needed are to check up on the treatment and to know that the preservative is penetrating the wood. In the railroad plants and the private plants it is used to show that they are forcing the preservative into the wood, while in the commercial plants it is called for in their contract and treating specifications. It helps to determine what life to expect from a stick of timber. If the preservative has gone to the center of the wood it can be expected to give a longer life than if the preservative had merely coated the wood. If the preservative has merely coated the wood, many bacteria will soon get into the wood where it is scarred in handling and destroy it from the center.

The color contrast in this test is greater than in any of the other tests. Wood ranges from white in pine, to red in cedar and a dark brown in walnut. Red will not show up as well with any of these colors as will a dark blue.

In conclusion, the advantages of the above test are:

1. It is the only permanent test as yet advanced.
2. It shows a much better color contrast than any other test.
3. The dividing line is permanent and sharp.
4. It is much easier to make than the other test because of the ease in making up solutions.
5. Solutions are much more stable.
6. Materials are much cheaper.

A CARBON FILM HIGH RESISTANCE; ITS CONSTRUCTION AND CHARACTERISTICS.

A. J. McMaster, University of Illinois

The problem of obtaining at low cost a satisfactory high electrical resistance, that is from 0.1 to 100 megohms, for use in experimental work is one with which many laboratories of physics have been confronted. The most common means of meeting this problem has been to use a graphite line on ground glass or hard rubber with some sort of pressure contacts as terminals. However in Dec. 1902, Prof. A. C. Longden described in a paper in the Physical Review* a new form of carbon resistance in which he used as a resistance material a film of smoke deposited from a flame upon a strip of glass. The terminals which he devised, and which are very satisfactory, consist of a film of silver deposited chemically on each end of the strip. The capillary attraction between the glass and the silvering solution causes the end of the film to be almost infinitely thin. The carbon film, when deposited over the central portion of the glass and onto the silvered ends, forms a very smooth and satisfactory contact. A small copper wire is copper plated to each of the silvered tips to complete the terminals. By treating the carbon film with alcohol vapor, it is sufficiently hardened to permit a thin layer of paraffin or shellac to be flowed over it. A number of such slides may be mounted in a dry wood or hard rubber case which is provided with binding posts.

It is this same type of carbon film resistance, but in a new and perhaps a little more convenient form and mounting, that has been the subject of the present investigation. The construction of the resistance is shown in detail in Fig. 1. Instead of a glass slide, a small soft glass tube, sealed at each end, is used, in which there is a slight constriction near each end. The silver copper terminals are constructed as prescribed by Longden. The silver is deposited chemically by Brashear's process for silvering glass, and the copper is deposited electrolytic-

* Phys. Rev. Vol. XV.—No. 6.

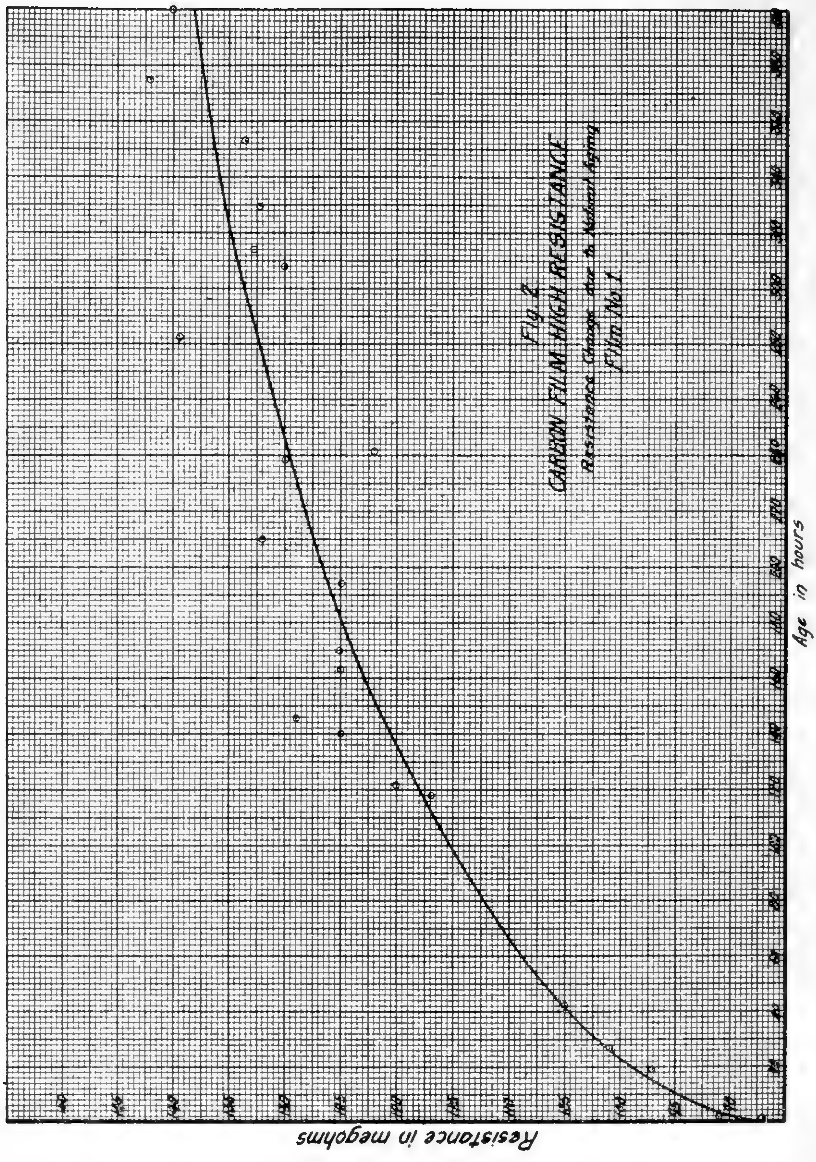
Fig. 2
CARBON FILM HIGH RESISTANCE
Resistance Change due to Natural Aging
Film No. 1
Age in hours
Resistance in megohms

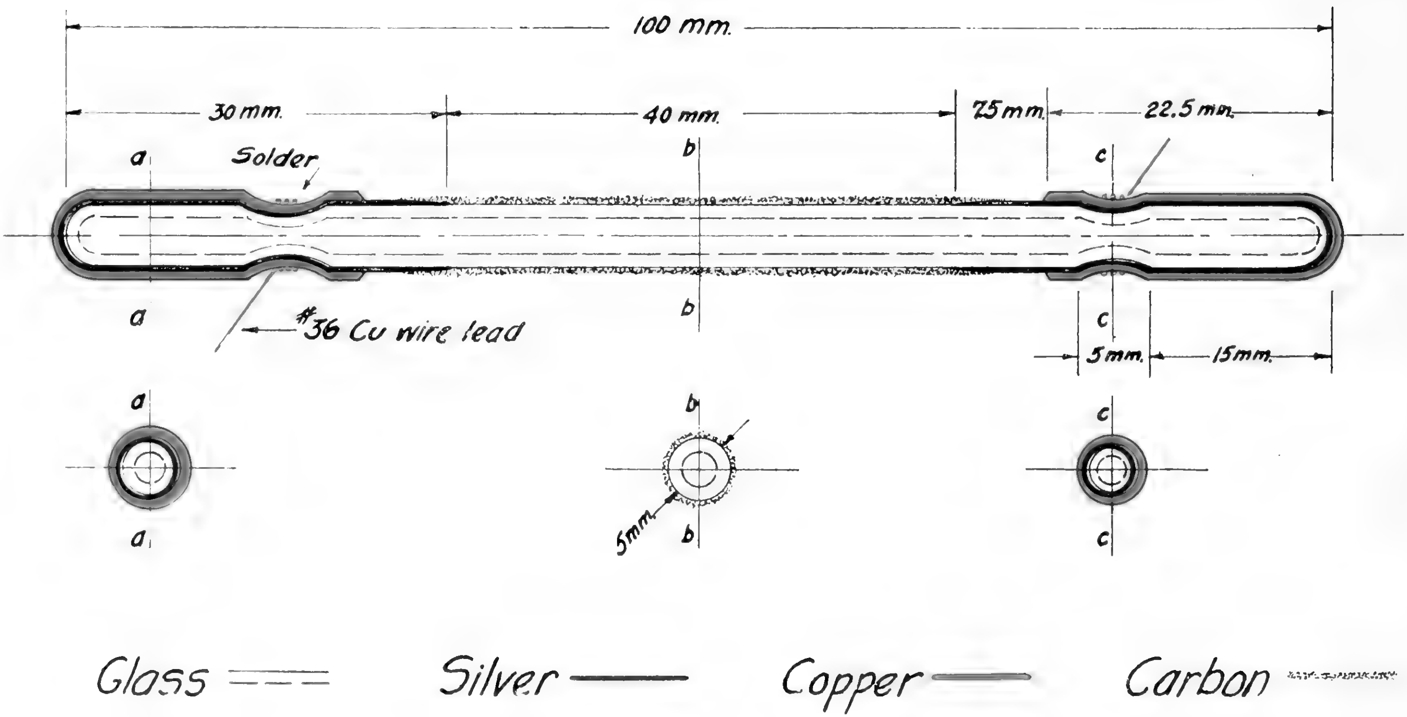

Fig. 1. Detail drawing of a carbon film high resistance.

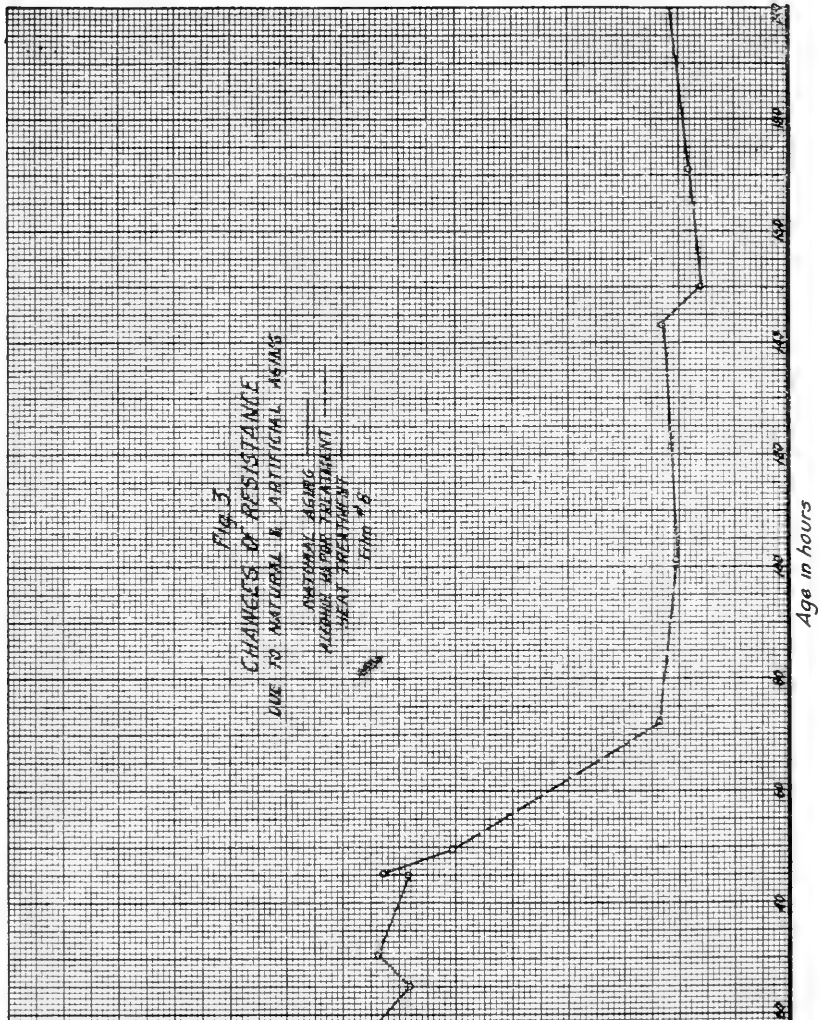
Fig. 3
CHANGES OF RESISTANCE
DUE TO NATURAL & ARTIFICIAL AGING
NATURAL AGING
ALCOHOL VAPOR TREATMENT
HEAT TREATMENT
Film #6
Age in hours
Resistance in megohms

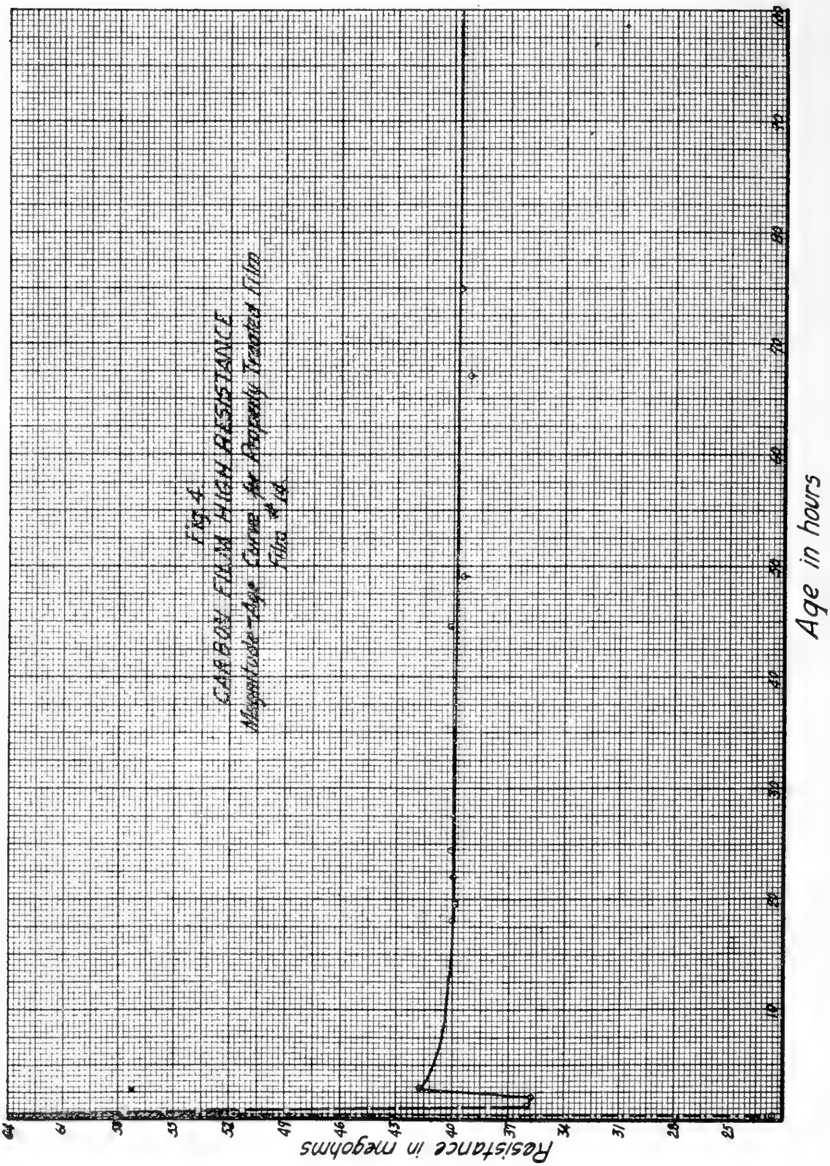
Fig. 4
CARBON FILM HIGH RESISTANCE
Magnitude-Age Curve for Properly Treated Film
Age in hours
Resistance in megohms

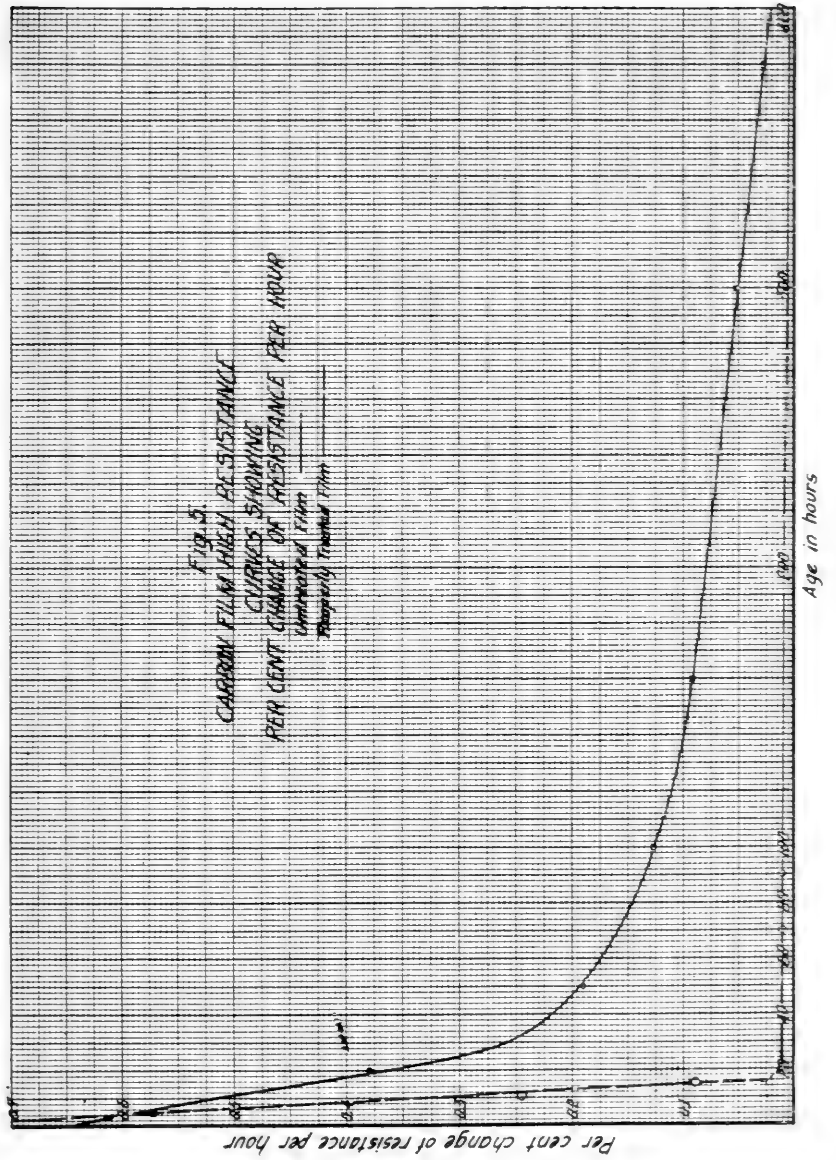
Fig. 5.
CARBON FILM HIGH RESISTANCE
CURVES SHOWING
PER CENT CHANGE OF RESISTANCE PER HOUR
Untreated Film
Properly Treated Film
Age in hours
Per cent change of resistance per hour

ally from a bath of forty parts of saturated copper sulfate solution, one part of concentrated sulfuric acid, ten parts of distilled water and a few drops of a thin solution of gelatine in water. After the copper plate is deposited the copper wire is cut off close to the tube, and a new piece attached at the constriction with a small drop of solder. After thoroughly cleaning the central portion of the tube, the carbon soot is deposited from the flame of burning camphor. The resistance after undergoing the treatment prescribed below is mounted inside of a larger protective tube. A small wooden terminal block is clamped to each end of this larger tube, and the terminal wires soldered to a binding post on each block.

The results of Longden's investigation of carbon film resistances showed, and the data obtained in the present work confirms the fact that the resistance of such a carbon film increases with age, very rapidly at first and later more slowly. Fig. 2 shows a curve in which the resistance of such a film is plotted on the ordinate against its age on the abscissa. The irregularity of the points plotted is due to the difference in temperature conditions under which the measurements were made. If this curve were continued over a period of several hundred days, it would become almost but not quite parallel to the time axis, indicating that the resistance had become almost constant. It has been the purpose of the present investigation to try by processes of artificial aging (artificial aging referring to any process which produces a definite change of resistance) to hasten the natural changes in resistance, in order that a film might be made to assume a practically constant magnitude in a short interval of time. To do this it has been necessary to study the effects of different aging processes. The results obtained in this study are listed below. Since these results have been obtained from work on not a very great number of films, they can not be stated as positive scientific facts, but they do suggest the probable effects of the different treatments applied. Furthermore, the results can be interpreted on a qualitative basis only, since there are a number of indeterminable factors involved in the procedure, such as the exact amount of treatment, the exact thickness of the film and the exact condition of the contacts, etc.

The following characteristics of carbon films as high resistances have been noted:

I. Changes in resistance produced by processes of artificial aging are followed usually by a recovery in which the resistance tends, partially at least, to reassume its former magnitude. This phenomenon is illustrated by the curve in Fig. 3. Here a film has been submitted to alcohol vapor and heat treatments.

II. Bathing a carbon film in alcohol vapor produces a decrease in resistance except in the following cases:

(a.) When one or both of the contacts between the carbon and silver are poor, the carbon is washed away from the silver producing an increase in resistance.

(b.) If the alcohol vapor is forced on to the film in such a manner as to disturb the mechanical arrangement of the particles of carbon, an increase in resistance will be noted.

(c.) If the alcohol vapor is applied repeatedly, without intervals of natural recovery between the applications, a limit is reached, after which no decrease can be produced. If the process is carried still farther, the result is an increase similar to that produced by natural recovery, but more rapid. It has been impossible to explain why this occurs, but trials in which the contacts were covered completely with paraffin have proved that these seemingly erratic variations are not due to defects in construction, and may be repeated quite regularly. This effect is shown also in Fig. 3.

III. Heating a film at a temperature from 80° to 110°C. produces a decrease in resistance due probably to the mechanical change in the arrangement of the particles of carbon when the glass and carbon expand and contract. (See Fig. 3.) Heating to too high a temperature usually causes some cracking of the silver copper tips, which will result in an increase in resistance.

IV. Bathing a film in liquid alcohol decreases the resistance except in those special cases described under the alcohol vapor treatment. As with alcohol vapor, an extended treatment in the liquid alcohol produces an increase. It is evident from examination of a film so treated that an extended liquid alcohol treatment washes off all loose particles of carbon and an increase in magnitude necessarily follows. The ordinary decrease noted at first with either treatment is due to the packing and hardening effect of the alcohol on the film. However, in depositing a film from a camphor flame, it is very probable that the particles of carbon in leaving the flame carry with them camphor vapor which is incompletely burned, and which becomes occluded in the film. It is possible that the natural change in resistance of an untreated film is due to physical or chemical changes in this occluded material. This camphor is washed to the surface of the film by the alcohol vapor treatment, and is in a large part removed completely by the liquid alcohol bath. For this reason, the liquid bath is preferable to the vapor treatment.

With this knowledge of the effects of artificial aging on the resistance of thin carbon films, it is possible to prescribe the following treatment in the preparation of such films for use:

It is desirable to cleanse the film as far as possible from all foreign matter and loose particles of carbon, thus bringing the resistance of the film as nearly as possible to its permanent magnitude. This is done most efficiently and quickly by immersing the film in liquid alcohol for ten to twenty minutes, and then drying for a half hour at 60° to 70°C. in an oven. The change in resistance of a film prepared in this way is shown in Fig. 4.

Fig. 5 shows by comparison the difference between an untreated film under the influence of natural aging alone, and a film which has received the above prescribed treatment. Here the per cent of change in resistance per hour is plotted against the age of the film. It will be seen that the change in magnitude of the treated film becomes much less at an early age than that of one which has received no treatment. The finished film should be mounted as described above, for protection and convenience in use. For best results the films should not be covered with paraffin or shellac since these materials cause undesirable changes in resistance with changes of temperature. The carbon film itself has a rather high negative temperature coefficient of resistance, which is, however, easily measured if necessary.

The results of this investigation can be confirmed only after a long interval of time, for time is the important test of the constancy of a resistance material. The points in the above report which have not been completely explained are to be investigated more thoroughly at a later date.

The writer wishes to express his appreciation of the help and criticism of Dr. E. H. Williams under whose direction this work has been carried on.

SOME ASPECTS OF PHOSPHORUS BEHAVIOR IN SOILS

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Phosphorus is one of the ten elements necessary for the growth and development of plant tissue. Phosphorus, also, is one of the three or four of these ten elements that may be lacking in soil for the optimum plant growth. In fact, it is one of the first ones that is usually deficient in the soils of humid regions. The question of phosphorus and its replenishment in the soil, therefore, becomes one of paramount importance in agricultural practice.

There are two main sources of phosphorus that are used by farmers in replenishing the soil, in order to compensate for the loss of phosphorus removed by farm crops: (1) farm manures, and (2) commercial phosphatic fertilizers. The phosphatic fertilizers, in their turn, could be subdivided into two main groups, namely: (1) rock phosphate, and (2) acid phosphate. Rock phosphates are the natural phosphatic deposits quarried and ground into a very fine powder, 80 to 95 per cent of which usually passing through a 100-mesh sieve. Acid phosphate is the product obtained after natural phosphate is treated with a weak solution of sulfuric acid. Natural phosphate is but very slightly soluble in water, while acid phosphate, freshly prepared, is easily soluble in water. The subdivision, therefore, could be made on the basis of soluble and insoluble phosphatic fertilizers. Other minor sources of phosphorus for use as fertilizers would fall into either of these two main groups.

According to the American Fertilizer Handbook for 1920, there were produced and sold in the United States in 1918, in round figures, 2,500,000 metric tons of rock phosphate, estimated as being worth over $8,000,000. At the same time 4,500,000 tons of acid phosphate were manufactured, being worth over $76,000,000. Nearly all of this vast amount of phosphatic fertilizers was sold on a domestic market and used by American farmers as fertilizer.

It is interesting to note that according to these estimates, rock phosphate is worth $3.20 a ton, while acid phosphate is priced at $16.89 a ton. In spite of this difference in price, acid phosphate ordinarily contains

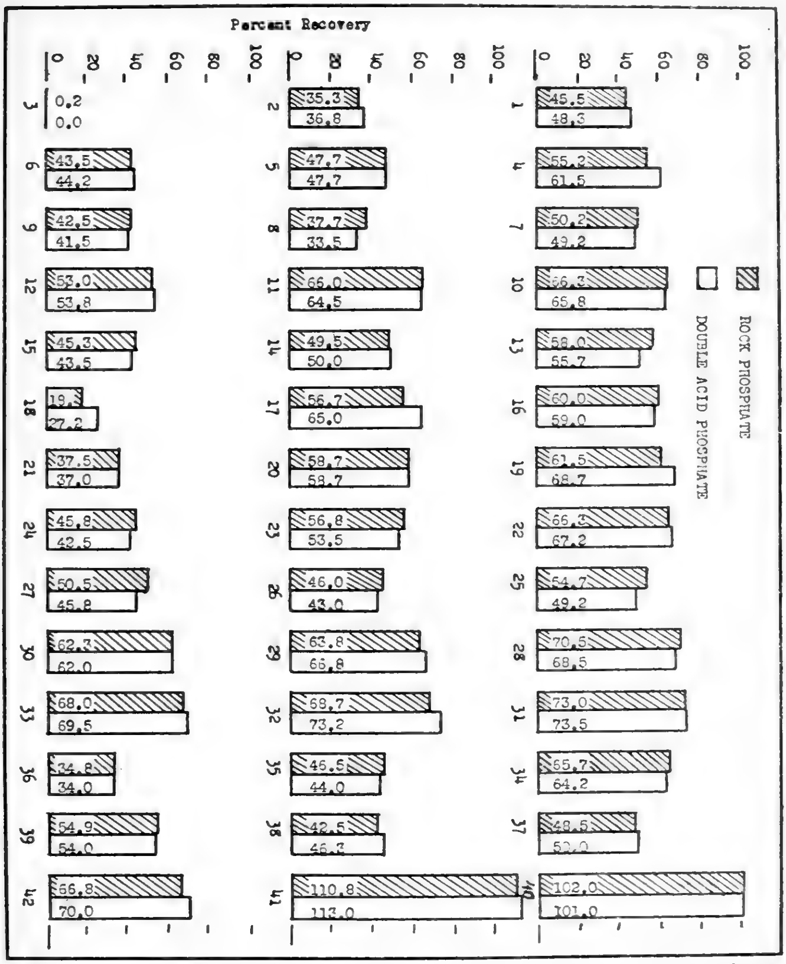

Fig. 1. Percent phosphorus recovery from Tennessee rock phosphate and double acid phosphate after different soils were treated with these substances in proportion of 4 mgs. of phosphorus per 25 gms. of soil; normal fifth nitric acid was used for extraction.

only one-half of the amount of phosphorus found in rock phosphate from which it is being prepared.

It is a mooted question among soil workers as to which of the two phosphatic fertilizers is better and the more economical to apply to the soil for crop production and

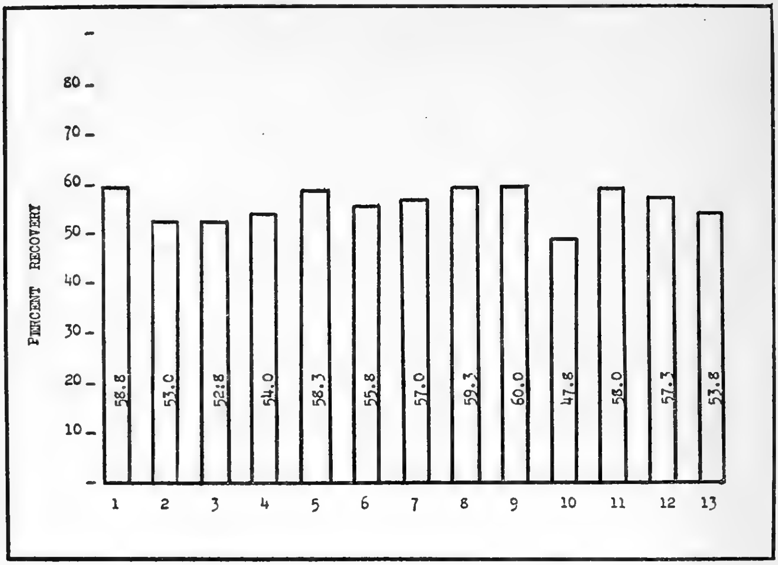

Fig. 2. Percent phosphorus recovery from phosphatic fertilizer treated brown silt loam. 4 mgs. of phosphorus were used for 25 gms. of soil. Nos. 1, 2, 3, etc. at the bottom of the figure refer to numbers opposite the fertilizer materials in table 3.

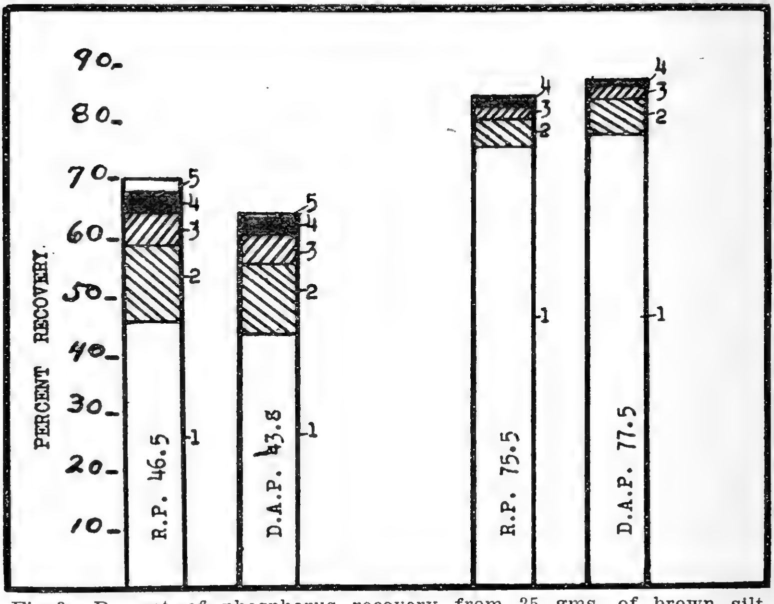

Fig. 3. Percent of phosphorus recovery from 25 gms. of brown silt loam and brown gray silt loam treated with 4 mgs. of phosphorus of either Tennessee rock phosphate, R. P., or double acid phosphate, D. A. P. Five consecutive extractions were made with HNO_3 N/5. First extraction data represented at the base line. Subsequent extractions are placed above, in order named.

the maintenance of soil fertility. Notwithstanding the great amount of work that has been done in various parts of the world, the question is far from being solved. The results are often conflicting and not strictly comparable.

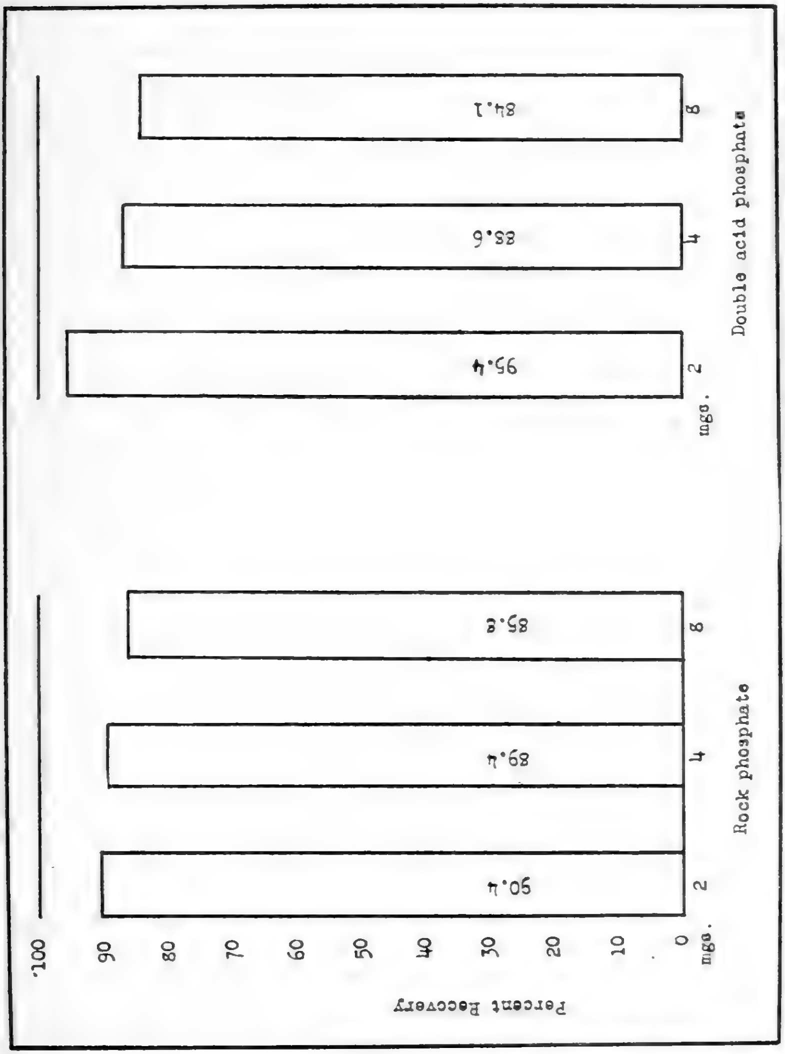

Fig. 4. Percent recovery of phosphorus from 25 gms. of coarse quartz sand treated with 2, 4 and 8 mgs. of phosphorus in the form of either Tennessee rock phosphate or double acid phosphate. Normal fifth nitric acid was used for extraction.

It was thought advisable, therefore, to compare these two forms of phosphatic fertilizers in their behavior after they are applied in various types of soil, and also to study some of the factors that influence their behavior.

It would be of fundamental importance to know: What becomes of phosphorus when phosphatic fertilizer is applied to the soil? What reactions take place? To what extent is phosphorus "available" when "water soluble" acid phosphate is incorporated with the moist soil mass?

As generally known, one of the strongest claims of acid phosphate advocates is that acid phosphate is water soluble and that when it is applied to the soil, it becomes available immediately for the use of plants, while phosphorus in the rock phosphate is so insoluble that its availability is too low for the immediate use of growing crops, The validity of this contention is often doubted, for it was observed that phosphorus of water soluble acid phosphate could not be extracted from the soil to which it was previously added. It is often argued, that although this phosphorus can not be extracted with water, it is absorbed or even adsorbed by the soil particles, and loosely held thereby. This phosphorus, however, is in such state that plant roots are able to extract it far more easily than the phosphorus of the insoluble rock phosphate. The data presented in this paper will tend to show that this general contention is also of questionable validity; that phosphorus of acid phosphate or even of double acid phosphate (super phosphate), after this material is applied to some agricultural soils, becomes very insoluble; and its solubility is not to any extent greater than the solubility of phosphorus from natural rock phosphate added to the same soil and under the same conditions.

EXPERIMENTAL

The present investigation was carried out on many soil types, the soils in the majority of cases being obtained from Champaign county, Illinois. The phosphatic fertilizers used were three different rock phosphates; five slags; ground apatite; iron and aluminium phosphates; steamed bone meal and acid and double acid phosphates. The composition of these phosphatic fertilizers is presented in Table 1.

The comparative work on different soils was carried out with Tennessee rock phosphate, as a representative of insoluble rock phosphate, and with double acid phosphate, as easily soluble phosphatic fertilizer.

The general procedure of the experiment was as follows: 25 grams of mineral soil or 12.5 grams of organic soil (peat) were placed in a 350 c. c. glass bottle, thoroughly mixed with a given amount of fertilizing material, moistened with distilled water, and let stand for seven days at room temperature. At the end of this period, it was taken with 250 c. c. of fifth normal nitric acid and shaken for three hours in a shaking machine. Then it was filtered on a dry filter paper. 200 c. c. aliquot of clear solution was taken for determination of phosphorus. Volumetric method of analysis was followed in this work. The average of two determinations is given in the tables.

It is recommended often in the studies of weak acid extractions to make the acids somewhat stronger than fifth normal so that after the soil bases are neutralized the remaining acidity will be equal to fifth normal. Such an arrangement, of course, would give the phosphatic compounds in different soils the same chance for equal solubility. This procedure, however, introduces a very objectionable feature for the comparative study of different soils. The solvent necessarily would be different for nearly every soil, and the results could hardly be comparable. It seems as though we should accept soils as such; accept the conditions under which any given soil has to function, and make our observations, preserving these conditions intact.

If we take two field soils and subject them to the same cultural and climatic conditions, we may safely expect the resultant soil solutions to be practically the same. Yet the ultimate character of these two soil solutions may be widely different depending on the physical and chemical character of these respective soils.

There are given two soils; one is abundantly supplied with carbonates, while the other is very deficient in them. The solvent action of acids formed in the soils will go very largely to neutralize the carbonates in the first soil, and will be available as a free acid in the second soil. Naturally there will be more phosphorus available for crops in the second soil than in the first. The field observations at various experiment stations show that soils excessively supplied with lime do not respond very well to the application of phosphates. This well known fact among soil workers seems to justify the procedure here adopted.

In time, the biological activities of these soils will also add to the modification of their soil solution, but this phase does not enter into the realm of the present study.

The comparative work was done on soils of different geological and morphological formations. Prairie soils were represented by three soils of brown silt loam, two of clay loam, and one each of drab clay loam, brown gray silt loam of tight clay, and brown sandy loam. Timber soils were represented by one sample each of the yellow gray silt loam on gravel, yellow silt loam (eroded) and yellow gray sandy loam. Terrace soils were represented by brown sandy loam. Mixed loam was used as a bottom land type formed along rivers; deep peat was a representative of swamp lands.

In each soil type the soils of three different depths were used for the comparative tests with the phosphatic fertilizers: (1) the plowed layer of 6 2/3 inches in depth, (2) the second layer from 6 2/3 inches to 20 inches, and (3) the layer from 20 to 40 inches. The second and the third layers, of course, differ from the first one in their physical and chemical properties, and the descriptive name of soils for each layer is given here in order to facilitate interpretation of the presented data. All soils in this experiment were ordinary stock samples collected in Champaign county for the soil survey analyses.

These fourteen soils of three layers each, or forty-two soil samples in all, were treated with either Tennessee rock phosphate or double acid phosphate in such amounts that in each case 4 mgs. of phosphorus were applied for 25 grams of mineral soil and for 12.5 gms. of peat of the first two layers. The results presented in Table 2 show the percent of applied phosphorus that was extracted with nitric acid fifth normal. In each case the amount of phosphorus extracted from the untreated soil was subtracted from the amount of phosphorus extracted from the treated soil. It constitutes a net gain due to the treatment, and it assumes that the amount of soil phosphorus extracted from the treated soil is the same under these conditions as the amount of phosphorus extracted from the untreated soil.

Examination of the results in Table 2 and of the accompanying Fig. 1 reveals the rather striking fact that the degree of recovery of phosphorus from nearly every soil studied is practically the same, regardless of the source of the phosphatic material. Water soluble double acid phosphate, after it is incorporated into the soil mass and moistened, becomes soluble in fifth normal nitric acid, only to the same extent as the Tennessee rock phosphate. There are some relatively small differences in solubility in some individual cases. On the whole, however, these differences are very important, as one can judge from the application of Student's Method of biometric analysis. Using 42 soil trials in which the mean deviation is only –.37, and the standard deviation 3.256, the ratio of the former to the latter, or Z, is only .113. This value is too small to be significant. The smallest value of Z used in Student's tables is .1 and such value gives chances from 10 to 12 times as small as those considered at all significant in calculations of probability.

Different soil types allow the recovery of different amounts of phosphorus. In this respect, the variations are very great. Thus, the soil of the third layer of one brown silt loam (Sample 3, Table 2) did not allow any recovery; while the surface layer of peat showed a complete recovery. Indeed, the amount of phosphorus recovered from peat of the second layer was greater than the amount applied. The differences are from 11 to 13 per cent, and seem to be larger than could be ascribed to the experimental error. In the majority of cases the recovery of phosphorus varied between 40 and 60 per cent. On the whole, the recovery was somewhat greater in the surface layer than in the subsurface. The third layer, or the subsoil, gave the smallest recovery of phosphorus in all cases.

In order to ascertain whether or not other phosphatic fertilizers would follow the same general mode of behavior observed on the Tennessee rock phosphate and double acid phosphate, an experiment was repeated on another brown silt loam, using various phosphatic fertilizers. As one notices from Table 1, these phosphorus-carrying substances varied in their phosphorus content very considerably. The amount of each substance used, however, was in every case equivalent to 4 mgs. of phosphorus, as calculated from their analyses. 25 gms. of soil were used in every case. Amounts of phosphorus extracted with fifth normal nitric acid, as well as per-cent of phosphorus recovery, are given in Table 3, and are shown graphically in Figure 2. The results show that, with the exception of iron phosphate and two or three brands of slag, the per cent of recovery is practically the same. Acid phosphate gave no larger recovery than the majority of the so-called insoluble phosphatic fertilizers. These figures are rather interesting, especially if one considers them in parallel to the data presented in Table 4, which has the amount and the per-cent of phosphorus recovery from the same amount of fertilizing material alone (without the soil), when the extraction was made either with distilled water or with normal fifth nitric acid.

The data in Table 4 show that phosphorus in acid phosphate is recovered with distilled water to the extent of 85 per cent, and from double acid phosphate to the extent of 90 per cent. None of the other phosphates had solubility in water amounting to six per cent; some of them, as apatite and one of the slags, were extremely insoluble in water.

When the same materials were extracted with fifth normal nitric acid under the same conditions, i. e., without mixing them with the soil, the per cent of recovery was around 100 percent in nearly every case. See Table 4.

It is evident that there is something in the soil that prevented this phosphorus recovery. Undoubtedly some of the acid, after it is added to the soil, reacts with some of the soil bases, forming nitrates. This would be true especially of carbonates of calcium and magnesium. Such a reaction taking place would decrease the concentration of the acid, causing a decrease in the amount of phosphorus extracted. Anticipating such action in some soils that are more or less supplied with carbonates, an aliquot of clear extracted solution was taken and titrated against a standard alkali (.1484 normal), using Methyl-red-Para-nitro-phenol for the indicator. The figures for relative titrations are given in Tables 2, 3, and 4 (last column). They show that fertilizing materials alone do not reduce the concentration of nitric acid to any appreciable extent. (Table 4.) The fertilizing materials after they are applied to brown silt loam, as recorded in Table 3, reduce the acid concentration rather uniformly to about 90 percent of its original strength. This in no way accounts for the reduction of phosphorus recovery to about 50 or 60 percent of its recovery from fertilizing materials themselves. The titrations recorded in Table 2 explain the failure of phosphorus recovery in only a very limited number of cases. The soil number "3", or the subsoil layer of brown silt loam, contained a large amount of carbonates, which used practically all of the acid present, thus making the phosphorus extraction impossible. Perhaps samples Nos. 21 and 24 also behaved in a similar way. With these three exceptions, however, the reduction in the acid concentration fails entirely to explain the behavior of phosphorus in all these soils. The lack of such correlation is very apparent, if one compares the surface soil with its subsurface and the subsoil layers in regard to the phosphorus extraction and the concentration of nitric acid at the end of the extraction.

Peat, or samples Nos. 40, 41, and 42, afford an interesting observation. The carbonates of the surface layer reduce the acid concentration to about one-sixth of its original strength. In spite of that, the phosphorus recovery was practically complete. In the subsoil layer, number 42, the acid concentration was over four times as great as in the surface layer, yet the phosphorus recovery was reduced to 70 percent. Again, with the acid in the subsurface layer, number 41, slightly weaker than that in the subsoil layer, the recovery was complete. There was even some stimulating effect noticed on the soil phosphorus.

Very little or no correlation could be traced if one compares, in this respect, the surface, subsurface or the subsoil layers by themselves. Noticing the fact that the subsoil layer of the peat soil contained a considerable amount of clay particles or mineral matter, it suggests for itself that the mineral portion of the soil forces phosphorus to react in the way here observed. It would seem probable that some double salts of phosphorus with iron or aluminum or with both are formed that are less soluble than the calcium, iron and aluminum phosphates. The presence of silica in the form of silicic acid perhaps has considerable influence on the formation of these complex combinations. However, the presence of bases commonly found in the soil is evidently essential for their formation. The silica of the quartz sand, which was rather coarse in texture, prevented some phosphorus from recovery, as one notices from Figure 4, in which data of another experiment are shown where different amounts of phosphorus were added to 25 gms. of quartz sand and later extracted with fifth normal nitric acid. The influence of silica (with or without certain bases) on the behavior of phosphorus is under further investigation.

In conclusion, I wish to emphasize the fact that the phosphorus, which fifth normal nitric acid fails to extract from a given soil, exists in the soil in such a complex combination that even subsequent extractions with fresh nitric acid of the same strength fail to bring the phosphorus in solution. Two soils, brown silt loam and brown gray silt loam, were treated with either Tennessee rock phosphate or double acid phosphate. The extractions with nitric acid were filtered and washed four times with warm distilled water. The residue was treated with fresh nitric acid, and the procedure was repeated five times. The results are presented in Table 5 and show that but a relatively small amount of phosphorus was extracted from those soils after the first extraction, and the amount was decreasing with every subsequent extraction.

The time at my disposal here precludes the possibility of discussing the various factors that influence the behavior of phosphorus in soil. This will be published elsewhere later in a report. The presented paper, being its integral part, will be reproduced in its essential features.

CONCLUSIONS

The foregoing data, it seams, justifies the following conclusions:

1. When phosphorus in the form of phosphatic fertilizers is applied to ordinary mineral soils, it becomes considerably less soluble in fifth normal nitric acid than phosphorus of the same material before application.

2. Peat soil, as an exception, does not depress the recovery of phosphorus under the same conditions.

3. After phosphatic fertilizers are applied to the soil, the recovery of phosphorus from soil treated with double acid phosphate is not any greater than the recovery of phosphorus from the same soil treated with natural rock phosphate, using fifth normal nitric acid for the solvent in each case.

4. After the first extraction with fifth normal HNO_3, the subsequent extractions with fresh acid fail to extract a considerable amount of additional phosphorus. Five counsecutive extractions fail to recover the entire amount of phosphorus applied either in the form of rock phosphate or double acid phosphate.

TABLE 1.

Phosphorus content of phosphatic fertilizers used.

	Percent Phosphorus	Amount of material containing 4 mgs. of Phos.
Tennessee Rock Phosphate	13.8	.0290 gms.
Double Acid Phosphate	19.94	.0201 "
Slag A	8.40	.0476 "
Slag B	9.30	.0430 "
Slag C	5.79	.0691 "
Slag D	6.61	.0605 "
Birmingham Slag	8.55	.0468 "
Blue Rock	13.05	.0306 "
Florida Soft Rock	14.77	.0271 "
Apatite	12.36	.0324 "
Iron Phosphate	16.36	.0244 "
Aluminum Phosphate	17.09	.0234 "
Acid Phosphate	9.54	.0419 "
Steamed Bone Meal	14.81	.0270 "

TABLE 2.

Percent phosphorus recovery from Tennessee rock phosphate and double acid phosphate after different soils were treated with these substances in proportion of 4 mgs. of phosphorus per 25 gms. of soil; fifth normal nitric acid was used for extraction.

	Description of soils.	Soil Survey Numbers.	Percent Phosphorus Recovery: From Rock Phosphate.	Percent Phosphorus Recovery: From Double Acid Phosphate.	Deviation + or —	Deviation Squared.	Alkali required per 10 c.c. extracted solution.
		PRAIRIE SOILS.					
1	Brown silt loam.......	7729	45.5	48.3	—2.8	7.84	11.4
2	Brown silt loam passing into yellow clayey silt	7730	35.3	36.8	—1.5	2.25	11.4
3	Yellow clayey silt with till	7731	0.2	0.0	+0.2	.04	0.2
4	Brown silt loam.......	7741	55.2	61.5	—6.3	39.70	10.6
5	Brown silt loam with some yellow	7742	47.7	47.7	0.0	......	10.7
6	Yellow clayey silt with some brown	7743	43.5	44.2	—0.7	.49	11.3
7	Brown silt loam.......	7765	50.2	49.2	+1.0	1.00	11.3
8	Brown silt loam with some yellow.........	7766	37.7	33.5	+4.2	17.64	11.2
9	Yellow clayey silt, more silty with depth.....	7767	42.5	41.5	+1.0	1.00	11.0
10	Black clay loam to dark brown	7840	66.3	65.8	+0.5	.25	12.4
11	Drab to black clay loam	7841	66.0	64.5	+1.5	2.25	12.6
12	Yellow to brownish yellow and drab clay...	7842	53.0	53.8	—0.8	.64	11.9
13	Black clay loam with some sand	7825	58.0	55.7	+2.3	5.29	12.2
14	Black clay loam, some gravel and sand.....	7826	49.5	50.0	—0.5	.25	12.1
15	Drab to olive colored clayey silt	7827	45.3	43.5	+1.8	3.24	11.8
16	Drab clay loam, dark..	7843	60.0	59.0	+1.0	1.00	10.0
17	Drab clay loam, lighter at 12"...............	7844	56.7	65.0	—8.3	68.90	10.2
18	Drab silty clay, pebbles and lime	7845	18.0	27.2	—9.2	84.64	10.5
19	Brown gray silt loam on tight clay........	7801	61.5	68.7	—7.2	51.84	9.3
20	Gray silt loam.........	7802	58.7	58.7	+0.0	......	8.9
21	Yellow to grayish clayey silt	7803	37.5	37.0	+0.5	.25	4.7
22	Brown sandy loam.....	7849	66.3	67.2	—0.9	.81	9.8
23	Brown sandy loam, some sand	7850	56.8	53.5	+3.3	10.89	10.1
24	Yellow sand, some silt.	7851	45.8	42.5	+3.3	10.89	4.2
		TIMBER SOILS.					
25	Yellow gray silt loam on gravel	7816	54.7	49.2	+5.5	30.25	12.0
26	Yellow silt loam.......	7817	46.0	43.0	+3.0	9.00	11.9
27	Yellow clayey silt, some gravel	7818	50.5	45.8	+4.7	22.09	11.8
28	Yellow silt loam, brownish, gravelly	7858	70.5	68.5	+2.0	4.00	10.6
29	Yellow silt loam to yellow sandy loam..	7859	63.8	66.8	—3.0	9.00	11.4
30	Yellow silt to gravelly sandy silt	7860	62.3	62.0	+0.3	.09	11.7
31	Yellow gray sandy loam, some brown...	7855	73.0	73.5	—0.5	.25	12.0
32	Yellow sandy loam, some gray	7856	68.7	73.2	—4.5	20.25	12.1
33	Yellow sand, little silt..	7857	68.0	69.5	—1.5	2.25	12.1

TABLE 2—Concluded.

	Description of soils.	Soil Survey Numbers.	percent Phosphorus Recovery From Rock Phosphate.	percent Phosphorus Recovery From Double Acid Phosphate.	Deviation + or —	Deviation Squared.	Alkali required per 10 c.c. extracted solution.
	TERRACE SOILS.						
34	Brown sandy loam.....	7852	65.7	64.2	+1.5	2.25	12.0
35	Brown sandy loam, variable	7853	46.5	44.0	+2.5	6.25	12.1
36	Yellow sand, some clayey sand	7854	34.8	34.0	+0.8	.64	12.0
	RIVER AND BOTTOM SOILS.						
37	Brown mixed loam.....	7861	48.5	50.0	—1.5	2.25	9.90
38	Brown mixed loam.....	7862	42.5	46.3	—3.8	14.44	10.5
39	Yellowish brown loam, some sand	7863	54.9	54.0	+0.9	.81	11.3
40	Black decomposed peat, shells	7870	102.0	101.0	+1.0	1.00	2.1
41	Black peat	7871	110.8	113.0	—2.2	4.84	7.0
43	Black to brown peat, drab clay at 30"....	7872	66.8	70.0	—3.2	10.24	8.8
	Algebraic sum				—15.6	451.	
	Mean deviation........				—.37		

$$\text{Standard deviation} = \sqrt{\frac{\Sigma D^2}{N} - M^2} = \sqrt{\frac{451}{42} - .137} = 3.256$$

$$Z = \text{ratio of mean deviation to standard deviation} = \frac{.37}{3.256} = .113$$

TABLE 3.

Recovery of phosphorus from different phosphatic fertilizers applied to Brown Silt Loam. In each case 4 mgs. of phosphorus was applied per 25 gms. of soil.

	Mgs. Phosphorus extracted	Percent Phosphorus extracted	Alkali required per 10 c.c. of extracted solution
Tennessee Rock Phosphate.....	2.35	58.8	11.6
Slag A	2.12	53.0	11.4
Slag B	2.11	52.8	11.4
Slag C	2.16	54.0	11.4
Slag D	2.33	58.3	11.4
Birmingham Slag	2.23	55.8	11.5
Blue Rock	2.28	57.0	11.6
Florida Soft Rock............	2.37	59.3	11.6
Apatite	2.40	60.0	11.6
Iron Phosphate	1.91	47.8	11.7
Aluminum Phosphate	2.32	58.0	11.6
Acid Phosphate	2.29	57.3	11.6
Steamed Bone-meal	2.15	53.8	11.6
Soil, alone			11.7
Acid, alone			12.7*

* 10 c.c. of distilled water was used to wet the soil after fertilizer was added to it. In order to make the results comparable, 10 c.c. of water was added to 250 c.c. of acid before titration.

TABLE 4.

Phosphorus extracted with distilled water and fifth normal nitric acid from different phosphatic fertilizers. 250 c.c. of either acid or water were used on fertilizer which contained per sample 4 mgs. of phosphorus.

	Water Soluble		Fifth normal HNO_3 Soluble		
	Mgs. Phos. extracted	Percent Phosphorus recovery	Mgs. Phos. extracted	Percent Phosphorus recovery	Alkali required per 10 cc. extracted solution
Tennessee rock phosphate...	.08	2.0	3.94	98.6	13.0
Double acid phosphate......	3.60	90.0	4.19	105.0	13.0
Slag A	0.0	0.0	3.89	97.3	12.9
Slag B	.03	.8	3.98	99.5	12.9
Slag C	.23	5.8	4.05	101.0	12.8
Slag D	.06	1.5	4.02	100.5	12.8
Birmingham Slag	.09	2.3	3.96	99.0	12.9
Blue Rock	.16	4.0	4.02	100.0	13.1
Florida Soft Rock..........	.09	2.3	3.98	99.5	13.0
Apatite	.01	0.3	4.08	102.0	13.0
Iron phosphate	.15	3.8	3.72	93.0	13.1
Aluminum phosphate	.22	5.5	4.07	101.8	13.1
Acid phosphate	3.40	85.0	3.88	97.0	13.1
Steamed bone meal	.20	5.0	4.01	100.2	13.0
Acid alone					13.1

TABLE 5.

Recovery of phosphorus from 25 gms. of Brown Silt Loam and Brown Gray Silt Loam treated with 4 mgs. of phosphorus of either Tennessee Rock Phosphate or Double Acid Phosphate. Five consecutive extractions were made with fifth normal nitric acid.

	Brown Silt Loam		Brown-gray Silt Loam	
	with Rock Phosphate	with Double Acid Phosphate	with Rock Phosphate	with Double Acid Phosphate
First extraction in Mgs. P......	1.86	1.75	3.02	3.10
Second " " " "......	.47	.46	.25	.24
Third " " " "......	.24	.21	.09	.10
Fourth " " " "......	.13	.12	.02	.05
Fifth " " " "......	.09	.02	.00	.01
Total " " " "......	2.79	2.56	3.38	3.50
Percent of phosphorus recovery in first extraction............	46.5	43.8	75.5	77.5
Percent of phosphorus recovery in all five extractions.........	69.8	64.0	84.5	87.5

NOTES ON THE QUANTUM THEORY AND RELATIVITY

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It has been shown by A. Sommerfeld that the fine structure of the lines of the Balmer series of the hydrogen and helium spectrum can be explained by a simultaneous application of the quantum theory and of relativity to the elliptic orbits of the electron revolving around the nucleus. The mass of the electron varies in its stationary elliptic motion according to the expression given by relativity, but during the jump of the electron from one stationary orbit to another one the mass is supposed to be constant in spite of the fact that this motion is accompanied by radiation, i. e., by emission of energy, and that the emission of energy is accompanied by a loss of mass of the radiating system, according to the equation

$$dm = \frac{dE}{c^2}$$

which holds in relativity as well as in classical electrodynamics if we assume an electromagnetic momentum in a beam of light. When the electron jumping from one orbit to another one loses energy $\triangle E = E_b - E_e = hv$, then it should also lose mass $\triangle m = \frac{hv}{C^2}$ in a discontinuous process. These masses $\triangle m$ would be the smallest particles at present suggested by our theories. It is surprising that they do not make themselves felt in the theory of the fine structure of the helium and hydrogen lines, nor in the doublets of the Roentgen spectra, where they are of considerable magnitude. There is probably a compensation in the mass.

A second remark is related to the previous one. The quantum theory and the theory of relativity seem to be at variance. The experimental basis of the quantum theory is much broader than that of the general theory of relativity. It may be that between the quantum theory and the generalized phenomenological theory of the electromagnetic field there exists a relation similar to that between the kinetic theory of the gases and the phenomenological gas equation $pv=RT$. What becomes of the four dimensional continuum of space and time if it has to be atomized or quantified?

PAPERS ON GEOGRAPHY AND GEOLOGY

THE ORIGIN OF THE CAHOKIA MOUNDS (ABSTRACT)

MORRIS M. LEIGHTON, ILLINOIS GEOLOGICAL SURVEY, URBANA

During the recent explorations which have been carried on by Doctor W. K. Moorehead of Andover, Massachusetts, under the auspices of the University of Illinois, four widely scattered mounds of the Cahokia group, northeast of St. Louis, ranging in height from 10 to 35 feet, have been trenched and opportunity afforded for the study of their constitution, structure, and in one case, their relations to the underlying materials of the alluvial filling of the Mississippi Valley. The Illinois Geological Survey was invited to make a geological examination, resulting in the accumulation of evidence decisively favoring the artificial mode of origin of at least those mounds which have been opened and examined. This conclusion is re-enforced by the artificial form of the mounds, their orientation, their grouping, and their geologic setting. Monks Mound, the dominating unit of them all, has not as yet been trenched or tunneled, and hence a positive conclusion can not be drawn as to its origin; but the materials revealed by auger borings made by the writer on the summit and slopes of the mound and its artificiality of form are suggestive that at least a large part of it is due to the work of man.

A full report of the geologic aspects of the Cahokia Mounds is now in press and will appear as Part II of a bulletin of the University of Illinois which treats of the explorations made up to and including the fall of 1922.

THE USE OF MOLLUSCAN SHELLS BY THE CAHOKIA MOUND BUILDERS*

Frank Collins Baker, Museum of Natural History, University of Illinois

The use of the Mollusca by aboriginal man has received scant attention from students of the Mollusca. Stearns,[1] many years ago, published a very able paper on the use of molluscan shells as primitive money, but the wide use of shells for many purposes has been noted almost exclusively by ethnologists. Figures and descriptions of these are scattered through the reports and bulletins of the Bureau of American Ethnology and in papers and reports by archeologists. One of the best summaries of the use of molluscan shells may be found in Moorehead's Stone Age in America, pages 117-133.

The excavation and study of the Cahokia group of mounds near East St. Louis, Illinois, carried on by Professor W. K. Moorehead under the auspices of the University of Illinois, has given unusual opportunity to study the use of the Mollusca by the ancient Mound Builders, at least in this region.

The molluscan shells may be divided into two groups: those of marine origin and those gathered from near-by streams and ponds—fresh water shells. The latter may be considered first.

FRESH WATER MOLLUSCA

An examination of the region about the Cahokia Mounds indicates that there were numerous bodies of water as well as creeks (and the Mississippi River) from which mollusks could be obtained. The collection contains specimens from both creek and river, as well as a few from ponds and swales.

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* Contribution from the Museum of Natural History, University of Illinois, No. 31.

1. Ethno-Conchology: A Study of Primitive Money. By R. E. C. Stearns. An. Rep. Smithsonian Institute, 1887, Part II, page 297.

MUSSEL SHELLS PROBABLY OBTAINED MAINLY FROM THE MISSISSIPPI RIVER

Elliptio dilatatus (Raf.) Spike or Lady-finger. Common. A fine specimen of this shell, which had been made into a nose or ear ornament, was found at a depth of 20 feet in the James Ramey Mound. The purple nacre of the interior was beautifully preserved.

Proptera alata megaptera Raf. Pink Heel-splitter. An effigy representing a human head was found in the Sawmill Mound (a burial structure) made from a piece of this shell. A gorget or ornament of peculiar design made from this species was found in burial mounds 19, 20, 21 (overlapping mounds). This species was not common.

Megalonaias gigantea (Barnes) Washboard. A medium sized specimen from the James Ramey Mound had been made into a shell hoe. Very rare. Fragments believed to be of this species were found mixed with deer bones.

Amblema costata Raf. Three-ridge. Found in all mounds, common. One specimen from James Ramey Mound made into a hoe.

Amblema peruviana (Lam.) Blue-point. Rare.

Quadrula quadrula Raf. Maple-leaf. Common.

Quadrula cylindrcia (Say.) Rabbit's-foot. Rare.

Cyclonaias tuberculata (Raf.) A specimen (broken) from mounds 19, 20, 21, had been used as a hoe. Rare.

Truncilla truncata Raf. Deer-toe. Rare. Found at depth of 21 feet in James Ramey Mound near the bottom of the structure.

Lampsilis fallaciosa (Smith) Simpson. Slough Sand Shell. Rare.

Lampsilis anondontoides (Lea). Yellow Sand Shell. Not common.

Lampsilis siliquoidea (Barnes). Fat Mucket. Not common.

Lampsilis ovata (Say). Pocket-book Mussel. Rare. A specimen from the cemetery at Pittsburg Lake, south of the Cahokia group, had been used as an ornament, several holes being drilled in the side.

Lampsilis ventricosa (Barnes). Pocket-book Mussel. Specimens of this mussel were common in all mounds and fragments occurred in village site debris. Two specimens from Pittsburg Lake cemetery had been variously cut along the anterior margin. It is thought that these were used as scoops or spoons.

Ligumia recta latissima (Raf.) Black Sand Shell. Rare.

SNAIL SHELLS

Anculosa praerosa (Say). River Snail.

This snail was used largely for beads. The side was ground until a perforation was made into the cavity of the body whirl and the shells could then be strung on threads or cords through this hole and the natural opening at the aperture. Shells thus prepared were common in the James Ramey Mound at various depths and also in other mounds.

Campeloma subsolidum (Anthony). Large River Snail.

This shell, which in life has a beautiful green epidermis, was also esteemed by the mound builders and used as beads in the same manner as Anculosa described above. These shells occurred in the mounds and in the village site material.

Campeloma ponderosum (Say). Heavy River snail. Rare. Two specimens were found in the James Ramey Mound.

Pleurocera acuta Raf.

A few specimens of these slender river snails were found in the James Ramey Mound. Their practical use is not indicated by marks on the shells.

Near the bottom (21 feet depth) of the James Ramey Mound, as well as in other mounds, a number of fresh water shells were found which evidently were not used by the aborigines for ornamentation or domestic use but were included when the mound was built. If the material from which the mounds were built was in part taken from the border or bottom of ponds which were dry in summer but contained water in the winter and spring, such mollusks as here indicated would be included. They occur abundantly in such locations in all parts of Illinois.

It is possible also that this depth (21 feet) marked the base of the mound and these shells may have lived in a swale on the original site of the mound. Three species were found, as follows: *Physa gyrina* Say, *Planorbis trivolvis* Say, *Lymnaea reflexa* Say. One specimen of *Planorbis trivolvis* was found in the upper eight feet of the mound. This must have been contained in the material used in erecting the mound.

Professor M. M. Leighton collected several shells from other mounds during his geological examination of this region. These are noted below. *Planorbis trivolvis* Say, *Segmentina armigera* (Say), *Lymnaea palustris* (Müll.) (fresh water shells): *Helicodiscus parallelus* (Say), land shell. From Sam Chiucallo's Mound, on outskirts of East St. Louis, Ill. These probably were included in building material.

Physa gyrina Say, *Vivipara contectoides* W.G.B., *Anodonta grandis* Say.

Fresh water snails and paper shell clam from the Kunnemann Mound. These probably were included in building material.

Nineteen species of fresh water shells are listed above as occurring in the mounds and as being used by the Indians for some purpose. Seven additional species probably were included in building material. The first mentioned species doubtless were used largely as food, for the ancient aboriginee, like his more modern descendant, probably esteemed this bivalve as a valuable part of his menu. The curious and brightly colored shells of the clams and the form of the snails doubtless attracted his attention and suggested ways in which they could be used for practical use as well as for bodily ornamentation. The shell gorgets and effigies also indicate that the large flat surface of some of the mussels created an art impulse which is reflected in these curious objects.

MARINE MOLLUSCA

That the Mound Builders and other aboriginal inhabitants of America were traders is evidenced by the presence of many marine shells which evidently came from the west coast of Florida or from the Gulf coast of the southern states. That certain of these mollusks were highly esteemed is shown by the number of fragments and finished objects made from at least one of these marine snails. It is probable that the canoes of the more southern tribes ascended the Mississippi River and barter was carried on between them and the Cahokia Indians.

Busycon perversa (Linn.). Marine Conch.

This mollusk, so common on the Gulf and Atlantic coast of the United States, is the most abundant snail in the Cahokia Mounds. Hundreds of specimens of the heavy axis occurred in the James Ramey Mound from top to bottom. This part evidently was used to make a drill, and it may also have been used for ornamental purposes. Beads, nose and ear ornaments, and gorgets were made from parts of this shell. A dipper made from the body whorl of this species was found in burial mounds 19, 20, 21. A gorget made from the side of the body whorl was found in the Sawmill Mound with skeleton No. 10.

Busycon carica (Gmelin). Marine Conch. Two specimens of this species were found in the James Ramey Mound.

Busycon pyrum (Dillwyn). Marine Conch. One specimen of this small conch was found in the James Ramey Mound.

Strombus pugilis alatus Gmelin. Stromb Conch. One perfect specimen and a fragment of this species were found in the James Ramey Mound. Used as nose or ear ornament.

Fasciolaria gigantea Kiener. A portion of the axis of this largest of American marine snails was found in the James Ramey Mound.

Fasciolaria distans Lamarck. A single specimen of this Banded Snail occurred in the James Ramey Mound. Its probable use was not indicated.

Oliva litterata Lamarck. Olive Shell. The spire of this specimen had been removed and it might have been used as a bead or as a pendant from a string of beads. From the James Ramey Mound.

Littorina irrorata Say. Periwinkle. A single perfect specimen was found in the James Ramey Mound. Its use was not indicated.

Rangia cuneata Gray. Marine Clam. Left valve of a medium sized specimen found at a depth of 12 feet in James Ramey Mound. Also found with surface material.

Marginella apicina Menke. This small marine snail occurred in abundance, especially in the James Ramey Mound. This species was used largely for the purpose of making beads, the side of the shell being ground down to the natural cavity, as in the case of the fresh water shells Anculosa and Campeloma. The number of specimens found indicates that this shell was a favorite for this purpose. A singular fact, through perhaps without significance, is that these shells were found only in the James Ramey Mound, none occurring in any of the burial mounds thus far examined. In the mound mentioned they were found at several levels between 1 and 12 feet below the summit, and from 20 feet deep to the base of the mound, 23 feet below the summit.

Ten species of marine shells have been found in these mounds, all but one being gastropods. Three of these species were used definitely for ornamentation, either as beads, nose ornaments, or gorgets. It is possible that these other species will be found to have been used for the same purposes when other mounds are examined.

COMPARISON WITH HOPEWELL MOUNDS OF OHIO

It is of interest to compare the mollusks found in the Cahokia group with those preserved in the Hopewell group of mounds in Ohio (Moorehead, Publication 211, Field Museum of Natural History, 1922). An examination of the collection on exhibition in the Field Museum shows that apparently only four species are common to both mound groups, *Busycon perversa, Fasciolaria gigantea, Cyclonaias tuberculata* and *Amblema costata,* the last two fresh water mussels.

Two large and characteristic species of Mollusca occur in the Hopewell group that are absent from the Cahokia group, *Cassis madagascariensis,* and *Cypraea exanthema.* This may indicate a different trade route, perhaps with different tribes, because these shells would appeal to the aboriginal mind on account of their size and striking appearance as well as attractive colors, and would have been sought eagerly by the Cahokia people.

These shells are found on both sides of the Floridan peninsula, their distribution including the east coast of Texas. The finest specimens, however, occur in southern Florida and in the West Indies.

The Hopewell people used these large shells (some of which are larger than any recent specimens the author has seen) for dippers and perhaps for drinking vessels. The interior whorls are usually removed, leaving only the large outer or body whorl. *Busycon perversa* is also of large size and seems to have been used as a dipper. Of these large shells, several were found with skeletons. The following were noted:

Cassis madagascariensis with skeleton 241 in mound 8; skeleton 192, in mound 4; as ear ornaments 8 inches long with skeleton 281 in mound 25. *Cypraea exanthema* with skeleton 191 in mound 4. *Amblema costata* with skeleton 173 in mound 20. A fragment of *Cyclonaias tuberculata* was observed with other mussel fragments.

It is noteworthy that in mounds in Calhoun County, Illinois, the large *Cassis madagascagiensis* occurs and is the same form as found in the Hopewell Mounds. This might indicate a different route of barter from that of the Cahokia group, possibly overland from Indiana and Ohio. That this large shell should be absent from the Cahokia Mounds is significant. Beads of *Anculosa praerosa* are more abundant in the Calhoun County mounds than in the Cahokia group.

The builders of the Hopewell mounds used shell beads, made of both marine and fresh water shells, to a marked degree, thousands of these being in the collection. Baroque pearls were also in demand, judging by the number of these in the collection which had been made into beads. It is probable that valuable free pearls were used also. None of these have as yet been found in the Cahokia Mounds.

It would be of interest to both Malacologists and Ethnologists if the shells found in various tumuli left by aboriginal people could be listed accurately and the uses of the shells indicated. The present paper is a contribution toward that end. All of the material listed from the Cahokia Mounds is in the Museum of Natural History of the University of Illinois.

FISHING WITH A HAMMER

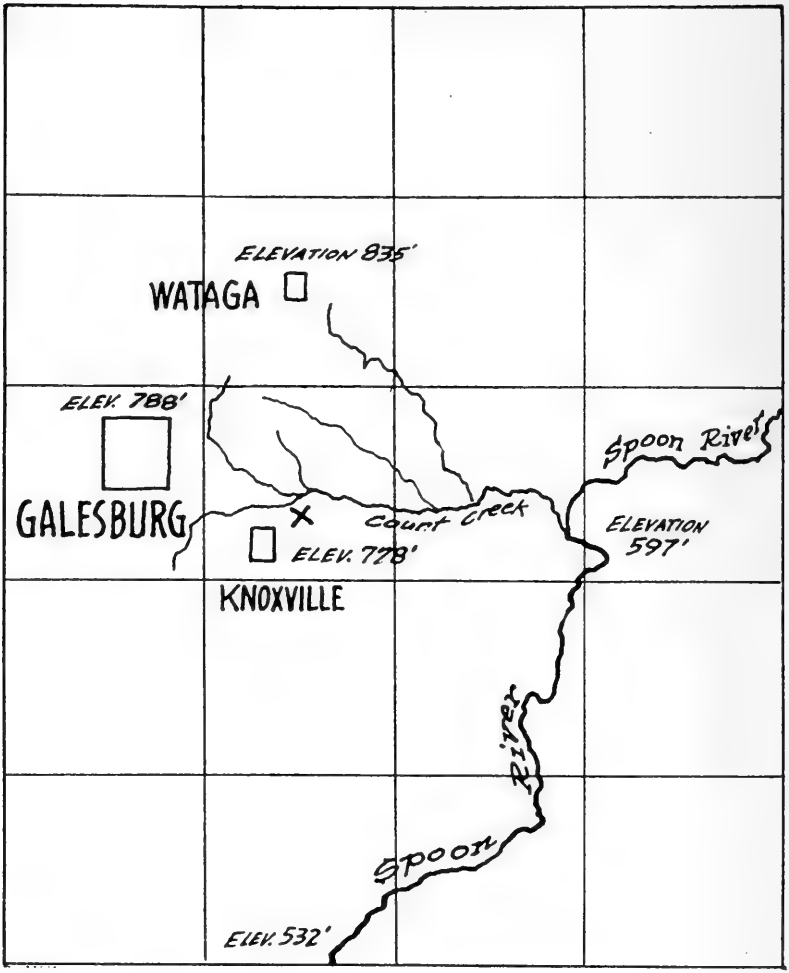
Fred R. Jelliff, President of Knox County Academy of Science, Galesburg

I presume that you all enjoy fishing with hook and line, but there is pleasure also in angling with a hammer. For a number of years I have found recreation in the examination of a layer of slate over a seam of coal five miles east of Galesburg due to the fish remains that it contains, and not merely fish but reptilian, crustacean, amphibian and molluscan. In a way it can be said to illustrate all the great kingdoms of animal life. This coal vein is probably what is known as No. 3 of the Illinois series, and it dips to the southeast at about the same angle as Court creek, so that when one reaches Spoon river he finds in places this slate and coal in its bed.

But the scene of our investigation is east of the city and is in and just above Court creek channel. On the south side of this is a high and steep bluff exposing the friable and bluish, and the ironstone layers and a heavier fossiliferous limestone and clay shale that lie above the slate. It is in this slate that one finds the remains of ancient fishes, for which but few counterparts are now known to exist.

We have compressed here in a very few feet a remarkably intermingled community of life forms. The slate varies much, some of it splitting into thin leaves, the surface of which may appear smooth save for an occasional fish spine or tubercle, and others being filled with nodules or elongated concretions that cannot be readily split. The probability is that the slate was deposited far enough from the shore to permit the accumulation of the finer vegetable sediment, for the slate is fine grained and consists of very thoroughly ground up vegetable material. In the nodules one often finds interesting specimens of the life of that ancient sea. These are composed of a much harder material than the slate, and constitute caskets around the remains of what were once organic beings. Usually by a careful application of the hammer on one end, the nodule will split open and disclose the specimen.

KNOX COUNTY, ILLINOIS.



X — Where fish remains were found.

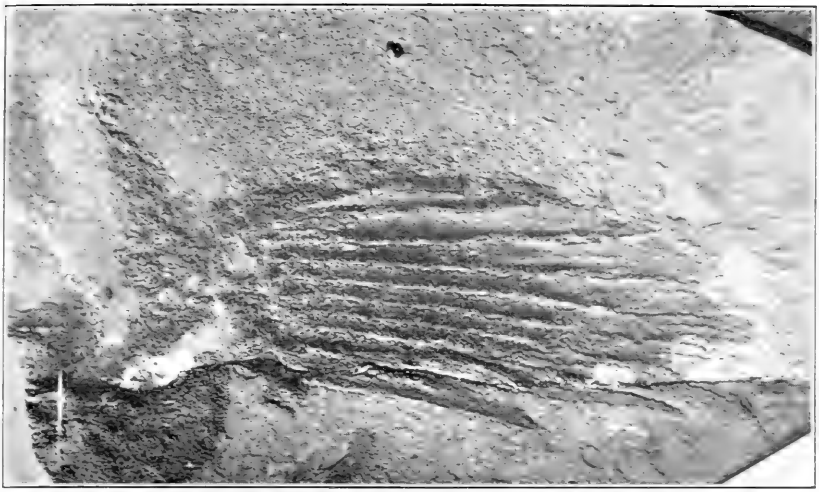


Fig. 1. Fin or paddle like form, order and species undetermined. Bony structure indicated, with what seems impression of integument.

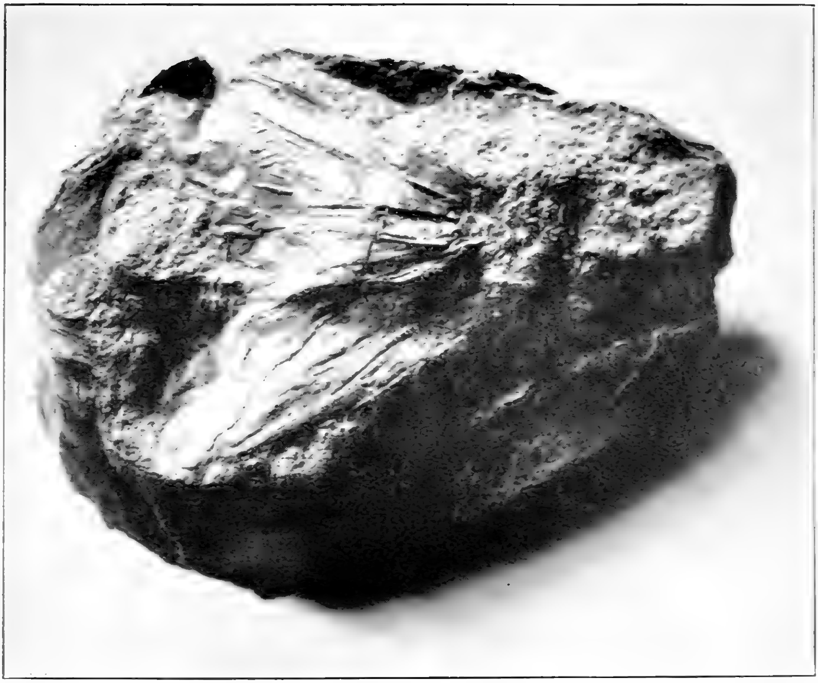


Fig. 2. May be caudal fin of crustacean. Other specimens have extending from this what appear jointed structures.

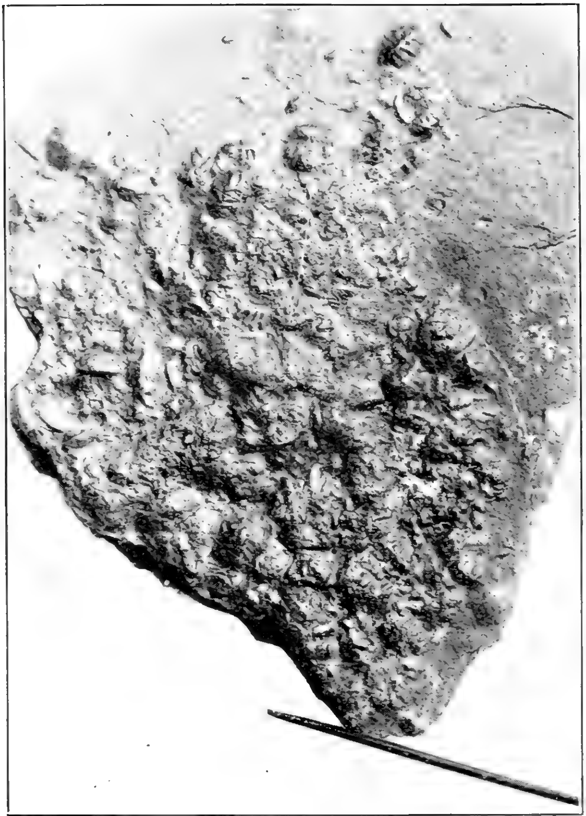


Fig. 3 Tubercles of shark, here massed together, often found singly.

In speaking of the preserving characteristics of this slate, Professor E. D. Cope, the noted paleontologist, wrote. "It will be worth while to make further examination in the slates, which are the best I have seen for the preservation of paleozoic fishes."

Among the animals thus found encased are large types of what for lack of a better English name I will call water fleas, a simple type of crustacean, some with carapaces or body casements plain, and some with carapaces covered with many lines of minute scales. Extending back from the sinus, or incurved beak portion, were several segments that terminated in two spines. This is true at least of some of the species. Creatures allied to this crustacean type are now quite small and are found in ponds, but in the slate one can find the carapaces alone from three to six or more inches long. From the abundance of the remains, one is forced to believe that these creatures constituted one of the leading features of the life of that sea or estuary, that they were of many varieties, and that they attained not merely great size but had their own beauty of form and motion.

In the slate are found also species of nautilus and parts of large shells of this order, some enclosed in nodules and some not. In fact, on top of one slab I found a large nautilus, six inches in diameter. In addition, in some of the lower layers one often discovers numerous scallop shells, types of which are contained both in the slate and the overlying layers, showing that they had a long lease of life; these are not unlike some of the forms that still exist.

Also quite frequently seen are the elegantly preserved parts of what some of our authorities call the wings of insects, but which from the numerous specimens examined seem to me the caudal or tail fin of a crustacean. In addition there have been noticed what appeared to be distorted fragments of a larger species of crab. On one leaf there was part of the skeleton perhaps of an amphibian, but not sufficiently defined to determine with exactness. Thus you see that there was quite a varied fauna of this minor life.

But it is the fish life that most concerns one, and it presupposes many other forms of life on which the fish subsisted, but whose remains may have been too soft to have been preserved. Still there are numerous marks and tracings on the slate which seem to reflect a multiplicity of forms, and not the least of these are what are presumed to be the teeth of mollusks.

One Thanksgiving day a number of years ago I split open a slab of this slate about two feet square and was about to strike it again when my attention was attracted by a row of sharp teeth along extended jaws or mandibles. At the same time there appeared over the surface of the slab a series of bones still showing the bony structure, and from them ran what seemed a short segment of the backbone. Stout spines, two or three in number, were back of the jaws some distance. The teeth were keen pointed and less than half an inch in length, with denticles each side extending up from the base of the tooth. Some of these teeth showed a curvature backward.

I sent the specimen to Professor Cope, then a recognized authority on fishes, and he became greatly interested in it, as it threw some light on controverted points regarding ancient fishes. He made the specimen, which he described as that of a paleozoic shark, the subject of a scientific description in a work that he was then getting out. Judging from the size of the jaws and the connecting bones of the skull, it was a shark of considerable size, and considering the teeth and their extreme sharpness, was capable of doing much execution on the other denizens of the water. Such backward curved teeth surely gave it ability to hold what it once gripped.

At the same time I sent Professor Cope another type of fish from the same formation, but evidently of different habits and adapted to other forms of food. It appeared to be somewhat reptilian in shape , with its long narrow head and the extension backward of the jaws. But its mouth was filled with crushing or pavement teeth, that is, teeth rounded on top with a raised center and somewhat corrugated. The dentition was thus in sharp contrast to that of the shark previously described. From the general appearance one would judge that this crea-

Fig. 4. Carapace of Ceratiocaris, water flea, abounding in slate, and of several varieties.

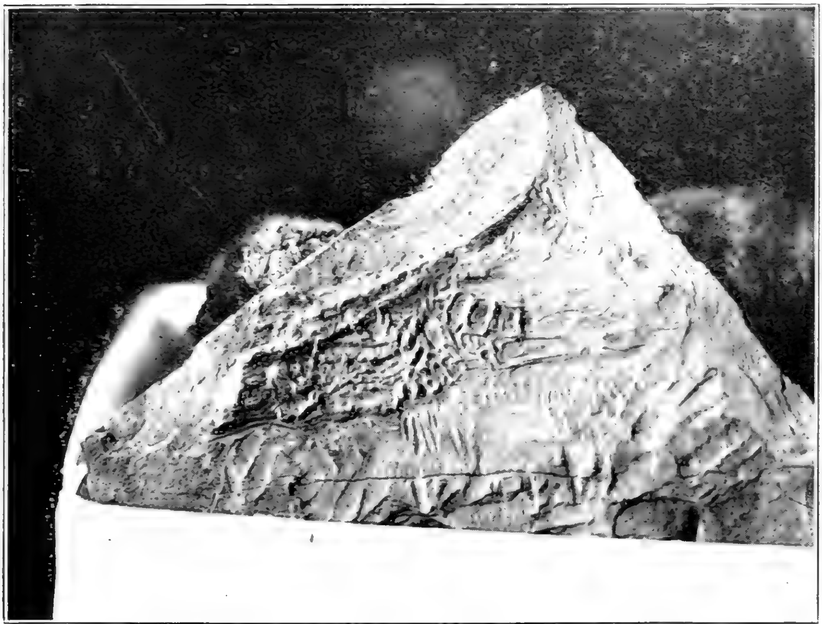


Fig. 5. Fish spine, with outward edge dentate, and what appears fin attached to other edge.

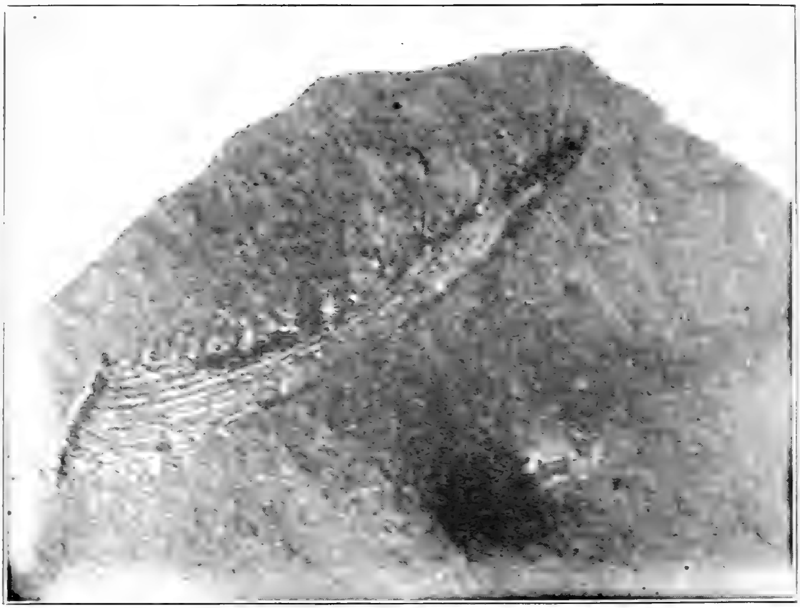


Fig. 6. Single fish spine. Listracanthus. A large slab shows number of these in connection with spicules, that appear to pass upward into these spine forms.

ture was capable of great speed, for back of the head there are the rays of powerful fins. You might ask what use this fish had of crushing teeth, and the answer would be that perhaps it fed on the water fleas and other shelly creatures that would require this form of dentition. Such teeth assumed a decided variety of shapes, and it would be easy for one if he met them separately to ascribe them to different species.

There were still other shark forms and there are indications that these also were of large size. Their remains are, however, so scattered that it is hard to frame a definite idea of their outlines. I found, for instance, a finely ornamented spine eight inches long that must have extended a considerable distance above the back. It has ridges running its full length and along these there are strings of little black knobs. As one looks at this specimen he can almost imagine a hungry shark with its dorsal or top fin attached to this ornamental spine cleaving the water, in zealous pursuit of its prey.

The tubercles that abound in the integument of certain sharks are frequent and are found at times in considerable number, clusters or masses. These are star-shaped with a raised center and with a base about a quarter of an inch in diameter.

Then there are other sharks that had numerous spines in the integument. Formerly I thought that these spines must be solitary, placed for instance on the backbone, but more recently I have found a large specimen that would indicate that they might have been scattered over the shark and in all stages of development, ranging from those shaped like a small v to those with three ribs and those of more up to a dozen, all apparently secured in the integument and so forming quite a defense. These or similar spines have occasionally a length of three to four inches, while still others, evidently of a different genus, are of a tapering spindle-like shape.

Some have tried to connect up these spine finned fishes with the Port Jackson shark, and they may be right but there is still need of light. They must have ranged from those small to those of large size, if the spines are any criterion. There is nothing to show what the dentition was, and the shark has been named from the spines, but I am sure that it will take much study yet to settle definitely its rightful affinities.

If you wish the scientific names of these three types of sharks you will find that they are Symmorium reniforme, Orodus basilis, and Listracanthus, the first two derived from the form of the teeth and the third from the spine.

Still another shark that Professor Cope passed on had small, very sharp teeth scattered over the palate, which he named stylobasis. Needle like as the teeth were, yet judging from the massiveness of the head it was of considerable size.

Aside from these more formidable types, which must have been the terrors of that ancient sea, there were several species of ganoids, an order of fishes that exist in our own day and have their chief representatives in the gar pike and the sturgeon. One of the most beautiful fossil fishes that I ever found was a ganoid, encased in a glistening, white armor of scales, lapping up one against the other, and all prettily decorated. It was five inches long and an inch or so in height, and evidently was as perfect as when the shale was sifted over it. This also was sent to Professor Cope for determination.

Another almost perfect ganoid shows scales and characteristic tail with peculiar scale markings. One often finds a single enameled scale, and even clustered scales, and this is sufficient to show that such a fish existed. These little ganoids were elegantly shaped, and when in schools must have made a brilliant spectacle. They connect the remote past with the present.

There are some remains that have not yet been figured out. These are paddle-like remnants with rays attached to parts like those of a wrist, evidently belonging to some creature that was neither fish nor reptile. Moreover one specimen shows the delicate backbone and impression of some animal allied to the reptiles.

We have then in this deposit a decided multiplicity of life forms, some of which have relationship with the present. I remember that on one occasion while at Spoon river, thirteen miles east of this city, I was made aware that a friend had caught a large bass, for his yell of ex-

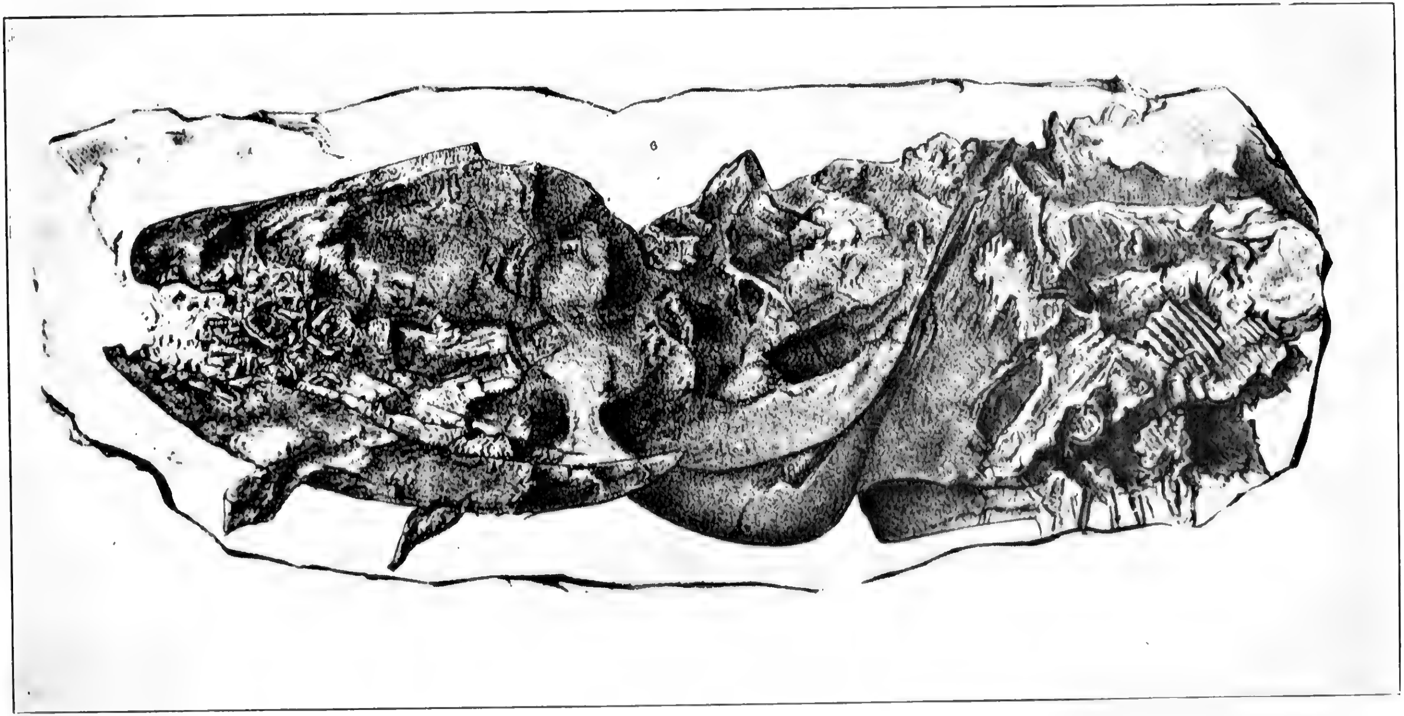


Fig. 7. Orodus basilis, shark form, anterior part, showing jaws and rounded, flattened teeth. These teeth are displayed in figures 7, 7a and 7b, plate 8.

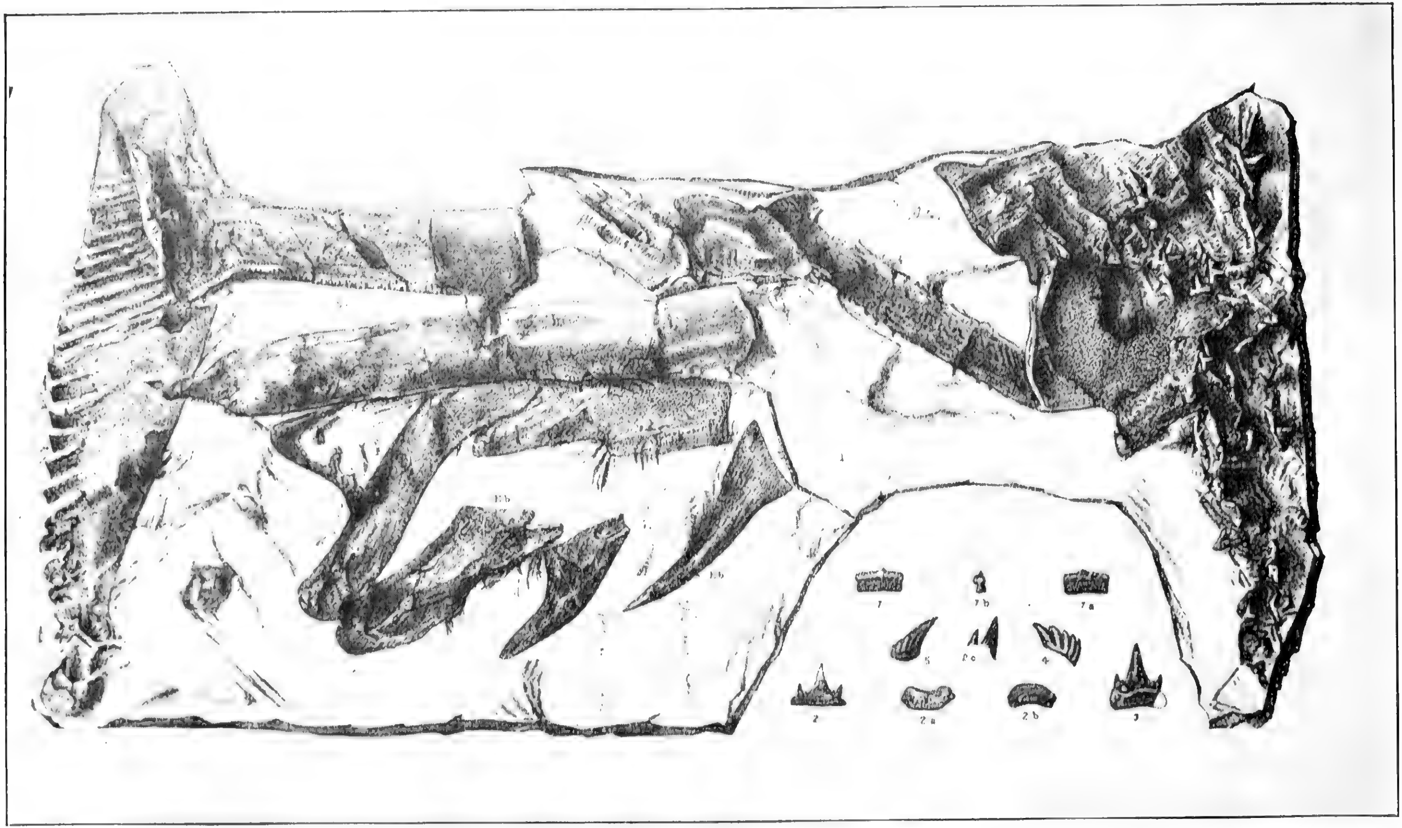


Fig. 8. Symmorium reniformis. Teeth shown not merely in engraving but in figures 2, 2a, 2b, 2c, 3, 4 and 5. Figures 7, 7b and 7c are of teeth of Orodus basils.

ultation echoed and re-echoed along the bluffs. I have read that the Director of the Geological Survey while on one of the mountains of Canada split open a rock and discovered therein a large perfect specimen of trilobite, that precursor of our modern crab, and he, too, yelled in triumph. I can assure you that when you go fishing with a hammer and split open a slab of slate and behold there the whole series of the teeth of a shark or the graceful outline of a large nautilus, or the glistening armor of a ganoid, you, also, will be tempted to make your pleasure audible.

But it all seems very strange that life should have existed so long ago on the earth and that there should be such a multiplicity of forms. Our own county furnishes a unique illustration. You may sit on a slab of slate in Spoon river bank and perhaps haul out bass, catfish, perch or sunfish, and then with your hammer find in the slate remnants of fish unlike anything that you have caught and that existed probably millions of years ago.

CORRELATIONS OF WELL DRILLINGS IN NORTHERN ILLINOIS, WITH OUTCROPPINGS OF EARLY PALEOZOIC BEDS IN WISCONSIN

A. W. Thurston, University of Illinois.

The correlation of the Lower Paleozoic formation in Illinois is somewhat difficult because of incomplete data.

The St. Peter sandstone outcrops at several places along the LaSalle anticline and in LaSalle County where its entire thickness is exposed. The Lower Magnesian or Prairie du Chien group is seen only in a few scattered outcrops and there only the top member is partially exposed. The nearest exposure of Cambrian rocks is near Janesville, Wisconsin, but most of the Cambrian formations outcrop near Madison Baraboo or farther north. These are traced into northern Illinois, a distance of 250 miles, by means of deep well records. Both the Illinois Geological Survey and the Wisconsin Geological Survey try to procure records and, if possible, to secure samples from the wells in their respective states. By this means only can subsurface formations be traced with certainty. The greater the number of well records available the more complete will be the data at hand and hence the more accurate will be the correlations that can be made.

Fossils are ground up in the well cuttings. Therefore, little or no paleontological evidence is offered to assist in the correlation of well cuttings.

The problem is entirely a stratigraphic one. The correlation is made by means of "key" horizons, or horizons which are recognized by certain peculiar characteristics which are maintained over wide areas. Formations may change lithologically from place to place because conditions for sedimentation were not the same. Nearest the shore the coarser materials are deposited. Farther out on the mud flats shale is deposited, and still farther out in quiet water lime mud which cements to form limestone is deposited. During the Jordan sea invasion central Wisconsin was near the shore, and the formation is a sandstone there, whereas during the same time northern IIllinois was farther from the shore where clear water prevailed and limestone was deposited. For the same reason sandstones in Wisconsin may become shales in Illinois. For similar reasons, formations underlying northeastern Illinois may differ from those underlying northwestern Illinois and vice versa.

Formations often pinch out laterally, giving a different stratigraphic succession of formations in northeastern Illinois from that in northwestern Illinois. Under these conditions it is necessary to have a large number of well records to note the progressive changes taking place at a distance from the out-crop.

F. W. Thwaites of the Wisconsin Survey gives the following succession of Cambrian, Ordovican, and Silurian rock formations in southern Wisconsin:

	Feet
Silurian—	
Niagaran limestone "Clinton" formation	300-670
Ordovician—	
Maquoketa shale	100-200
Galena-Platteville dolomite and limestone	200-450
St. Peter sandstone	325
Prairie du Chien	700
Shakopee limestone	
New Richmond sandstone	
Oneota limestone	
Cambrian—	
Madison limestone	50
Jordan sandstone, grades to limestone towards the south	75
St. Lawrence sandstone, grades to dolomite below	35-150
Mendota dolomite	0- 20
Devils Lake sandstone, local depth unknown	
Franconia sandstone	90-175
Mazomania sandstone, gray to red	100±
Dresbach sandstone	40-180
Eau Claire sandstone and shale	70-410
Mt. Simon, coarse to medium ss.	

Not all of these formations are recognizable in northern Illinois and probably all are not present. The Niagaran, a light gray dolomitic limestone, caps the hills in northwestern Illinois, and in Cook County it is the first stratum to be penetrated by the drill.

The Maquoketa shale lies immediately below the Niagaran, and in northwestern Illinois some difficulty is encountered in differentiating it from the clays of the glacial drift as the unindurated material above it caves and glacial pebbles fall in and re-mix with the samples.

The Galena and Platteville limestones are 170 to 450 feet thick. The Galena is dolomite; the Platteville is a calcareous shale or limestone. These formations outcrop in broad irregular belts extending north and south in north central Illinois, in east and western parts of the State. The Platteville is found only in drill records. It lies uncomfortably on the St. Peter. This is of the same general horizon if not identical with the Platten of southern Illinois. The Galena dolomite is about equivalent to the Kimmswick of Missouri.

The St. Peter sandstone outcrops in a small area near Ottawa, LaSalle, Sheridan, and Troy Grove. This is a key horizon, and the sand grains are more rounded than those of any other sandstone formation. They are perfectly sorted and are very uniform in size. The St. Peter maintains the same characteristics over wide areas. There is an unconformity at the base where it overlies the Shakopee limestone. It ranges in thickness from 65 to 325 feet.

The Lower Magnesian group is composed of three divisions: The Shakopee dolomite, New Richmond sandstone and the Oneota dolomite. Only the Shakopee outcrops in this State. The outcrops are at Split Rock near Utica and a few scattered inliers along the LaSalle anticline. Nowhere is its entire thickness exposed. The New Richmond sandstone is a medium to coarse sandstone about 20 to 70 feet thick. The Oneota dolomite is the lower member of the lower Magnesian group. It is known only in well cuttings, a light gray somewhat cherty dolomite. The three members can be recognized in the northwestern part of the State as far east as Dixon, Amboy and LaSalle. Farther east the New Richmond and probably the Shakopee are absent. If they were deposited there it is probable that they were eroded away in the post Prairie du Chien erosion period. The base of the Oneota is glauconitic and in some wells there are about 15 to 25 feet of glauconitic sandstone at the base.

Underlying the Oneota sediments are the rocks of the Cambrian period. These in Wisconsin are about 1000 feet thick, and in Illinois they have been penetrated to nearly that depth. It is from these strata that most of the artesian water in northern Illinois is obtained.

The Madison limestone is absent in the Illinois section.

The Jordan formation which outcrops as a sandstone in Wisconsin become more calcareous southward, becoming a dolomite in Illinois where it can not be distinguished from the underlying St. Lawrence limestone.

The St. Lawrence is a dolomite, either pinkish, purplish or dark gray in color. The combined thickness of the St. Lawrence and Jordan dolomites is about 150 to 175 feet; one or both of these formations are known from Dixon westward, but neither one has been recognized in the eastern part of the State.

The Mendota dolomite may be present near Chicago, but can not be distinguished from the Oneota. Its presence is indicated by the thickness of the Oneota dolomite, which is greater than that of the Oneota formation northward, and part of this increased thickness may be the St. Lawrence dolomite.

In Illinois the Devils Lake and Franconia formations are either absent or indistinguishable from the Mazomanie formation. The Mazomanie formation is a sandstone, containing some limestone and shale lenses. The sandstone is angular or subrounded, and poorly sorted. It has often been confused with the Jordan sandstone in this State. It is the first thick sandstone below the Oneota. This immediately underlies the Oneota in Kane and Dupage counties and probably in Cook and Lake counties.

The Dresbach sandstone is in most places a medium white sand. However, in Cook and Lake counties it may contain dolomite and shale. There is the possibility that the Mazomanie formation does not extend as far east as Cook County, and that the first Cambrian sandstone penetrated in Cook and Lake counties is the Dresbach, and that the dolomite and shale belongs in the Eau Claire formations which is quite variable in its lithology. This interpretation would make the Eau Claire considerably thicker there than elsewhere. The Eau Claire in the northwestern part of Illinois is a gray or pinkish sandstone with a thin shale showing in some wells. It is a rather variable formation and in northeastern Illinois it consists of shale, sandstone, or red marl. This red marl is rather persistent. In the eastern part of the State the formation is 65 to 175 feet thick. At Savanna there is a conglomerate at the base.

The Mt. Simon sandstone is an unsorted sand with medium angular to subrounded grains, which are rather coarse toward the base. This is the basal formation of the Cambrian of Wisconsin, and probably of northern Illinois also. F. T. Thwaites claims that the Dixon and Rockford wells both penetrate this formation and enter the Huronian below*. If this is true the sediments below the Mt. Simon are sandstones resembling those of the Mt. Simon. They would probably be Keweenawan sediments instead of Huronian quartzites such as occur in the Baraboo region and appear in some of the records of Wisconsin wells. It seems more probable to the writer that those lowest sandstones are of Cambrian age and belong to the Mt. Simon formation. More definite information will be available after a larger number of well samples have been sent to the Geological Survey office and studied so that the data will be more complete.

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* Norton, W. H., Hendrixon, W. S., and Simpson, H. E., Muzner. U. S. G. S. Water Supply paper 293, pp. 67-78.

PLEISTOCENE DEPOSITS IN LAWRENCE COUNTY *

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LOCATION

Lawrence County is one of the border counties between Illinois and Indiana, in the southeastern part of the state. Since at this place the Wabash river furnishes the boundary line between the two states, it forms the eastern boundary of the county. The largest tributary entering the Wabash from the west is the Embarrass river and it flows through Lawrence county to its junction with the Wabash in the southeastern part of the county. The southern border of the Illinois Drift Sheet is about thirty miles south, while the moraines marking the southern edge of the Early Wisconsin Drift Sheet are about forty miles north of the county. This portion between the edges of the two drift sheets is significant because the mantle rock which covers the county was derived chiefly from the Illinois and Wisconsin Ice sheets. (See Map.)

ELEVATION

The average elevation of Lawrence County is approximately 450 feet above sea level. The range of elevation is not great, about 250 feet. There are, nevertheless, two distinct physiographic divisions, the upland and the lowland. About one-third of the county is occupied by the lowland of the Wabash and Embarrass rivers, while the remaining two-thirds are upland. The mantle rock which covers the county are Pleistocene deposits of the Illinois and Wisconsin Ice sheets, and because of the number of oil wells that have been drilled in the county it has been possible to learn something of the character and depth of these deposits.

Since this paper deals with differences between the upland and the lowland it is necessary to point out their respective locations.

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* This paper should be read with a map of the area before one. The best map of Lawrence County is the topographic map, which may be secured from the State Geological Survey at Urbana, Illinois for from ten to fifteen cents.

The lowland lies along the Wabash and Embarrass rivers, and extends for some distance up the small tributaries. The greatest extent of lowland is along the Wabash river above its junction with the Embarrass. This lowland is narrow in the northeast corner of the county, at which place the hills of the upland push almost to the river, but extending south, it widens rapidly toward the west until it meets the lowland of the Embarrass just north of Lawrenceville, the county seat. Southeast of Lawrenceville, it narrows to a width of two miles at the junction of the two rivers, and below the junction a width of about two miles is maintained. The Embarrass river lowland enters the county from the north with a width of about three miles, and extends in a southeastern direction until it merges with that of the Wabash north of Lawrenceville.

Two tributaries enter the Embarrass river from the west, Indian Creek, about six miles above the river's mouth, and Muddy Creek in the north part of the county. From the northeast, Brushy Fork flows into the Embarrass a few miles below the mouth of the Muddy Creek. A number of artificial ditches drain the wide expanse of lowland between the Wabash and Embarrass rivers and it is significant that almost all the water from these ditches drains into the Embarrass river. The southern part of the county is drained by Raccoon Creek, which flows in a southeastern direction and enters the Wabash a few miles south of the southern boundary of the county.

The upland, occupying the remainder of the area, is divided by the Embarrass river into two portions. One is a V-shaped section in the northeastern part of the county between the lowland of the Wabash and Embarrass rivers. The other occupies the western and southern portions. This second part is comparatively narrow at the north, being about three miles in width. It widens, however, gradually, until along the southern boundary it extends across almost the full width of the county.

The upland is gently rolling, with a difference in elevation between the divides and the valleys of not over fifty feet. The valleys are wide and the divides, between the drainage basins of the small creeks, are low hills which have such slight relief as to be scarcely recognizable as divides. The lowland consists of flood plains, low and level near the rivers, and terraces that are wide but elevated only slightly above the flood plains. There are two conspicuous hills upon the wide lowland between the Wabash and Embarrass rivers, the Sand Ridge hill east of the Embarrass just opposite Lawrenceville and the Dubois hill just west of the Wabash river opposite Vincennes, Indiana.

The stratified rocks lying just beneath the loose mantle rock consist of the McLeansboro formation of the Pennsylvania series. Although these upper layers of stratified rocks lie practically in a horizontal position, the difference in the elevation of the upper surface of the solid rock is much greater than the difference in elevation of the upper surface of the soil. This is shown clearly by the following table.

SURFACE OF THE SOIL

Highest point in Lawrence county	641 feet
Lowest point in Lawrence county	391 feet
Difference	250 feet

SURFACE OF THE ROCK

Highest known rock surface	625 feet
Lowest known rock surface	249 feet
Difference	376 feet

THE MANTLE ROCK

If the unconsolidated clay, silt, sand and gravel that everywhere cover the solid rock were removed, the topography would be much rougher than at present. The upland would present a topography differing but little from the present one, although it would lie somewhat lower. The lowland, however, would lie many feet below its present surface. The Wabash river would flow from 100 to 175 feet below its present bed, and the Embarrass would join it at as low a level. Brushy Fork and Muddy creeks would join the Embarrass about 50 or 60 feet lower than at present, and Indian Creek would enter it at least 95 feet lower than at present. There would be a deep depression in the southeast part of the county under what is known as Wolf prairie where drilling has shown that it is 176 feet to solid rock. The wide stretch of country between the Wabash and Embarrass would be in places at least 100 feet lower and would no doubt be rougher, and the Sand Ridge and Dubois hills, with their crests as high as at present and their bases as low as the rivers were then flowing, would stand up as very conspicuous hills.

The question naturally arises as to the origin of the deposits of mantle rock that have covered the rougher rock topography and have given the region a comparatively gentle undulating surface. The soil under physical and chemical tests shows that it has not been derived from the rocks upon which it rests. It contains particles entirely foreign to the underlying rocks. Over the upland, resting upon the rock surface, is a pebbly bowlder clay with some sand and gravel near its basal portion. Its lower part is made of blue clay, but that within 10 or 12 feet of the surface is light yellow clay. The yellow color is due probably to weathering rather than to any original differences in composition from the blue clay. This formation is the glacial till of the Illinois Drift Sheet which spreads over southern Illinois as far south as the spur of the Ozarks.

By examining the logs of a large number of oil wells upon the upland, the variation in the depth of the mantle rock is found to be from 0 to 36 feet. Over the lowland the material of the mantle rock is different from that of the underlying rocks and very different also from the glacial till of the upland. The deposits of this portion are much thicker, showing a variation of from 60 to 176 feet. An examination of these deposits of the lowland shows that they are river laid deposits. They consist of sand, gravel, and silt. With such, the lowlands were elevated from 50 to 175 feet. The evidence given by wells, gravel pits, and any excavation that goes but a short distance below the surface of the lowland indicates that it is underlain by thick deposits of gravel. Above the gravel may be found sand, and over all the lower portions, above the sand, is silt. In places the sand has been piled up into dunes by the wind, and the higher parts of the lowland and the adjoining parts of the upland are covered with loess. The position of the Wisconsin Ice Sheet leads one to believe with scarcely a doubt that it was the source of supply for the thick lowland deposits.

The source of the Wabash is far north of the southern limit of the Wisconsin Ice Sheet. The source of the Embarrass is also north of the this same position, but it is not very far north. It rises just south of the Champaign moraine, the first stopping place of the Wisconsin Ice edge as it retreated towards the northeast. Its stop at this place was brief. The tributaries of the Embarrass, Muddy, Brushy Fork, Indian and Raccoon creeks had their sources far to the south of the Wisconsin Ice edge.

When the ice edge stood along the line which crosses the state near Shelbyville, Mattoon, Charleston and Paris, the rivers that flowed southward from it were much larger and much more heavily laden with rock material than at present. Throughout the long ages during which the ice advanced, retreated, halted, readvanced and retreated again, until its final disappearance from the region, great torrents of water were borne away by the Mississippi, Illinois, Wabash and Embarrass rivers. It was chiefly by means of the gravel, sand, and silt which the Wabash and Embarrass carried that the low lands of Lawrence County were built up from 50 to 175 feet higher than they were in pre-glacial times. Since the Wabash was a much larger river at the ice edge than the Embarrass and since it had a number of tributaries that also flowed from the ice edge, it contributed much more material toward the building up of the lowland than did the Embarrass; and since its source lies far to the north of the southern edge of the Wisconsin Drift sheet, it and its tributaries continued to furnish gravel, sand, and silt long after the ice edge had retreated north of the source of the Embarrass.

Under the circumstances described above, from the time of the farthest advance of the Wisconsin Ice sheet the Embarrass and Wabash began building up their valleys. Since the tributaries of the Embarrass, Muddy, Indian, and Raccoon creeks were not receiving supplies of gravel, sand, and silt, from the ice edge, they could not build up their valleys as fast as did the larger streams. The result was that they were damned at their mouths and ponded. Lakes covered their valleys which later were filled with lake deposits. On such a basis may be furnished the explanation for the extremely level surface of these tributary valleys.

When the ice edge retreated north of the source of the Embarrass, its supply of gravel, sand and silt were, for the most part, shut off, but the Wabash continued for a long time to build up its valley. The result was that the Embarrass was ponded for a distance up its valley. Under such conditions, it is natural for the drainage ditches, which for the most part follow the lines of old channels, to drain into the Embarrass rather than into the Wabash. This ponded condition also gives a good explanation for the meanders of the lower Embarrass. When the ice edge was near its southern position, the material carried by the Wabash was coarse and the gravel deposits were then laid down. As the ice edge retreated farther to the north, the deposits became finer, and first the sand and then the silt were laid down. When it retreated so far to the north that it was beyond the source of the Wabash and its water found a lower outlet, the river began to lower its bed by cutting through its deposits. This has proceeded only a short distance, but it left broad terraces standing only a little higher than the other portions of the lowland, and it permitted the Embarrass and its tributaries to lower their courses enough to drain the ponds in their valleys, or if they had become filled by lake deposits, it permitted these streams to lower their channels slightly below the level of the surface of those deposits.

THE USE OF THE MICROSCOPE IN THE STUDY OF SUBSURFACE STRATIGRAPHY

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For many years paleontology and lithology have been the bases for correlation of sedimentary rocks, but up to comparatively recent years only the grosser characteristics have been made use of for this purpose. It has also been customary to study the cuttings from wells for many years, but again it is only of late, with the stimulation of interest in the field of sedimentation, that a really critical examination of the lithology of cuttings has been at all extensively undertaken. With the closer study of the lithology of rocks has come either contemporaneously, or as a result thereof, the closer study of the minute or microscopic fossils.

The microscopic study of sediments, as has been implied, may be divided into two general classes, lithological and paleontological. The first concerns itself with the state of aggregation of a rock and the constituent minerals forming the aggregate. That is, it deals with the mineral composition of rocks, the size and shape of the mineral grains, the nature of the cementing material, and in some cases, with the chemical composition. If the rock is crystalline the nature of this phenomenon is also considered. Various methods are employed to determine these data, but at present the two most common modes of examination consist in the study of rock powders and of thin sections. The first, as the name implies, consists in the examination of the rock either as an artificially produced or natural powder. As the cuttings from wells drilled with a churn drill are commonly broken up rather finely, this method of study is especially applicable in such cases.

This detailed study of lithology has been used very satisfactorily in the case of well cuttings for separating one formation from another, as follows: Estimates are made of the percentages of sandstone, shale, and limestone in the various samples under a microscope, and these percentages are then plotted as a composite or synthetic log. The formational changes are shown by an abrupt increase or decrease of one or more of the three major sediments, the sandstone, limestone, or shale.

The second method of study, that of thin sectioning, gives more exact details than the first, and in the case of consolidated rocks, such as limestones and sandstones or unpulverized samples, is often the more satisfactory. It necessitates the making of a thin section which involves the expenditure of some little time but affords a detailed knowledge of the crystalline structure and mineralogical character of the specimen examined.

In the study of the paleontology of sediments with a microscope, the procedure consists in the examination of the rock as small fragments or thin sections. If the rock to be studied is a shale, it is soaked in water and washed under a strong stream of water until the fine shale particles have been removed and only the larger and heavier fragments of calcareous or siliceous material remain. This residue contains whatever minutia or small fossils the original shale contained. It is dried, sieved to various sizes, and examined under the binocular microscope.

Limestones, particularly shaly limestones, are treated in a somewhat similar fashion. They are soaked in water, then very carefully granulated with particular care that none of the finer chips be lost. The resulting fragments and powder are dried, sieved, and also examined under the binocular microscope.

As previously stated, this method is satisfactory with shales or shaly limestones, or even granular limestones, but its use with dense, fine-grained limestones is rather doubtfully successful. In studying this last kind of rock it may be necessary to resort to thin sections and from them determine, if possible, what diagnostic life forms the rock contains. If the fossils in the limestones are silicified, however, very satisfactory results can be obtained in some cases by breaking the specimen into small pieces and allowing them to etch in dilute hydrochloric acid. The etching removes the calcium carbonate and leaves behind whatever siliceous or argillaceous material was contained in the rock. In this residue the silicified minutia are found if present.

The minute fauna that is found in limestones and shales of different ages are varied. The unique character of some of these forms led earlier workers to consider them diagnostic of specific beds. As the evidence accumulates, however, it becomes apparent that only in rare instances is a single form diagnostic of a certain bed, and that rather an association of forms is the better diagnostic evidence. The search for horizon markers has been extensive and even skeletal parts have been made use of, not as wholly diagnostic in themselves, but as corroborative evidence.

Diminutive species of larger forms, such as brachiopods and pelecypods, are not uncommonly met with in the microscopic study of sediments. The forms which are more novel, however, and are receiving more attention at present, may be mentioned briefly.

Ostracods:—small crustaceans with a bivalved shell.

Foraminifera:—small protozoans with a skeleton of calcium carbonate. The tests are of varied design, some being coin-shaped, some like a grain of wheat, and others composed of a series of globular chambers arranged in regular or irregular patterns.

Bryozoa:—colonial or encrusting molluscoidea, some of which possess skeletons with intricately developed lace-like patterns.

Diatoms:—very small one-celled plants, with siliceous cell walls. These forms are not known in any of the Illinois rocks.

Other less common remains than those mentioned above, but forms which in combination with others are in cases of diagnostic significance, are sponge spicules, Echinois spines, Productus spines, worm casts, anelid jaws, and fish teeth.

The geological usefulness of this sort of work is appreciated readily when it is considered that in many places the bed rock is concealed beneath a covering of later sediments, wind-blown material, or glacial drift, and it is therefore impossible to determine its nature. The bed rock may come to the surface at some distant place and an examination of the outcrops be possible there, but in some cases the beds at the outcrop are so different from those which are concealed that what is true of them at one place is not true at the other. It is obvious that only a detailed, careful, and extensive study of the cuttings from wells drilled in such covered areas will enable the geologist to know the formations underground. The geologist desires to know, however, not only what the formations underground are like, but also what their structure is, whether they are flat-lying or folded. Where it is possible, the structure may be determined from a key bed of some particular sort which is encountered in the wells. In case there are no such beds, however, it is necessary to rely on some other means of identifying beds other than by gross lithological similarity. This is where the microscope finds its usefulness, and with its aid an attempt is made to determine what characteristics, either lithological or paleontological, can be used to identify certain horizons from which the structure of the beds may be interpreted.

Aside from the purely scientific value of the information obtained bearing on the subsurface structure of beds, a practical worth is apparent. Oil and gas are found associated with certain rock structures, and in the scientific prospecting for oil and gas and the successful exploitation of known deposits, it is desirable to know the structure of the rock from which the oil or gas is obtained. If the microscopic study of sediments, either lithological or paleontological, aids in securing such data, it renders a valuable service.

The study of cuttings, however, particularly the lithologic study, is not confined to the identification of beds of like stratigraphic position. The increase in the amount of sand in a shale formation from well to well may indicate the approach to an old shore line, where sand lenses, possible oil reservoirs, may be expected. Of a somewhat different nature are the determinations of porosity and the state of aggregation of oil- and water-bearing sands, which have, in cases at least, had a definite bearing on successful and maximum oil production.

In the oil fields of the southwestern part of the United States the microscopic study of cuttings has been found to be of great value in determining many of the above factors. The large oil companies have established laboratories and employ men to study the cuttings not only after they have been brought to the laboratory, but also to collect and in some cases study them as they come out of the wells. It is of interest to note that perhaps the greatest impetus has been given to this work by commercial enterprises. It seems to be a paying proposition with them on a dollar and cents basis.

The problem which presents itself in Illinois and the need for microscopic study are understood readily when it is considered that the bed rock of at least two-thirds of the State is obscured by glacial drift or loess, and the determination of structure is therefore very difficult and unsatisfactory. The rocks that do outcrop occur along the margins of the State, along the Mississippi and Ohio rivers and the adjoining territory, and in the northern part of the State along the larger streams and in artificial exposures. In some cases these beds continue into the central part of the State with the same lithological characters they display at the outcrop, but in others they change very markedly, due to differences in position with reference to the shore lines of the seas in which they were deposited. One group of rocks in particular, which outcrops in the southern part of the State, exhibits this phenomenon. This is the Chester group, one of the important oil-producing groups of rocks in Illinois. In outcrop, the sequence of the Chester formation has been well established, but as the rocks pass to the north and into the central part of the State they become covered and also change markedly. In this central area key beds are not numerous, and such phases as red rocks and colored shales are used for the lack of better evidence on which to base correlations.

It is obviously impossible to use the same large fossils in identifying the cuttings from wells that it is possible to use in identifying the beds at the outcrop, but it may be possible to identify in the cuttings from wells the same small fossils which may be used to identify the beds at the outcrop. With this in mind approximately 1,800 samples of the Chester rocks have been obtained very carefully from typical outcrops. These samples were taken from every different layer of the exposure being sampled, and in some cases this has meant a sample every six inches or less. The samples of the limestones were blocks about 3 by 6 by 1 inches, and in case of the shales, sufficient fragments to make up a corresponding amount.

The microscopic study of Illinois sediments is just beginning. The washing of shales has been tried with both satisfactory and unsatisfactory results. The sandy shales of the Chester formations seem to be practically barren of minutia and so do also some of the dense siliceous limestones. On the other hand granulated samples of some of the coarser grained, more fossiliferous limestones have yielded a number of small forms which, though they have not been and may not be established as diagnostic, at least hold out a hope for such results with further work. Up to the present time the thin sections made are mainly from the lower Chester formations, and it is quite possible that some of the bryozoa and foraminifera which appear therein may prove later to be diagnostic of these formations.

As yet no definite course has been pursued with reference to the detailed study of the lithologic characteristics of the samples. This feature is so variable from place to place in many of the formations that at the present time its use for "long distance" correlation is looked upon as corroborative rather than determinative.

The amount of work done on the minutia of the Paleozoic rocks such as are being studied here in Illinois is not so extensive as that devoted to the younger and less consolidated sediments. However, the fact that so much of the bed rock of the State is obscured by drift rather urges an attempt to make use of all possible means of subsurface correlation, and it is hoped that the future work will show results as worth while as those from the younger formations.

A COLLEGE COURSE IN GEOGRAPHY OF ILLINOIS

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Having lived in Illinois only a few months and having seen only a very limited part of the State, it may seem like presumption, on my part, for me to give instructions as to how a course in Illinois Geography should be taught. On the other hand the newcomer has some advantages in such a study for he does not have to unlearn so many things, overcome so many prejudices or feel so much responsibility as does the native.

Geography treats of the relation of a social group to the area in which it is. It is not simply facts, nor a mass of hypotheses, nor a mere collection of parallels. It must be objective rather than subjective, or, as Dr. C. O. Sauer says, "It must be theme and not a viewpoint; scientific and not temperamental. It is concerned with the utilization of an area rather than with the influence of an area on man." To quote further from the same authority, we note that this investigation involves three factors; —(1) Extent of Use, (2) Kind of Use and (3) Effectiveness of Use. Such topics as trend of population and wealth, stability, conservation, regional economy, etc. are special themes.

The modern trend of Geography seems to be rather away from the physiographic and geological and towards the economic and sociological. Bryce says, "Geography gathers up the results which the geologist, the botanist and the meteorologist have obtained and presents them to the historian, the economist and the politician" but Ripley, in his "Races of Europe," says "The study of physical environment must, at the outset, clearly recognize its own limitations arising from the power of historical elements, of personality, of religious enthusiasm and of patriotism."

Some of the French Geographers have rather overestimated the importance of the historical approach to Geography of some regions. Incidentally, I notice that the courses offered in a leading French University comprise some half dozen Geography courses based on

Europe, half a dozen on Asia, four on Africa and one on North and South America. And yet the French complain that we are not sufficiently interested in France!

Illinois offers both distinct advantages and disadvantages as an area for special study. The modern idea is that an intense study of a very restricted area has distinct advantages over the cursory study of a great area. Professor Jones, of Chicago, says that now that he has attempted to study Patagonia and extensive sections of Southern Asia he is going to study Chicago and vicinity next. For such intense study a State may be too large, but for the undergraduate, in less intense work, where the desired results are more general, a state may not be too large. Professor Ridgley says; "A geographical unit should be large enough to permit the development of the main lines of geographic thought; it should be small enough to be comprehended with accuracy and vividness in its statistical facts; it should be sufficiently diverse in physical and climatic conditions to lead to interesting contrasts." Illinois is all this.

At the Ann Arbor Meeting of the National Council of Geography Teachers, Professor Branom of St. Louis presented an excellent paper on State Geography with special reference to Missouri, but with many general applications and suggestions that have helped me in planning this Course. For organization and method I drew extensively from a Graduate Course on "Geography of Michigan" that I took at the University of Michigan. It is one thing to name the materials that *could* be used in such a course and an entirely different thing to list the materials that were used and worth using again. A text, "The Geography of Illinois", was in the hands of each student, and this book by Ridgley played an important part especially when you take into account the fact that most of our students seem to know little about formal lecture work and are still considerably impressed with "the Book". The statistical work was based principally on the publications of the Fourteenth Census, especially those bulletins dealing with Illinois population and agriculture. State Geological Survey Bulletins, especially Numbers 15 and 27, were used; also a great variety of maps put out by the Survey. Map filling can degenerate into mere busy work but it can be made to serve a most important function in college work. We used a large relief model of the State and one of the Chicago Area. We also made effective use of such books as; "Starved Rock State Park and its Environs" by Sauer, Cady and Cowles, "Geography of the Chicago Area" by Salisbury and Alden, etc. Some railroads furnished us material of value, but literature sent out by Commercial Clubs and other booster organizations is apt to be over enthusiastic and not always absolutely reliable in the matter of statistics. An attempt was made to use the daily press and other current publications selecting such material as had geographical value.

It was understood that at least two quarters of Geography should precede this course, for it is the policy of our institution to have a course in Principles and one in General Regional Geography precede all others.

Altho most of our pupils have had no geology save what they have gleaned from Geography courses I see nothing impossible or undesirable in using considerable geological material. Some structural, some economic and even some historical can be introduced and appreciated. We learned to talk fairly intelligently about the LaSalle Anticline and its various types of expression as seen in the exposures near Dixon and LaSalle and in the oil and gas fields of Crawford, Clark and other counties where it is deeply buried. There are some fine geological profile maps that help to show these conditions. I see nothing at all impossible about learning the approximate extent of the Niagaran Formation. Is it too much to expect that a college student may know that three-fifths of the State has a rock formation referred to the Pennsylvanian? The well drillers and many farmers know the St. Peter sandstone by name and understand its economic importance. Certainly we can go as far, and I see no reason why we can not theorize a little as to its probable origin. When it comes to understanding conditions in the glaciated areas of the State it is hard to see how much can be done without a fair knowledge of glacial geology. This is true especially of the northeastern part of the

State. A person might travel from DeKalb to Chicago and never know or care about the Bloomington or Valparadio moraines, but when he has had his eyes opened to such things the landscape takes on new meaning and new interest.

The Physiographic divisions of the State offer a varied and interesting field for special study. The Lake Plain, the Morainal Plains, the Driftless Area, the Ozark extension and the Gulf Embayment, with their modifications and extensions, offer fields for study usually but little appreciated by the average student. Could such a study be supplimented by systematic personal observation it would be much more effective, but how can such things be?

Plant and animal life and its distribution are receiving deservedly more attention in the field of Geography. The person who puts down Illinois as a "prairie" state gets somewhat of a jolt when he comes to study vegetation conditions and finds that the region classified as "natural forest" is so extensive. Seventeen counties are counted as being entirely in the forest area and only three entirely outside. And is the rest true prairie? Perhaps the term "prairie" is correct, but the term "steppe," which fits the region immediately east of the Rockies, can hardly be applied to any of Illinois. In 1919 Illinois mills sawed about 65,000,000 feet of lumber, of which 35,000,000 was oak, 5,000,000 elm and 4,000,000 walnut. Only sixteen states cut more oak and only five more walnut. The total value of Illinois timber products in 1919 was greater than in Tennessee, Kentucky, Indiana, Maine, Georgia or Minnesota, all known as lumber-producing states. Are not these facts worth knowing?

Some English Geographers, Unstead for one, have criticized certain publications called geographical by American authors. The grounds for this criticism lie in the fact that too much of the material is purely historical. History is not Geography, but that there is a geographical basis for much of the history of Illinois seems to me to be absolutely clear. Did the Indians burn the prairie grass and forest edge periodically to increase the buffalo pasture? If so, we have there an illustration of a social group using their environment and modifying it, too, to their own advantage. Why were Illinois Indian towns located at certain spots along the rivers? If this was due to the fact that sandy soils could be cultivated by the Indian women while the regions of tough prairie sod could not, we have there a distinct geographical background.

Then there is that marvelous story of the French. The vision of LaSalle, in which he was allowed to see the possibility of a great inland, agricultural empire, was based principally on his experiences in what is now Illinois. The death of LaSalle and the loss of the New World by the French meant that many years must elapse before the tardy English settlers crept up the rivers from the South and settled in the rougher and more wooded sections first, before trying the prairies, long regarded as a menace to health and as areas of superstitious dread. When the Great Lakes began to contribute something more in the way of transportation a counter movement from the Northeast set in and development proceeded rapidly. To my knowledge there is no place where geographical influences on history are shown more clearly than in our own State.

For special studies of various kinds and especially for agricultural production, certain counties were assigned to each member of the class, keeping the areas as complete physiographically as possible. One important set of maps was made to show percent of improved land devoted to the different crops. When completed, these shaded or colored maps show very emphatically the centralization of corn in the northeast central part on the Wisconsin Moraine, of wheat farther south and west, of oats in the corn area and a little to the north, of hay in the dairying regions, of rye on the sandy soil, etc. Distribution of farm animals, such as horses, mules, dairy and beef cattle, etc., formed the basis for other maps. This type of work, involving a certain amount of exact quantitative ideas and considerable computation, is found to be remarkably instructive and effective. To know some of the possibilities and advantages of the use of statistics is one of the many requirements demanded of the Geographer, be he professional or amateur.

Just how much attention to pay to soil study is a problem I have not fully solved. Here is a study that ties into both the physical and the industrial. We made use of several soil maps of the State and of various counties and tried to relate these studies to the uses of the land in these same areas.

Of course manufacturing and mining are both very important in Illinois and both received their share of time and attention, but the beef packing, the iron industries and the coal mining received a lion's share.

As a special phase of the transportation problem each member of the class took some railroad for special consideration, plotted main and branch lines on a base map and did what he could to study and report on such topics as terminals, cities en route, extensions outside the State, history, passenger and freight service, financial condition and probable future. The history of canal and river transportation and the possibilities and advantages of revival discussed so much these days were given careful consideration.

The city of Chicago should have its full share of time, not only on account of its size and rank, but also because of a series of curiously interesting conditions that have combined to make it important. Its remarkable physiography brought out so well in the model by Siebenthal, its relation to the Great Lakes and Great Plains, its relation to centers of population, area, and manufacturing, its rapid growth in spite of some local disadvantages, its history, present industrial expansion and future possibilities are topics each worthy of at least one lesson. We made a map of the State on which we indicated growth or decline of cities based on census figures of the last forty years. Many cities offered distinct problems, some of which were very difficult to solve. Each member of the class made a special study of the cities in his area and we all paid particular attention to the study of the ten or twelve largest.

The matter of distribution of population finds expression in many other ways besides in the location, size and growth of cities. The general decline of rural population, especially in the good farm areas, the increase in the size of farms, the distribution of negro and foreign born population can be made to appear in an almost startling manner when graphically expressed. For example, the massing of the negro population into Northern Industrial centers is quite characteristic of our age, but on the other hand, the relatively high percentage of negroes in Massac and Pulaski Counties shows the older type of negro concentration of the South. The lack of negroes in the mountains is a negative expression of the same thing. In the northern counties the number of male negroes seems to be greater than the number of females. Perhaps this is but another illustration of the industrial colonization promulgated by the northern manufacturers during and since the civil war.

Towards the close of the Quarter we spent some time comparing the problems of Illinois with those of some of our chief competitors and nearest neighbors. The following problems of our State have distinct parallels in other states but vary greatly in their seriousness.

1. Soil Erosion in Ozarks. Compare Kentucky.
2. Great Coal Production and Reserves. Compare Pennsylvania.
3. Conservation of Forests. Compare Wisconsin.
4. Use of Cut-over Land. Compare Michigan.
5. Influence of a very great City on a State. Compare New York.
6. Live Stock and Dairy Problems. Compare Wisconsin and Iowa.
7. Price of Land and Land Tenantry. Compare Iowa.
8. Trend of Population from Country to City. Compare New England.
9. The Negro Problem. Compare Missouri.
10. Iron and Steel Industries. Compare Pennsylvania and Ohio.
11. Outlet from Lakes to Sea. Compare Wisconsin.
12. Revival of River Trade. Compare many States.
13. Good Roads. Compare any State.

An almost endless list of such problems and projects could be considered and the outside comparisons help to fix the local conditions in mind. Because of the ease with which statistics can be obtained for states we are all apt to overestimate the importance of a political boundary, especially when it consists in a river.

The topics of State Government and Education have some place in the Geography of the State.

This paper attempts to give only those suggestions that are easily possible and clearly practical for a college class. New material is being collected all the time and I hope I am learning to use what I have more and more effectively. My chief regret is that we were unable to do any field work as a class. The course was given in the Winter Quarter. Most of the pupils were, to my notion, overloaded with work. However, I believe that such field work could be made a very important part of such a course. Another line of application which I was unable to follow out was the application of Illinois Geography to literature.

At the close of Branom's Work Book on Illinois he suggests that the pupils sing the Illinois State Song, as a sort of doxology, I suppose. We can hardly do that. I have suggested already some things that seem rather elementary for college classes, but before even a modest structure can be raised a reasonably detailed foundation of facts must be laid. We need to lay such a foundation for our State Geography study. The idea is that from this time forth the pupil is constantly to add to his fund of information, that he will be alert to know the facts about his state and apply them in his daily work, in the performance of his duty as a citizen and in his contributions to society. It is with some such general aim rather than for some exact scientific object that this course of College grade in the Geography of Illinois has been planned and presented.

THE MINERAL RESOURCES OF THE REGION ABOUT LASALLE

G. A. Buzzard, Magnolia, Illinois

The LaSalle Region, as used in this paper, includes an area which, in regard to certain mineral resources, extends some distance beyond the city of LaSalle. This is particularly true with regard to coal.

The mineral operations of the region under discussion are grouped in five classes:

1. Coal Mining.
2. Zinc Smelting.
3. Cement Manufacturing.
4. Sand and glass manufacturing.
5. Brick and Tile manufacturing (Clay products).

1. *Coal Mining.*

LaSalle is located near the northern margin of the coal field called by the state geological department, The Northern Illinois Coal Field (Bull. 16). It extends from LaSalle and Cherry, Bureau Co., on the north, to Roanoke, Woodford Co., on the south; from Streator on the east, to a line extending from Seatonville, Bureau Co., through Granville, Putnam Co., and Toluca, Marshall Co., on the west. LaSalle and Bureau are the two leading counties in the field in producing coal. The coal mining industry in LaSalle County is centered principally in two sections, one district being in and near LaSalle, and the other in and around Streator. There are at present five shaft coal mines in LaSalle and Peru; the Streator district for many years, however, was the leading coal producing area for the Northern Illinois field.

The first coal shaft was sunk in LaSalle in 1855 or 1856, at the time when the Illinois Central Railroad was being built in the city. The building of this railroad of course gave impetus to coal mining and numerous shafts were sunk in and near the city. LaSalle County led all the counties of the state in coal production in the years 1881, 1882 and 1887, though the amount of coal produced was only 624,900; 2,365,000, and 1,125,235 tons respectively for those years. Accurate statistics are not available prior to that date. This leadership in coal production resulted rather from the fact that the counties that are now the leaders in production had not started mining, rather than from the fact that LaSalle County produced so much. The greatest amount of coal produced in the whole Northern Illinois Field was in 1913, when 4,697,000 tons were mined. This seems rather insignificant when compared with the 12,723,000 tons produced by Franklin County alone in 1921. In that year (1921) the Northern Field produced 2,041,000 tons and LaSalle County produced 614,000 tons. However, in the period from 1881 to 1921, the Northern Field produced a total of more than 118,000,000 tons, and this furnished fuel for developing a rather highly diversified and quite extensive industrial area.

As stated above, the immediate vicinity of LaSalle was a pioneer in coal mining on a commercial scale in the state. The relatively small production of coal in the field compared with that in other fields farther south in the state is due largely to the fact that the coal veins in the Northern Field are thin veins, averaging only 3 ft. 8 inches, whereas in the fields farther south the veins vary from 5 to 10 feet or more in thickness, averaging 6 to 8 feet in many mines. It is much cheaper to mine coal from veins of this thickness than from thin veins; therefore the industry has shifted very largely to those newer and more profitable fields. The mines near LaSalle do not now supply enough coal to furnish the industrial plants so that coal from the fields farther south in the state are shipped into the region.

2. *Zinc Smelting.*

There are two large zinc smelting plants located in LaSalle and Peru, and another at Depue, eleven miles west of LaSalle. The Matthiesen-Hegeler Company was the first to establish a zinc smelting plant in the city. This was in 1858, a date nearly contemporaneous with the sinking of the first coal shaft in the region. The zinc ore was brought from the mines in southwestern Wisconsin or northwestern Illinois in the early years of the smelting industry in the region. As LaSalle is located on the northern edge of the Illinois Coal fields, it was the first place where the zinc ore, being shipped east or south, would meet the coal. As it requires about two and one half tons of coal to smelt one ton of the ore it was found cheaper to haul the ore to the coal than to haul the coal to the ore.

In recent years the ore for these smelters has been brought largely from the zinc mines in southwestern Missouri. Since the ore from that region would meet the coal, say of southern Illinois, more conveniently than at LaSalle it seems only reasonable that smelting in those fields will sometime displace the industry at LaSalle. The matter of an early start in the industry and the convenient location with regard to a market for the product are the advantages that still retain the industry in its present condition of prosperity. Of the ten zinc smelters in the state in 1920, only three, the ones mentioned above, are located in the north half of the state. The others are in coal mining centers farther south. The plants in the LaSalle region were located there as a response to the local coal supply.

3. *Cement Manufacturing.*

Of the five cement plants listed in the directory of Mineral Operators in Illinois in 1920, four are located in or within five miles of the city of LaSalle. A plant for the manufacture of hydraulic cement is located at Utica, five miles above LaSalle; two Portland cement plants are located at Oglesby, just across the river from LaSalle, and one Portland cement plant is located in LaSalle.

The conditions for the manufacturing of cement are particularly favorable in the vicinity of LaSalle. Here are found the coal, the clay and the limestone, located in the order named, above the others. The clay and the limestone are the necessary raw materials for the making of the cement, and it is an advantage to have the coal in close proximity to the other materials. From Bailey's Falls on the Big Vermilion river to the mouth of that river, the LaSalle limestone is exposed at the surface. Directly beneath it lie soft carboniferous clays, and still lower are seams of excellent coal. Portland cement is made from limestone and clay, which are ground, mixed in certain proportions and fired. In this industry, as in smelting, more fuel than raw material is required. All these materials are bulky, so the industry can be carried on profitably only where limestone, clay and coal are found intimately associated. Near the river the limestone underlies a thin covering of earth, which can be stripped off with ease. The limestone has an average thickness of 24 feet and is underlain by 16 feet of clay. The coal is mined by shafts adjoining the plants, though it has been found necessary to import some coal from other fields in the more recent years.

The plants in LaSalle and Oglesby employ about 1800 men, and produce more than 10,000,000 barrels of cement annually. The marvelous development of the industry has built the city of Portland or Oglesby, and stimulated the growth of LaSalle and Peru, for many of the men employed in the two plants in Oglesby live in Peru and LaSalle. This industry is much newer than the zinc smelting industry, and is still expanding extensively.

4. *Sand Products—Glass Manufacturing.*

Sand for many uses is mined at many places along the Illinois river, particularly in the vicinity of Ottawa. Glass manufacturing has become a great industry, first at Ottawa, and later at Streator. Much sand is mined cheaply at Ottawa by hydraulic methods. The glass sand industry has become important locally because, first, the St. Peter sandstone is soft, of even texture, and may be worked with ease, in many places with pick and shovel; second, the sand is of the highest quality for the manufacturing of glass, being almost pure silica and free from loam; third, with one exception this is the only outcrop of this sandstone in the state which is used commercially; fourth, the sandstone occurs in bluffs that are along the railroad lines in the Illinois valley, and is loaded directly from the pits into the cars. The glass manufacturing industry in Ottawa has decreased in importance in recent years, due to the difficulty of getting good fuel. In Streator, however, which has many coal shafts working, this industry is of great importance. Two plants which specialize in the manufacture of milk bottles and a plant which manufactures plate glass and skylight glass employ a total of about 1,800 men in that city. The statement was made by a superintendent of a glass factory in

Streator to the effect that the Streator companies produce 3,000,000 square feet of rolled plate glass annually, and that they furnish 80% of the skylight glass for the loop district in Chicago.

The location in proximity to the coal, the excellent glass sand near by, and the location of the city on excellent lines of transportation to Chicago are reasons for locating successfully the glass manufacturing plants in Streator.

5. *Clay Products—Brick and Tile.*

Plants for the manufacture of clay products, ranging from common drain tile to paving brick, pressed brick and fire brick, are found in numerous places in LaSalle County, Streator and Oglesby being the centers for more of these plants than other cities, though LaSalle has three plants. The plants in Streator are the largest in the region, have their own coal shafts on their premises, and make a variety of products, such as paving brick, fire brick or tile, as conditions warrant, each plant tending to specialize in one of the products. The favorable location with regard to a fuel supply, with access to an excellent fire clay, and the excellent transportation facilities to Chicago are the factors most largely responsible for the development of the brick and tile manufacturing industries of the region.

In 1920, LaSalle County was credited by the Illinois Mineral Operators' Directory, with having 67 different producers of mineral products. Cook County alone of the other counties of the state equalled this number. Of these 67 producers, 21 are located within a radius of five miles of the city of LaSalle. It is doubtful if a similar area anywhere in the state can equal the area near LaSalle in variety of products and the value of the minerals produced.

OIL PRODUCTION IN ILLINOIS

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Object of the paper: A review of past results and a consideration of the geological basis for guidance in future oil development.[1]

The production of crude petroleum in Illinois for 1922 was nearly 10,000,000 barrels. The peak of Illinois production occurred in 1908, when about 33,000,000 barrels were produced, giving Illinois third place among the states, with Oklahoma leading and California second. These latter have retained their relative prior positions, but newer gusher fields have been discovered in the southwestern and western states, and Illinois has now dropped to eighth place. The decline curve for Illinois (Fig. 1) shows the trend of the annual production from 1905 to 1922 for the whole State and from 1905 to 1918 for individual pools. The decline in 1922 over the previous year was about 6 per cent. The low decline rate is due in part to the long life of the average Illinois oil well.

The main oil fields of Illinois are situated in the southeastern part of the State in Edgar, Coles, Clark, Cumberland, Crawford, Lawrence, and Wabash counties, in which the areal limits have been fairly well defined. Lesser amounts are produced in a number of small fields scattered over southwestern Illinois. These are mostly younger fields and are still being extended. The total actual producing acreage is only about 250 square miles, or the equivalent of about seven townships. This seems very small compared with the total area of the State. The smallness of the actual producing areas is significant and indicates the precariousness of drilling a well just anywhere, even in a general area regarded as having probabilities.

It is absolutely essential to use every guide from geology and from the study of production and drilling data in neighboring or similar areas so that the larger, prob-

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[1] Special acknowledgement is due to the State Geological Survey of Illinois for the information and records on which this paper is based, and to Miss H. Christensen in particular for her kind assistance in the compilation of data and preparation of the accompanying map.

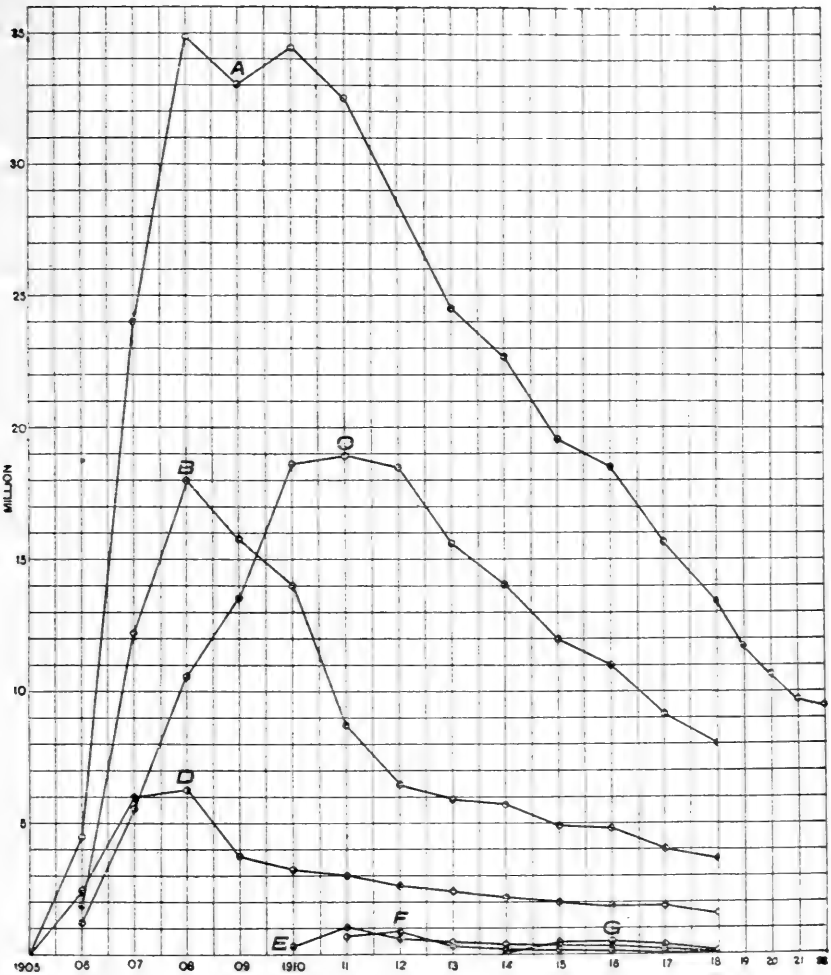


Fig. 1. Diagram showing rise and decline of oil production in Illinois, 1905-1918, expressed in barrels of 42 gallons.[a]

A. Total for State.
B. Crawford County Pool.
C. Lawrence County Pool.
D. Clark County Pool.
E. Sandoval Pool.
F. Carlyle Pool.
G. Plymouth Pool.

[a] Statistics on oil production for individual pools are not available after 1918.

ably barren areas may be discarded and the oil well tests for new production be confined to the small areas of greater promise. Although the element of chance is more or less still present in drilling these promising areas, "wildcatting", as it is called, can only thus be brought within the bounds of good business judgment.

The annual decline of production has not been so rapid as the natural exhaustion of the older wells. New production has been obtained from time to time through proper development and prospecting. Outside the old fields new small pools have been discovered and developed. Within the old fields drilling of both inside and edge wells has still brought in some additional production. Deepening existing or exhausted wells has resulted in some cases in finding other producing sands. Improved methods of recovery such as the use of the vacuum pump and in some cases the practice of returning compressed gas or air to the sands have helped also to keep up production.

It is not expected that there will be discovered in Illinois any further oil fields of sufficient magnitude to raise the total production above the present figure, but it is reasonable to expect, as will be seen later, that new production will be obtained from time to time which will in a great measure offset the decline due to the exhaustion of the older wells, many of which are now approaching the limit of economic life. It will be shown that the finding of further accumulations and the obtaining of higher yields from existing wells or fields can best be brought about by the proper use of geology.

The results of the drilling done during 1922 show that in the older fields of the southeast 118 holes were drilled, of which 36 were dry and 82 were producing wells with a total reported flush production of 1300 barrels per day. These include a few rank wildcats which unfortunately are located often without the basis of reliable judgment. But the majority were drilled in development of inside acreage of light production and to determine the edge limits of the main producing fields. In the rest of the State 223 holes were drilled, of which 53 were dry, while 170 were wells with a reported flush production of 4,590 barrels. These include development wells in and around the older producing small fields, but a large proportion represents wildcat drilling, some of it well advised, more of it ill advised, or lacking any basis but that of ''hunch'' or superstition, and some based on nothing but a scheme of the promoter to make some money. Fortunately these last two types are becoming scarcer. A summation of the above figures gives a total of 341 holes drilled in the State for the year; 89 were dry holes and 252 were wells bringing in a total flush reported production of 5,890 barrels. The dry holes are 25 per cent of the total wells drilled, or 35 per cent of the number of producing wells. There were 71 wells abandoned in the old fields that had reached the limit of their economic life at the prevailing price of crude oil.

In estimating the economic success of the exploitation of crude oil production, it appears on the basis of these figures that against the value of the oil obtained must be charged not only the overhead, drilling equipment, and producing costs of the producing wells, but also an additional 35 per cent of the drilling cost must be charged to take care of the dry holes drilled incident to the development. A rough estimate at prevailing prices of the value of the new production obtained during the year indicates that after deducting all development charges, the industry shows profitable returns. It is evident, however, that the cost of drilling dry holes must be brought and maintained at a minimum by the utilization of all available information and experience that will enable the best judgment to be used in the location of exploratory drilling. This is one of the main functions of geology as applied to the oil industry. It is one of the objects of the State Geological Survey and of the geologists working for oil interests in the State to localize development and to limit exploratory expenditures to areas where the chances of finding oil are greatest. Only by such guidance can the ratio of dry holes to producing wells be reduced to, and maintained at, a minimum while development of the oil reserves continues.

Correct judgment of the oil geologist must involve the following considerations, and their application in Illinois will be discussed briefly.

REGIONAL STRUCTURE

The bedded rock formations in Illinois, as far as the drill has reached, are composed mainly of shales, sandstones, and limestones. These beds are so tilted and folded that in central Illinois they form a spoon-shaped basin, a gentle rise continuing out to the edges of the State with the exception of the eastern edge of the basin where the beds rise sharply forming an uplifted fold called the LaSalle anticline. This is the most pronounced uplift or folded structure in Illinois, and the main axis of the folding runs in a direction slightly east of south from the northwest of the State through LaSalle to the vicinity of St. Francisville near the Indiana boundary in the southeast with a general inclination or pitch to the south. In contrast to the dip or inclination of the beds, the rock surface in Illinois was more or less base leveled by erosion, and over this surface was deposited the glacial drift consisting of clay, silts, sands, and gravels, which at the present time cover the surface of most of Illinois. These late deposits are cut through by the present larger rivers and streams exposing the underlying rock, the out-crops of which afford a source of considerable information to the geologist. However, there are large areas where no outcrops can be seen, and the geologist has to derive much of his knowledge of the subsurface conditions from a study of the logs of wells and samples of the rock beds penetrated.

The important relationships of oil to the structure or folding of the bedded rocks was first recognized by I. C. White and is known as the anticlinal theory of oil accumulation. In a general way this has been found to hold true for oil accumulation in Illinois, although oil geologists are recognizing other relationships which are applicable in certain circumstances, and in others modify the application of the anticlinal theory. Thus we note (Figs. 2 and 3) the main oil fields developed along the axis of the LaSalle anticlinal uplift in southeast Illinois. The producing area is subject to certain limitations toward the north, due partly to the pitch of the axis. Most of the oil producing horizons come up to the surface towards the north and have either been eroded or were never deposited.

Other small anticlines or local folds or domes are known in the gently rising beds to the southwest and western parts of the State, some of which have proved productive. No production has been found in Illinois as yet that is not in some way connected with anticlinal structure or doming of the strata.

SHALE CONDITIONS AND POSITION IN THE ROCK SECTION

SHALE AS A SOURCE

Oil is generally believed to have had its origin in shales containing certain kinds of organic material which have been converted by pressure and some heat to the hydrocarbon constituents of oil particles. These were collected by the aid of circulating fluids and rock movements and accumulated in favorable traps in reservoir rocks.

The presence of the necessary shales as a source either in juxtaposition to the reservoir rock or connected with it at some time by porous channels is one of the requisites to bear in mind when considering an area for possible oil accumulation. The exact nature of the shale necessary as a source, its history of sedimentation and subsequent alteration are subjects about which the oil geologist should know to enable him to apply more fully the science of geology to the economic problem of finding oil accumulations. It is hoped that the results of present studies of sedimentation, now being undertaken by some of the leading geologists, will be especially helpful to the oil geologist.

At present, however, ahead of actual drilling, certain areas can be considered as having very slight chance for oil when we know that the underlying or associated rock section does not contain adequate amounts of shale.

IMPERVIOUS CAPPING OF RESERVOIR ROCKS

Shale as an impervious medium overlying reservoir rocks has an important role in the accumulation of oil in the tops of anticlinal folds and domes. In areas where the known dip or regional rise of the strata has brought a shale capping to the surface where it has been largely or entirely eroded, oil probably would not be retained in an immediately underlying porous rock. Any oil previously accumulated would have escaped long ago during the preglacial erosion. This is applicable in Illinois on the northward extension of the LaSalle anticline due to the southward pitch of the axis, and also around the rim of the central structural basin in southern, western, and northern Illinois where the formations have been truncated by erosion.

SAND AND RESERVOIR ROCKS

Where the necessary capping shales in the rock section are present, the question of reservoir rocks should next be considered. The positions of most of these are known in the Illinois rock section. Structure and area of deposition or subsequent erosion will affect the number of any such horizons that are present and can be penetrated by the drill at any given locality. The probable productivity of the sand, if it contains oil, compared with the cost of drilling necessary is also an important consideration. The records of past drilling and statistical information of oil production of the old fields in Illinois are particularly beneficial in this connection, although many operators have been very slow to realize the great importance of keeping and preserving good records.

There are some lenticular porous sands in Illinois and other beds which grade from impervious to porous, both laterally and vertically. It is quite possible to find oil accumulation in areas of regional folding without the presence of complete local reversals, but for the same reason that oil accumulates gravitationally in the arch of an anticline, so oil in porous lenses with water saturation would be expected in the higher parts of the lenses. There have been cases of this kind in Illinois, notably in the Colmar-Plymouth field, and probably there are others awaiting discovery. It is impossible, however, to obtain any indication of the presence or actual location of such local petroliferous lenses from surface observations on outcrops, or from the data supplied by former neighboring wells. But horizons containing such lenticular "sands" likely to occur in Illinois are fairly well known and in several localities supply an extra sand chance in addition to the regular sands or more prevalent porous horizons that have produced oil.

PRESENCE OF LOCAL FOLDS AND UNCONFORMITIES

The stratigraphic position and the nature of the shale and reservoir rocks may be ideal, but in Illinois at least the oil accumulations are associated with anticlinal folding or doming of the beds. This, then, is of vital importance in recommending the most likely places for oil tests. In addition to the extension of the old fields on the La-Salle-St. Francisville uplift there are many local minor structural anticlines and domes in the south and west parts of the State. The knowledge of the presence and location of these structures is one of the keys to the wise location of exploratory test wells.

In Illinois, as elsewhere, there have been time intervals of erosion accompanied in some instances by some tilting or warping of the strata between successive depositions of sedimentary strata. The bedding of the overlying strata may not, then, conform exactly with the bedding or the eroded surface of the underlying formations. This sometimes results in favorable traps in reservoir rocks suitably capped or pinched in by impervious beds, but they can not be predicted directly from knowledge of the dip of the strata outcropping at the surface. The presence of such unconformities at certain horizons is known, however, from other geological evidence, and their influence on oil accumulation can be more or less evaluated by the oil geologist.

The geological information that the oil geologist can bring to bear on the oil problems of Illinois can be obtained in part by studies and surveys of rock outcrops, but in very large measure it must be obtained through the study of subsurface records and samples of cuttings taken from drilling wells. The State Geological Survey has available extensive information of this kind. Bulletins are published frequently and cooperation is maintained with those interested in oil development. Based on the study of the accumulated subsurface data and the original surveys and surface observations of the Survey, the accompanying map (Figs. 2 and 3) has been prepared to show in a general way the location of the various oil producing areas of Illinois, the localities where favorable structures exist, and the proportion of those outlined that have been tested and found productive. General inferences may be drawn as to the probabilities of finding further producing areas in Illinois and the general geographic position of the areas of greater promise.

Outside of the actual producing areas in Illinois, with which may be classed probable extensions, the remainder of the State can be divided approximately into provinces representing, according to our present knowledge, four different grades of merit as to the chance of finding commercial accumulations of oil: (1) best possibilities; (2) possible; (3) improbable; and (4) very improbable. The differentiation has been made largely on the basis of known or expected presence of favorable structure.

(1) An area of best possibilities may be described as extending north from the common line of Cumberland and Clark counties where the LaSalle anticlinal uplift is developed into two folds, one axis continuing west of north through LaSalle County, while the other appears to run more directly north to Iroquois and Kankakee counties. The area north of the producing fields immediately along these axes has good possibilities where slight cross folding is present. In this same class should be included an area immediately west of the central structural basin, running south from western McLean County, including the west portion of DeWitt and Macon counties, the east half of Logan and Sangamon counties, of Christian, Montgomery, Macoupin, Madison, Bond, a west portion of Fayette and Marion, Clinton, most of Washington, St. Clair, Randolph, Perry, Jackson counties, and possibly in the southern part of the State, parts of Franklin, Williamson, Saline, Gallatin, and portions of adjoining counties to the south; and in addition, the area

in the west including the east half of Jersey, most of Greene, Scott, Brown, and Schuyler counties, with adjoining parts of Cass, Morgan, Pike, and Adams, most of McDonough, with adjoining parts of Fulton, Knox, and Hancock counties.

(2) The second grade considered "possible" should include the rest of the State not included in the two following grades.

(3) The area considered "improbable" includes the central structural basin running south on the west of the LaSalle anticlinal uplift, including small parts of LaSalle, Marshall, Woodford, and Livingston, the central north and south portions of McLean, most of DeWitt, east half of Macon, Piatt, Moultrie, Shelby, west portions of Douglas, Coles, and Cumberland, Jasper, Effingham, east portion of Fayette, all but a western part of Marion, Clay, Richland, west part of Lawrence, Edwards, Wayne, most of Jefferson, Hamilton, and White counties, with adjoining portions of Saline and Gallatin counties.

Another area of similar status is the trough or syncline between the two folds of the LaSalle uplift flanking the areas along the axes including parts of Ford, Champaign, Douglas, and Coles counties. Also the flank on the east of the uplift including parts of Iroquois, Vermilion, Edgar, Clark, and Crawford counties should be included.

In the general area in the northern part of the State where, due to the northward regional rise of the strata particularly along the axis of the pitching LaSalle uplift, most of the formations containing oil horizons are not present. The so-called Trenton or Galena limestone and the underlying St. Peter sandstone outcrop here. Oil has never to our knowledge been obtained in commercial quantities from the St. Peter or underlying older formations. These contain few shales and apparently have not the requisite source or favorable conditions governing accumulation of oil. The areas on the flanks of the anticline where no adequate capping exists for the outcropping Galena limestone should be included also in the improbable area. This includes most of Winnebago, Boone, with adjoining portions of McHenry and Stephenson, most of DeKalb with adjoining portions of Ogle, Lee, LaSalle, and Kendall counties on the east, and parts of JoDaviess, Carroll, Whiteside, Lee, and Bureau counties on the west of an area along the axis of the LaSalle uplift and other minor folds.

(4) The central area last mentioned along the axis of the LaSalle uplift in the north of the State must be considered as very improbable, and is so graded because even the Trenton is absent here or very thin and no oil has ever been found geologically below it. This area includes the adjoining parts of JoDaviess, Stephenson, Carroll, and Ogle, the central part of Lee, and small parts of Bureau and LaSalle counties.

THE ANALYSIS OF RESULTS OBTAINED IN TESTING THE AREA REGARDED AS HAVING BEST POSSIBILITIES PROJECTED AS A FORECAST FOR FUTURE SUCCESS

The areas of the northward extension of the LaSalle anticlinal uplift have very few outcrops, and little or no testing has been done in the areas of greater promise. (Figs. 2 and 3.) Although these areas have potential possibilities of production from one or two horizons, no definite percentage of success to be expected in test drilling can be suggested.

The results obtained in the remainder of the area of best possibilities are given in the following table:

Portion of Illinois	Structures mapped in detail (10-, 20-, and 25-foot structure contours) average of two oil horizon chances									Further structures expected in area now mapped only on large scale (50-foot structure contours); 50 per cent of structures mapped on small scale assumed; similar sand and regional structural conditions			Further structures expected in area now unmapped; similar sand and regional structural conditions		
	(1) Area mapped in detail	(2) Number of structures mapped in detail	(3) Number of structures completely or partially tested		(4) Number of structures found productive		(5) Productivity per cent (4b) of (3a)	(6) Number of structures untested	(7) Structures expected to be productive in those untested from (5)	(8) Area mapped on large scale	(9) Number of structures to be expected from (2) and (1) less 50 per cent	(10) Number of structures expected to be productive in this area from (5)	(11) Area unmapped	(12) Number of structures to be expected from (2) and (1)	(13) Number of structures expected to be productive in this area from (5)
			Total Number	Per cent of Complete testing	Actual number at present	Plus allowance for complete testing									
	Square miles		(3a)	(3b)	(4a)	(4b)				Square miles			Square miles		
Western......	2442	22	16	68	3	4.4	27	6	1.6	508	2.3	.6	2785	25.	6.8
Central.......	2763	24	24	83	12	14.4	60	...	...	3854	17.	10.	48	.4	.2
Southern.....	1820	19	9	62	2	3.2	35	10	3.5	924	4.8	1.7	375	3.9	1.4
Total or Averages.....	7025	65	49	...	17	22	...	16	5	5286	24	12	3208	29	8

By using percentages from the past results of exploration, we can estimate very roughly the amount of new local accumulations of oil that future exploration may be expected to find.

In completing the thorough testing of the structures now defined and partially tested we may expect the equivalent of finding five new local producing structures.

In the remainder of the area of best possibilities where regional structure and the number of sand chances are similar to the areas that have been mapped in detail we may expect to find further structures in proportion to areal extent as already obtained in the studied areas as follows:

(a) In areas where large scale mapping has already been done we may expect the equivalent of 24 further smaller structures of which about 12 may be expected to be productive.

(b) In areas as yet altogether unmapped we may expect relatively the equivalent of about 29 local structures, of which about 8 may be the proportion of those found productive.

CONCLUSION

To the 17 producing structures that we have today we may expect to add the equivalent of five more when all the structures now outlined have been tested thoroughly. It is also to be expected that about 50 other local folds or favorable structures may yet be found of which a proportion of something like 20 may be expected to be productive. This is slightly more than the number of producing small structures that we have had up to the present.

It appears, therefore, that there are many local oil accumulations capable of supplying commercial production that yet await discovery in Illinois. The proper use of geology, both surface and subsurface, will insure the greatest efficiency in the exploration and development of these resources so that the industry may continue on a paying basis. Owing to the slowness with which subsurface information comes to light the development of the potential reserves will extend over a number of years.

The new production being obtained from time to time will continue to offset partially the natural decline of the older wells, and serve to maintain the annual production of Illinois with a very low decline rate.

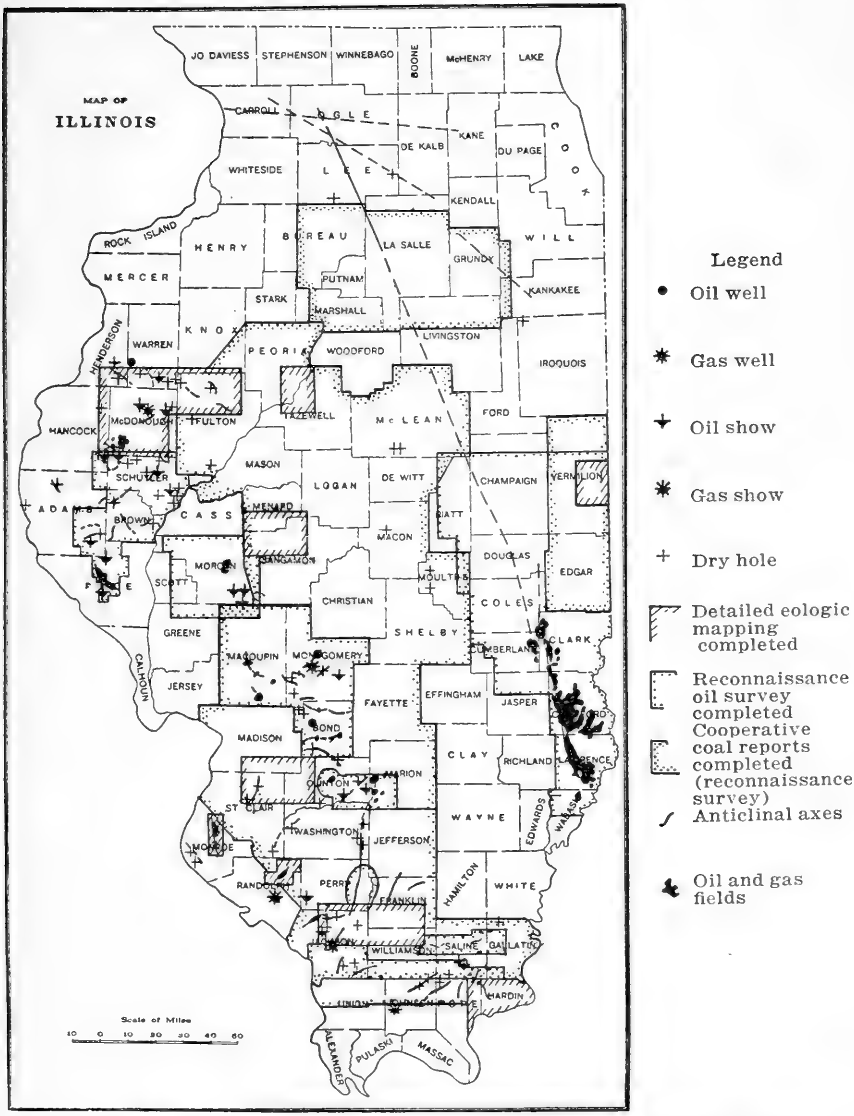


Fig. 2. Map of Illinois showing location of oil and gas fields, anticlinal axes and results of testing the anticlinal structures. Outlined areas indicate whether detailed or reconnaissance geologic surveys have been completed.

TIMBER PRESERVATION—A FORM OF FOREST CONSERVATION

F. C. Bohannon, Galesburg High School

Theodore Roosevelt and Clifford Pinchot did the people of the United States a great service by calling attention to the problem of conservation of our forests. The Forester now has his work well organized and under way; it remains for the work of the timber engineer to be recognized by the public and for his methods generally to be adopted, to complete the program of conservation.

Saving the supply of timber already grown is doubtless as important as growing a new supply. U. S. Bulletin of Agr. 112 is responsible for the statement that we are using 40 billion feet of lumber and 87 million hewed railroad ties annually, besides pulpwood and fuelwood. W. B. Greeley, chief of the U. S. Forest Service, urges preservative treatment of railroad ties, mine timbers, fence posts, telegraph poles, shingles and construction lumber. He endorses an estimate of 3,650,000,000 board feet as the annual saving by this method. The importance of saving becomes significant when we are told in the same bulletin that "We are taking about 26 billion cubic feet of material out of our forests every year and growing about 6 billion feet in them".

Our outgo in forest resources is more than our income. Bankruptcy of natural forest resources is inevitable unless we face the situation and save what we have. First, we can produce more; every state has its program of forestation, but without hope of catching up to increasing demand in an economically active country. We are now using one half of the consumption of forest products of the entire world. Yet in the state of New York, as reported by its conservation commissioner, the number of wood-using factories including furniture factories, agricultural implements plants, and concerns using lumber in the form of plank had shrunk from 3,300 plants in 1913 to 2200 in 1900, 1100 industries having gone out of business in six years.

We can use less timber; the older nations of the earth have reduced their consumption to a very low and stable level; these countries are industrially stagnant; but industrially active countries such as England and Germany are great wood consumers. We must not consume less at the expense of useful industries. We can substitute other materials for wood, such as cement for water-troughs and piling, steel for bridges, implement frames and tongues. Galesburg's shale is being converted into paving bricks which are taking the place of wood blocks in her own streets and in the main streets between here and Panama, where a large consignment of Galesburg brick was used. But with all the substitution, important as it is, the saving affected is estimated by W. B. Greeley at only 150,000,000 cubic feet or about one-half of one per cent of the drain upon lumber. We can, by preservative treatment, effect the largest saving as indicated above. This saving of lumber is secured mainly along two lines, first by increasing the average life of timber four or five times, secondly by allowing the use of inferior woods, such as rapidly growing cotton wood, as railway cross ties in place of slower-growing relatively-important white oak.

Preservation was secured in the old days by applying tar to the outside surface with a brush. Nowadays, the same material is utilized in the form of creosote oil, a coal tar product forced into the wood under pressure and at a high temperature and made to penetrate into the heart-wood of the tie or pile, thus lengthening the life of the timber which is equivalent to increasing the visible supply. The following treatments are used at the Burlington Tie Plant, Galesburg, Illinois:

First: Straight Creosote

Second: Card Process (zinc chloride and creosote)

Third: Burnettizing Process (zinc chloride)

Mr. J. R. Waterman, Superintendent of timber preservation for the Burlington Road, recommends the first or creosoting process as being the most effective, but because of the lessened cost he recommends the card process, from an economical stand point. The relative merits of the above processes are submitted below from data compiled by Mr. Waterman, One of the oldest examples of creosoting timber under conditions similar to the present practice is that of the New Orleans and North Eastern Railroad across Lake Pontchartrain, 5.82 miles in extent. The piling of yellow pine, having not less than 12 inches of heartwood at the head, were treated with from 10 to 12 pounds of creosote per cubic foot at a temperature of 175 degrees under a pressure of 150 pounds per square inch after steaming and vacuum treatment. A report of the Interstate Commerce Commission Valuation Division Engineer in 1918 makes the following comment, "A very remarkable state of preservation—The original timber in good condition and apparently carefully selected and well creosoted—Estimate remaining service life of this trestle thirty-five years". These pilings had already had a life of thirty-five years, making a total expected life of the trestle seventy years.

In order to understand what has happened to the tie or pile when treated according to the specifications sketched above, a description of an up-to-date plant and processes used, follows. The main features of a modern wood preserving plant are, first, the ten or twelve huge cylinders, 6 or 7 feet in diameter and 120 feet to 140 feet long. These retorts are mounted on heavy concrete bases which are not continuous but allow more or less access below the retorts. There are doors at one or both ends, which, after the admission of timber to be treated, are closed by fifty large steel eye bolts. Tracks extending from the storage yards approach the entrance to each retort, where a gap of about 8 feet is bridged by a movable car in a pit. This car bears a section of track, continued in a well at the bottom of the retort. When the door of the retort is to be opened, the carriage bearing a section of the track is removed, allowing it to swing open readily. The well contains pipe connections to tanks of treating fluids, air compressors, steam pipes, etc. The engine room, which contains all necessary pumps and generating machinery, is located in an adjoining room on re-enforced concrete foundations. One of the most interesting of its varied equipment is an elaborate system of automatic recording apparatus, a steam meter showing steam consumed, thermometers, pressure gauges, and the like. By means of these ingenious devices a complete record of temperature and processes is made on circular discs from day to day and filed away for future reference. (By courtesy of Mr. Shinn, Superintendent of the Galesburg plant, I am able to exhibit a card showing temperature and pressure record.) Adjacent to the main plant is to be found huge tanks having a capacity, in case of the Galesburg plant, of one half million gallons each. In addition, the Galesburg plant has a mixing tank into which creosote, zinc chloride, etc. may be pumped in desired proportions. The treating fluids are obtained from standard dealers, such as The Tar-Via Company. Much of the creosote has been produced as a bi-product in Germany.

Timber to be treated is seasoned by piling in the open for about one year. The ties are stacked cob-house fashion so that air will circulate freely and rain water will run off readily. No successful method of treating green timber has yet been devised. The tie is next placed on low cars or cradles in compact form so that the encircling hoops when packed full will fill approximately the bore of the retort. A series of the cradles are coupled together and drawn into the treating chamber by a wire cable, the power being supplied from winding a drum. The retort is closed, and steam is admitted for a period of one or more hours according to the size and nature of the material treated. This process effects an even distribution of moisture and ensures uniform drying, while excess water which accumulates is forced into outside tanks, since the pressure in the retort is greater than in the tanks.

The second step in the treatment is the creation of a partial vacuum. This is a real drying process, as evaporation goes on rapidly where a vacuum of twenty inches or more is maintained. The third step is the admission of creosote oil, at first without pressure: afterward the pressure is brought up to 175 pounds or more; later the oil is forced back to the working tanks from the retort by compressed air, the door is opened and the load drawn. The wood has absorbed about 12 pounds of creosote oil per cubic foot and has been made so heavy that it will sink in water. How complete is the penetration of the fluid is shown in the cross section (Exhibit 1) of a pile which shows that every portion of the pile has been affected, with small areas at the side of the center showing less pronounced effect.

The charge after being with-drawn is stacked in the open in the material yards until it is needed. Power derricks, which lift the entire content of a cradle, are used in loading and unloading ties. Where the loading of ties in a box car precludes the use of power, an ingenious trolley system facilitates the rapid loading by hand.

The results obtained by Mr. Waterman in timber preservation are set forth in his recent report to the officials of the Burlington Road, from which report the following conclusions are presented:—That there are two causes for the failure of ties, 1st., decay due to moisture, etc., 2nd, failure due to mechanical causes. Since moisture is a great factor in decay, observations by the above authority show that ties last longer, other things being equal, west of Nebraska points than east. Observations of recorded portions of track show that such woods as hickory, poplar, cottonwood, elm and red-oak compare favorably with white oak, as ties, when given preservative treatment, whereas the tendency of each of these woods to decay when in contact with damp soil is common knowledge. The accompanying chart (after F. S. Shinn, Superintendent of the Galesburg Plant) shows that, of 3200 zinc-treated ties, only 15% had been removed after 17 years, while 26% yet remained in service after 22 years, whereas untreated ties are shown to last about 5 years, in case of white oak, and less time in case of the woods mentioned above. The preservative treatment, then, conserves both timber supply and replacement costs.

An examination of the table appended will make apparent how inferior woods, by treatment, may be made to do the work of the more expensive and relatively-scarce white oak ties.

When treated by the most commonly used card process the following show that other woods compare favorably with similarly treated white oak ties, in serviceability, where under similar conditions, 8.8% of a number of white oak ties were removed on account of decay and 11.8% for other causes. There were removed:

	From decay.	Other causes.
Elm	2.5%	6.8%
Cottonwood	2.7%	15.5%
Red Oak	3%	11.3%
Hickory	6 %	21 %
Poplar	7.3%	30.1%

Untreated, the score for the same woods is very poor in comparison with white oak. There were removed from trial sections of track after exposure: untreated

	From decay.	Other causes.
White oak	61.5%	10.3%
Hickory	92.3%	7.7%
Elm	93.8%	6.2%
Poplar	95.1%	3.71%
Red oak	96.1%	3.1%
Cottonwood	96.5%	5.5%

There follows a more complete report on these woods as ties subjected to identical usage in observed portions of track:—

Process	Number of Ties	Removed	Percent Decay	Percent Other Causes
EAST.				
Creosote	2027	140	2.8	4.1
Card	10259	2003	5.9	13.6
Burnettizing	1584	526	19.	14.2
Untreated	2040	1963	88.9	7.3
WEST.				
Straight Creosote	1117	107	7	8.8
Card	4929	1099	5.9	16.4
Burnettizing	842	273	9.5	22.9
Untreated	1075	1033	89.4	6.9
ELM.				
Creosote	206	13	2.9	3.4
Card	597	56	2.5	6.8
Burnettizing	224	28	7.2	5.3
Untreated	112	112	93.8	6.2
HICKORY.				
Creosote	10	0	0	0
Card	185	50	6	21
Burnettizing	16	0	0	0
Untreated	65	65	92.3	7.7

COTTONWOOD.

Process	Number of Ties	Removed	Percent Decay	Percent Other Causes
Creosote	88	3	1.1	2.3
Card	296	54	2.7	15.5
Burnettizing	56	56	96.5	3.5

RED OAK.

Process	Number of Ties	Removed	Percent Decay	Percent Other Causes
Creosote	164	4	0	2.4
Card	777	111	.3	11.3
Burnettizing	159	35	6.3	15.8
Untreated	128	127	96.1	3.1

POPLAR.

Process	Number of Ties	Removed	Percent Decay	Percent Other Causes
Creosote	50	2	0	4.1
Card	396	148	7.2	30.1
Burnettizing	50	20	20.	20.
Untreated	81	80	95.1	3.71

WHITE OAK.

Process	Number of Ties	Removed	Percent Decay	Percent Other Causes
Creosote	15	0	0	0
Card	136	28	8.8	11.8
Burnettizing	15	3	6.7	13.3
Untreated	39	28	61.5	10.3

Data furnished by F. S. Shinn, Supervisor of Galesburg Tie Plant, and J. H. Waterman, Supt. of Timber Preservation, C. B. & Q. R. R.

MARENGO CAVE, MARENGO, INDIANA

W. N. SPECKMAN, ELMHURST COLLEGE

Marengo Cave is situated within the corporate limits of the town of Marengo, Crawford County, Indiana, on the Louisville, Evansville, and St. Louis Division of the Southern Railway, thirty-eight miles west of Louisville, Ky., and twelve miles north of the Ohio River.

It is said to have been discovered accidentally by hunters in pursuit of a rabbit which took refuge in a hole which led into the Cave. Others say that parents, missing their children while at play during the day, watched their disappearance into an opening in the ground which was found to descend gradually into the mouth of the Cave, the first room of which had furnished an excellent hiding-place and playroom for the children.

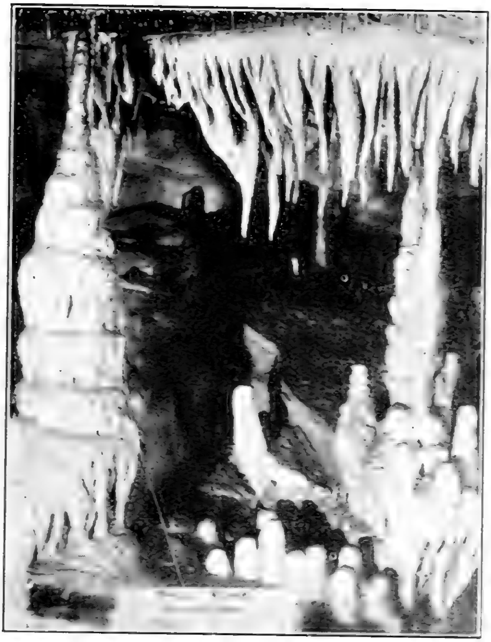
The formation of the rock about Marengo is of limestone. A large limestone quarry has been opened on another side of the town adjoining the railroad track and a considerable quantity of material has already been removed. The existence of the Cave has been known but forty years, having been discovered in 1883. A writer says, "Although this land has been the center of civilization for more than three fourths of a century, and a little town with its places of trade and shops of industry had existed for nearly half a century, yet not until the year 1883 was it known that this grand work of Nature lay hidden beneath the surface here."

The hill under which the Cave lies is rolling and gradually elevated above the surrounding country. On its sides are outcroppings of limestone formation. The present entrance is near a beautiful grove about two hundred yards north of a sparkling stream which is fed by the water of two large springs in North Marengo. These springs issue from small caves in the sides of elevations. The one has a semi-circular entrance with sloping stone ceiling from which stalactitic formations depend and is in itself worth seeing. Quite a stream of water flows from it and plants grow at the entrance. The original entrance to Marengo Cave has been closed and another made, which descends at an angle of about forty-five degrees and is some sixty feet in length. An upright door secured by a lock opens into a cemented arch covering the stairway. Lanterns and torches are used to light up the crimean darkness. On the sides of the stairs one finds cave crickets, *hadaenuci subterranei,* which are colorless and blind. The temperature of the Cave is noticeable especially on a hot day, remaining the same summer and winter, namely fifty-six degrees Fahrenheit.

The interior consists of avenues, chambers, domes, and grottoes. Most of the walls, floors and ceilings are of limestone ornamented with formations in grotesque shapes. The floor of the greater portion of the Cave is dry; but where the most of the limestone formations are taking place, it is damp. At the foot of the stairs is Grand Entrance Hall, which leads into the portion of the Cave known as the Long Routė. There are four grand divisions of the Cave called respectively, The Long Route, Washington Avenue, Western Avenue, and Crystal Palace. A picture cannot do justice to Crystal Palace with its stalactites and stalagmites. One must see it to appreciate it. Tourists consider it "the most beautiful of any natural underground room that has ever been discovered." Crystal Palace is about twenty feet wide, forty feet high, and two hundred feet long. The whole Cave varies in width from ten to seventy-five feet, in height from eight to forty feet, and the total length of the chambers and passages is about three and one-half miles.

The four divisions of the Cave are subdivided into halls which have been named, usually by visitors, for their resemblance to the original: Statue Hall, Congress Hall, Odd Fellows Hall, Mammoth Hall, Music Hall, and Elks Hall. Many of the beautiful formations have also been given names. The Vault in Cave Hill Cemetery is an interesting example. Others are Charleston Jail, Prison Cell, Statue of Liberty, Tower of Babel, Baby Elephant, Jumbo, Elephant's Head, Diamond Dome, Leopard Ceiling, The Gods of Athens, Solomon's Temple, Fish Market, Lovers' Retreat, Niagara Falls, and Mt. Vesuvius. The Railroad Crossing is a strange formation on the ceiling, consist-

Vault in Cave
Hill Cemetery,
Marengo Cave,
Photo by L. R. Davis.



Washington's Plume,
Marengo Cave.
Photo by L. R. Davis

ing of what seem to be parallel tracks. One of the most wonderful formations is that of the Pipe Organ. The Manager, who guided me through the labyrinthian passages of the Cave, struck several of the stalactites which resounded with musical tones. Other beautiful and curious stalagmites are Washington's Monument and Washington's Plume.

In one part of the Cave beautiful stalagmites resembling bouquets of flowers or stalks of celery may be seen. To me they were the most wonderful of all formations. The way in which calcium carbonate trickling from the ceiling forms crystalized stalactitic and beautiful stalagmitic columns with glittering domes is certainly interesting, and the floral-like formations are exceedingly wonderful. The underground water of that locality contains much dissolved limestone. Upon seeping through the roof of the Cave it begins to evaporate, losing its carbonic acid, and limestone is deposited on the ceiling around the edge of the drop of water. Other drops form below this one until a tubular pendant develops, which at first is hollow but later the opening is filled and successive layers are formed on the outside. When the stalactite thus formed reaches a certain stage, if the seepage is sufficient, the drops will fall to the floor and build up a stalagmite. These, meeting the pendants from the ceiling, form columns as shown in The Visitor's Wonder or Haines's Alcove. The general yellow color of cave formations is caused by the presence of iron oxide. Most of those in Marengo Cave are translucent and some are almost snow white.

Marengo Cave is one of Nature's greatest works of art. It is a sight of beauty and of wonderful ornamentation that makes a lasting impression on the mind of the observer. J. S. Diller in a Governmental Publication says: "All caves are not so beautifully ornamented. Mammoth Cave of Kentucky, although remarkable for its size, contains a very small amount of cave deposits such as are shown by the two illustrations," referring to Luray Cave in Virginia and Marengo Cave in Indiana. A trip to Marengo Cave is well worth one's time. The expenses while there are reasonable.

LAKE ABRAM, BEREA, OHIO

W. N. Speckman, Elmhurst College

Among the geological formations of the Berea, Ohio, Quadrangle, left at the close of the Glacial Period, is a depression just northeast of the village of Berea in Cuyahoga County, which is filled with water and surrounded by muck lands. It is found at the top and near the middle of the old bed of the Rocky River and is drained by Abram Creek into the present Rocky River.

When the glacier passed over this region the old channel of the river was filled up, with the exception of the places occupied by Lake Abram and other water-holes or depressions in the quadrangle known as Duck Pond, etc. A large disk of ice was probably left in the present location of Lake Abram which interfered with the filling-up process and, when melted, formed the original lake. On the recession of Lake Erie, which was comparatively shallow in this vicinity, currents of water formed the sand ridges, found in this locality, out of the debris left by the glacier. In the water, bars were composed of the sand, gravel, stones and other material which now compose the ridges.

The muck land about Lake Abram is at least 25 to 30 feet deep. A fence board 16 feet long has been pushed down into it in some places without reaching the bottom. The muck runs out from the center to a shallow edge. The pond is gradually filling up with clay, etc., washed in by the intakes, from fields now plowed. Formerly the water was clear. When the bottom of the Lake is touched, it is found to be of pebbly boulder clay, and on the ledge in places underlying the muck is the original shore-line of the original lake. It consisted of a pond of clear water with a shore of white pebbles and sand. Next to the bottom are great quantities of marl, greenish in color and made from the shells of freshwater snails, clams, etc. There is a marl bed under the whole country in the vicinity of Lake Abram. Years ago the Lake was three fourths of a mile in diameter and from two to three miles in circumference, being irregular in outline; now it is less than a mile around it.

The farms in the vicinity have been drained. For years the farmers had lawsuits pending against the Big Four Railroad Company, claiming that the tracks prevented the drains from carrying off the water. The railroad company had built an arch under its tracks, which rests on oak timbers eighteen inches square that were sunk into the ground below the Lake outlet. As year by year the drains failed to carry off the water, the farmers blamed the railroad company, not realizing that when their land was drained the muck soil had shrunken and sunk below the level of the timbers, which are now exposed at the foot of the arch. The drain is consequently nearly four feet below the timbers, since the general level of the muck has sunk from four to six feet. The lake, however, is still at its former level, except that it is gradually filling up.

Vegetation about Lake Abram consists of alders, elms, ashes, maples, pond-lilies, cat-tails, and mosses, which have formed the muck. The region to the northeast of Berea, although at present dry land, was a swamp in the recollection of the older citizens. Podunk Swamp, as it was called, extended to the present town of McKinley, about half the distance to Cleveland. The country was so low and wet that corduroy wagon roads were once in evidence. Heavy forest timber extended along the Big Four tracks, and when the Railroad used wood for fuel in its locomotives, cord wood that the Company bought up was piled along the tracks for long distances.

A few years ago a railroad line was surveyed to connect Youngstown, Cleveland, and Lorain. The plan was to make a fill at the northern end of Lake Abram. Thousands of yards of dirt were taken from lots in Berea and dumped upon the muck; but it soon sank in, forced itself down, and disappeared beneath the surface, leaving a water-hole. As the dirt went down it crowded up the muck a distance away. Although quite an excavation still exists in Berea where the dirt was removed, no effect was visible at Lake Abram and the project had to be abandoned.

An early story of old Lake Abram is told of a man who rode out to the lake and, after hitching his horse to a tree, commenced to converse with a friend, who after a while asked him how he had come out. He replied: "On horseback". "Where is your horse?" said his friend. On looking around he said he had tied him to yonder tree. The horse had disappeared beneath the surface of the earth.

MEDICINE AND PUBLIC HEALTH PAPERS

ESSENTIALS OF A SAFE MILK SUPPLY IN CITIES OF FIVE THOUSAND AND UPWARD IN ILLINOIS

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It is to be noted that the discussion does not turn upon the production of an ideal milk supply. An ideal milk supply would be one in which a clean milk is available within a few hours to every household. An ideal milk supply would involve cows scientifically cared for as to the hygiene of diet, personal health, range and housing. It would involve strict cleanliness of the animal and the milker. The milk must be cooled promptly, stored, transported, delivered and stored again so as to avoid contamination or a temperature favorable to bacterial growth.

It is a pleasure to recognize that the items just mentioned are receiving much attention and to some degree have become fixed in dairy practice. It is on the basis of the increasing attention to healthy and clean dairy animals, healthy and clean milk handlers and proper home storage that even a safe milk supply can be predicated. A safe milk supply is one which secures the proper pasteurization of good milk. Pasteurization does not imply the cooking of dirty and infected milk. Warfare must be kept up to secure all the results of a clean milk.

But there are factors in milk production and distribution which make necessary the proper pasteurization of all milk produced in quantity for distribution to communities of at least five thousand population and above. These factors are:

1. Continuation of sources of contamination.

Dairy barns, milkers and milk handlers do not provide for the same degree of cleanliness found in domestic food handling processes in the dwelling of the dairymen. The housewife has abundant facilities and a long tradition for the cleanly production of foods; besides, she has the cooking art as a constant ally: but the dairyman works with a living animal in a barn, and with a feeble tradition of personal cleanliness outside of the house and not always a robust personal tradition of cleanliness in the house. About the barn the dairyman is a barn and field worker; the provision in the barn of water supply, soap and towels approximates the barn level rather than the dwelling level. Though improvements are acknowledged, a barn will remain a barn for a long time to come.

2. Infection of milk. For a good while to come milk will be exposed to sources of infection especially in the animal and the milker. Only a few herds are tuberculin tested, and most of the items of veterinary hygiene are scarcely dreamed of. As to the controlling of disease carriers among humans, we have hardly begun it. The average disease carrier of an enteric, a respiratory, a genito-urinary or a skin disease is not thought of as a carrier until after he has spread contagion for a life time; then his control is a very indifferent matter. Milk borne epidemics of disease are started usually by milk handlers in approximately good health.

3. Cooling, storage and delivery of milk.

A strictly fresh milk, even if produced in a clean manner, must be transported and stored, not reaching the consumer as a rule for twenty-four hours and upwards. There is always some bacterial life in any milk, either pathogenic or such as to change the milk materially in palatability and digestibility. Time and temperature are the factors for the increase of this bacterial life. Proper pasteurization only can defeat the effects of this contamination in a clean milk delivered to the consumer in the usual time.

PASTEURIZATION NOT AN EXPERIMENTAL PROCEDURE

In speaking confidently of pasteurization an experimental procedure is not being considered. The greater cities require it invariably. No unpasteurized milk is sold to the public in Chicago, New York or other large cities, but most of the smaller cities lag behind. Evanston on the north side requires pasteurized milk; Cicero on the west side does not. The only down state cities in Illinois which have a milk ordinance requiring pasteurization of milk at all are Savanna, Decatur, Pontiac, El Paso and Staunton. Such cities as Peoria, East St. Louis, Joliet, Rockford, Galesburg and practically all the rest do not require a safe milk supply.

This constitutes one of the greatest public health causes in our State at the present time. We may expect morbidity and mortality rates in cities not safeguarding their milk supply to exceed those which do. Milk borne epidemics will be in proportion to the proper pasteurization of the milk supply of a community.

TREATMENT OF LEPROSY

By Dr. Arthur Stilliams, Northwestern University

(The above paper has been published in "Medical Insurance, Combining Practical Medicine and Surgery."

Vol. XXXIX, page 141.)

A PRELIMINARY REPORT ON A SANITARY SURVEY OF GALESBURG, ILLINOIS

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The object of this sanitary survey is to determine general sanitary conditions in the city of Galesburg and to make specific recommendations for the betterment of the same.

Location. Galesburg, the county seat of Knox County, lies on a high prairie in the upper Illinois glaciation, on the crest of the water-shed between the Illinois and Mississippi rivers. It is 165 miles southwest of Chicago and about 50 miles east of the Mississippi river. It is a large railroad center, an important division point of the C. B. and Q. railroad, has large shipping and switching yards, employing in normal times over 3000 employees, some 25 manufacturing plants and two flourishing colleges. Its area has a total of about 5,760 acres. It is a well treed city, has 38 miles of paved streets, and about 60 miles of water mains and sewers. It has four parks containing over 200 acres, and there are in its environs several small artificial lakes which give a surface water supply for the railroads and some factories.

Topography. Galesburg lies in an upland prairie district; the soil is mostly brown silt loam, sprinkled here and there, particularly in the southeastern part of the city, with light clay loam and in the eastern part with yellow silt loam. The valley of Cedar Fork, an open sewer which flows through the town, is a deep glaciated deposit, but in most parts of the city the drainage is poor because of the impervious clay subsoil. The surrounding region is rolling prairie, but there is very slight drainage for the city sewage.

Climate. Galesburg climate is favorable to health. It meets Huntington's requirements in that it has rather sudden changes and great extremes in temperature. The mean temperature in summer is about 79 degrees Fahrenheit and in winter about 40 degrees Fahrenheit.

Population. At the last census the population was 27,696, the greatest percentage being American born, although the Swedish population is quite large. There are also many negroes, mostly in the southwest part of town, some Irish and Germans, a few Italians, fewer Slavs, and a small colony of Mexicans, most of whom are employed by the railroads.

Water Supply. Galesburg is well supplied from the St. Peters and Potsdam sandstones. There are three wells in use ranging from 1,245 to 2,240 feet in depth. The city pumping plant contains seven pumps, five of which are emergency pumps. There is in connection with the pumping station a reservoir of about 6,500,000 gallons capacity with a daily consumption at the present time of about 1,250,000 gallons. The reservoir itself is in need of more adequate protection against pollution, and better fencing should be used to keep trespassers off the premises. During the summer months, the water receives copper sulphate treatment for algal growths and is tested each week by the state bacteriological officers.

Milk Supply. The milk supply is not so adequately protected. In the first place there is no adequate supervision by the city authorities of either dairy herds or dairies. The state inspection of dairy cattle is not checked up by the city health authorities and in consequence some milk from tubercular cattle sifts into the city milk supply. Some of the dairies are sanitary and would comply with a moderate grade of inspection, but several of them are notoriously dirty. Pasteurization is made by some dairymen, while others supply raw milk. Tests made at the laboratory of Knox College of several different milk supplies revealed usually a high butter content but also a high bacterial count. There is need of this city adopting the standard Pasteurization requirement now being adopted by many cities of the state, but this requirement would be inadequate with the present health machinery of the city.

Protection of Health. At the present time the city of Galesburg has no adequate health department capable of maintaining health standards. There are on the statute books many model sanitary statutes although no sanitary code as such has been compiled. There is, however, no machinery capable of carrying out their statutes. The amount of money spent, for example, by the water department of the city of Galesburg, according to the 1921 tax levy order, is $3.19 per capita. The fire department spent $1.158 per capita. The police department spent .976 per capita. The health department, which consists of the mayor, a health commissioner and a city physician, spends only .177 per capita. In a comparison with a number of other cities of the same size in the United States, Galesburg stands at the foot of the list in the amount of money spent for health protection. Fortunately for the city there are a number of health organizations, such as the Red Cross, a Visiting Nurse Association, a Day Nursery, The Associated Charities, The Free Kindergarten and the Salvation Army, all of whom aid indirectly in maintaining the health of the city. Two school nurses are provided also by the Board of Education. The city of Galesburg should change its present method of health expenditure and obtain the services of a full time health officer who would have jurisdiction over milk and food supplies as well as public health statistics and other health matters.

Sewage Disposal. Galesburg has been criticised as a city with an open sewer. No time will be spent here in discussing this situation, as an adequate report has been made by Paul Hansen in his article entitled "The Pollution of Cedar Creek by Galesburg", pages 196-224, University of Illinois Bulletin, Vol. 13, number 19, Jan. 10th, 1916.

Garbage and Refuse Disposal. The city of Galesburg possesses an incinerator which is capable of burning about 25 tons of garbage daily. At the present time this incinerator, which is located within the city limits, is doing its work in a manner offensive to the people of the neighborhood. The garbage collection is also inadequately taken care of, some parts of the city in particular receiving extremely poor service. The garbage disposal force should be increased and the incinerator either be moved to a location outside the city limits or some smoke-consuming device should be installed which would prevent the odors now being given out.

Ashes are not collected by the city. In most cases they remain on the premises during the winter and are collected and dumped during the spring.

Food Inspection. So far as can be learned little or no attention is given by local health authorities to inspection of foods or manufacturing plants in which foods are handled. Some manufacturies and slaughter houses are in need of attention by the proper authorities. A full time health officer would remedy this condition.

Housing. The housing conditions have been particularly the object of investigation by the classes in public health in Knox College for the past three years. In the survey to date 327 out of a total of 506 city blocks have been surveyed; 65% intensively and satisfactorily. In the surveyed area there are a total of 3,239 houses. Of these 12.1% are brick; 87.9% are frame; 52% are classified as being in good condition; 24.7% in fair condition and 23.3% in poor condition. Turning to the sanitary conditions of the environment we find that there are in this area 395 localities where there were rubbish heaps, containing either ashes, manure, or materials capable of holding water. There were in the total area surveyed 1,828 privies and 1,854 wells, an average which means a well and a privy for every third house. Of the total number given 67% of the wells were within 100 feet of a privy, and 42% of both wells and privies were in use.

In this connection it is striking to note that the seventh ward, which is located in the extreme southeast part of the town and contains one of the two colleges of the town, is found to contain the most wells and privies. This and certain other similar wards are the ones that are served least adequately by sewers and water mains. It is stated also by physicians of the city that the typhoid outbreaks, which occurred in the years 1910, 1911, 1918, and 1919, were traced in most cases to the areas having the most wells and privies.

THE INTENSIVE SURVEY

General Housing Conditions. Galesburg has within its relatively small limits sanitary conditions of both extremes. The best residential district is found in the third ward, or those blocks north of North Street and east of Broad. There excellent housing conditions prevail and the environment is good. There are smaller areas scattered around in the southeast and west parts that are good also, but there are no very large areas that do not have insanitary and poor housing conditions scattered through them.

Cedar Fork. The greatest potential source of danger to the city is Cedar Fork, the open sewer which runs diagonally through the center of the city. It and its tributaries form an environment in which are found some of the poorest and filthiest areas of the city. This creek has slight natural current, and the sewage wastes of almost the entire city are emptied undiluted into this creek through 30 large sewers. Samples of water tested showed the presence of the colon bacillus and over 250,000 colonies of bacteria to the cubic centimeter. Besides these sewers there are two large tributaries which contribute their waste to the main stream. One enters the stream at Holton Street and carries the wastes from the Standard Oil pumping station in the southwest part of the city. The banks of this stream are used as a dumping ground for refuse and garbage. The other branch is called Silver Creek and enters the main stream at West Street. There is almost no current in this stream and there is a filthy scum on its surface. The stream lies in the region of the poorest section of the city, and on the banks are wells, privies, manure heaps, and dilapidated structures used as homes for negroes and the poorest white people. About half a block up stream from the entrance of Silver Creek is another sewer that discharges daily about 8,000 gallons of the black oily gas house wastes into the stream. In the summer when the wind is in the right direction, the odor from the stream can be noticed for long distances from Cedar Fork, while people living on its banks find it almost unbearable. In times of drought the lowered stream leaves a sludge along the banks open to flies, dogs and small children.

Wells and Privies. Another great problem for Galesburg is that of the wells and privies. In an area of 30 blocks in the 7th ward, there were 248 houses and 245 privies, meaning a privy for almost every house in that territory, and there were 236 wells within 100 feet of the privy. There are a negligable number of privies adequately protected and screened. In the region of Silver Creek, some of the filthiest privies are used by both whites and negroes, and many of these privies are within 25 feet of the stream. There is a decided indication of infection of the drinking water in such districts. In 1918 there were 32 cases of typhoid fever; in 1919, 46 cases; and most of these cases were found in the seventh ward, an area where there is an inadequate city water supply. Within 25 feet of Silver Creek is a well used by three families for drinking water. Two ladies, living at the foot of the slope to Silver Creek, complained of "being ailing all winter". It was found that all their drinking water came from a shallow well at the foot of the slope on which there were a number of houses and privies. Three wells taken at random in this region were tested and found to show the presence of the colon bacillus.

Rubbish and Garbage. In the main business district of the city the alleys are in a deplorable condition. One, which lies back of some very sanitary appearing food stores, extends east from Seminary Street, and is full of refuse and debris. No garbage cans are used, and the decaying food and vegetables are thrown out to the flies and rodents. A privy was moved recently but the vault was not cleaned out and an old box was thrown over the contents. The alley south of the Main Street business houses, between Prairie and Kellogg Streets, is filled with ashes, garbage, boxes and other refuse. On north West Street, near Silver Creek, are several barns beside which the manure is piled nearly as high as the buildings. A block from Cedar Fork is a large horse and mule exchange from which the manure is not hauled daily. The exchange is not screened. There is opportunity here for the breeding of flies on a large scale which could have easy access to the open sewer not a block away, and this might result in an epidemic of flyborn disease.

On the corner of Seminary and Simmonds Streets, at the rear of a large and well equipped grocery store, is a fenced-in area where garbage and rubbish are thrown, but the white latticework fence can hide neither the sight nor the odor from the passerby. In a number of cases the garbage from private homes is thrown out to the chickens, and in the summer the decaying food causes a very offensive odor. In a section of the southeast side the garbage cans were full and overflowing, owing to the fact that the city had not collected for several weeks. Numerous calls to the health department had not relieved the situation. In the extreme south part of the city there was an even worse condition. At several houses visited the garbage was "just thrown out the front door".

Housing. There is very little overcrowding, and tenement houses are unknown in Galesburg, yet there are a large number of extremely poor houses. These are especially numerous in the Silver Creek and Cedar Fork areas. In the southeastern parts the houses are small but in good repair; they are quite sanitary except for the large number of wells and privies. In the southwestern part of town, south of Monmouth Boulevard and west of the C. B. and Q. yards is a large negro district, marked by small houses filled with large families. The houses lack paint and need repair. While some of these show thrift and cleanliness, others indicate shiftlessness and insanitation. This area is not adequately supplied with sewers and water mains, as shown by the large number of wells and privies found there. On east South Street is a large frame house of eleven rooms in which are living thirteen people, mostly foreigners. This a very dilapidated structure and should be condemned, for the foundation is crumbling, making the place dangerous to its occupants. There are several open garbage cans and a well and privy at the rear. Back of stores on the east side of Seminary Street, a block from Main Street, is an old house used for cheap lodgings. The floors are filthy and the walls and bedding are vermin infested, while near the back door is a shallow well and within a few feet is a large open privy.

Food Stores. The main food stores in the center of the city are for the most part sanitary and in good condition, although there are a few which are not as clean as they should be. For example, in one on the south side of Simmonds Street between Prairie and Kellogg Streets. the kitchen was very dirty and the employees were not clean. The greatest trouble with the food stores is found in the small grocery and ice cream parlors which abound outside the district. There are at least a dozen of these located near the open sewers of the town, close enough to receive their share of flyborn disease from these sources. It sometimes appears as if the dirtiest and most insanitary districts were picked for the location of these small stores. One is placed on the bank of Cedar Fork at West Street, one on the bank of Silver Creek at North Street, one on the bank of another tributary at Academy Street and a fourth on the bank of Silver Creek at West and Locey.

Streets. There seems to be little regard for cleanliness and sanitary rules at any of these places. There are also some very small and crowded stores and eating places at the southwest corner of the public square which are operated by colored people, and the rear parts of the store and the upstairs parts are used as living rooms. Recent raids have proven the existence of dope dives here. This locality should be cleaned up, both physically and morally.

Recommendations. It is evident from the special evidence just cited in the above paragraphs that in addition to the establishment of an adequate health department the sewer and water supply should be extended into such parts of the city as do not have service at the present time, and that above all a Sanitary District should be established to take care of Cedar Creek and Silver Creek sewage.

The writers of this preliminary survey wish to thank the members of the public health classes of Knox College for the privilege of using first hand materials gathered by them, and wish to express their thanks to Prof. G. W. Hunter of Knox College for his suggestions and direction.

HEART DISEASE AS A PUBLIC HEALTH PROBLEM

Dr. Sidney Strauss, Secretary, Chicago Association for the Prevention and Relief of Heart Diseases

It is no news to you to say that Heart Disease exists everywhere; undoubtedly all of you have instances in your own family. Nor does the mere existence of heart disease make it a public health problem. To become a problem for the public, it must be demonstrated that the public will be benefited by a concerted effort for the control of this disease and that a concerted effort of all concerned, doctors, social workers, hospital and dispensary boards and the public is necessary for its control.

While numbers alone do not make any disease a publis health problem, before it does become such a problem the incidence of the disease must be so great that it has grown beyond the reach of the few actively engaged in combating it. There is no doubt that we do not need an organization for the control of every disease known to man, for instance such a disease as pernicious anaemia, which the doctors and nurses can take care of very well. It is different, however, with heart disease, which in its various forms causes more deaths yearly than any other one disease and which causes as much or more sickness and disability than any other ailment. This includes pneumonia, cancer and tuberculosis, against which much good has been done by adequate organization. It has been shown by reliable statistics that diseases of the heart cause ⅛ of all deaths of all ages and 1/5 of all deaths beyond the age of forty; but, striking as these statistics are, this is not the most important fact which concerns the public. From examinations for the draft and adequate examination of school children in New York City it has been shown that about 2 per cent of children and young adults have heart disease. Examinations by life insurance companies show about the same percentage. That is to say, in a city of three million inhabitants there are about sixty thousand who have heart disease. You may say—"Well! What of it? Let the doctors take care of them!" But there is more to it than that. This great number cannot properly be taken care of without the aid of the public, and, under present management, the number is increasing. This means not only great and perhaps unnecessary suffering to the individual but a great economic loss to the public. Dr. Halsey has conservatively figured that each cardiac patient admitted to a hospital costs the community $200.00, $100.00 for care and $100.00 from loss of work. In the cardiac clinics in New York in 1922, there were 4,000 under treatment, which would mean a loss of 8 million dollars from this source alone. When you consider that a large number of heart patients, if not properly managed break down and have to enter a hospital repeatedly during a year, you can see what an enormous loss to the community this one disease is. From this one stand point alone, heart disease is certainly a public health problem.

This is not, you can well imagine, the reason why the doctors, nurses and social workers, who are constantly dealing with those handicapped by heart disease, decided that they needed help. Every one who is in any way connected with public hospitals knows that the heart cases fill the wards; not only because there are so many but because the same patient returns time after time with his heart broken down, until the final break-down comes. It was this fact that induced Dr. Hubert V. Guile to start a cardiac class at the Bellevue Hospital in 1911, to see if he could not prevent some of these returns. His results were brilliant, and others rapidly followed his example so that now there are 38 such classes in New York, seven or more in Chicago and many in other cities.

With the establishment of these classes or "cardiac clinics" as they are called, it was soon found that, though much could be done by the clinics, in order to get the best results for the patient many other agencies were needed. Some of these agencies perhaps existed, many of them needed to be enlarged and many other social organizations needed to be formed. It was thought that the entire problem could be handled best by associating all these organizations, and in 1915 the Association for the Prevention and Relief of Heart Disease was formed in New York City. The war interfered somewhat with the progress of this organization, but following the war it grew rapidly and within the last few years organizations have been started in various cities of the country. Our Chicago organization was launched in April, 1922. In June of that year a meeting of the men from several cities of the country was held in St. Louis under the initiative of the New York association, and it was decided to form a rather loose union of all the organizations existing or that might come into existence in this country.

The purposes of these organizations are, first, education of the public; second, coordination of all organizations in a community which deal in any way with the problem of heart disease and aid in establishment of such new organizations as are needed; third, promotion of research in the problem of heart disease, especially as it relates to public health and the gathering of adequate statistics.

The question which you now ask is: Are such organizations needed and have those which have already been formed justified themselves? It has been stated above that in so far as numbers are concerned, the heart problem offers food for thought to any community, and more especially to the larger ones in which the laboring class makes a good body of the population. It remains to be seen whether this problem has or has not been handled properly without such organizations.

Let us go back to the time when patients suffering from heart disease were treated exclusively in the general dispensary. The patient came to the out-patient department, was examined, was given instructions perhaps and digitalis or other medicine if needed. Among the instructions might be included the recommendation to stop work and rest for a month or so and often to change the occupation. I well remember having a strapping, healthy looking teamster come to me for examination shortly after his discharge from the hospital. He had had a breaking down of his heart secondary to a valvular lesion; his heart had compensated fairly well with rest and he was sent to the dispensary for further care. He looked well and strong, he was young, only thirty-five, and had a family whom he wished to support. He didn't want charity. My recommendation that he should rest and change his occupation wasn't worth anything. We had no convalescent home to which to send him, and we had no vocational school or employment bureau for the handicapped, in which he could learn a new trade and get adequate employment in that trade. The result was that after a few months, during which he followed his old trade, he was in the hospital again with a broken down heart. This continued for several years until his death. Such cases as this one is what brought about the formation of cardiac clinics and with this, when case after case such as the above were examined, such problems as the above were encountered repeatedly and it was found that cardiac clinics alone could not do the work. All organizations and agencies having to do with heart disease were needed, and above all the public had to be educated so that the proper organizations could be formed.

In Chicago I am better acquainted, our organization is in its infancy, our needs are great; hence I shall describe the situation there. The Cardiac Section of the Illinois Conference of Social Workers, with Miss Schoenfeld as chairman, recently made a study of the heart cases under care at the hospitals and dispensaries in Chicago for a period of two months. Among other striking things it was found that out of 344 hospital cases, 194 of which were adults, 88 were *laborers*, that only five of this number were reported at cardiac clinics after discharge from the hospital and that only eleven were sent to convalescent homes. 46 out of 194 returned to the hospital again broken down within this period.

I cite this small number of cases because they demonstrate better than anything I can say the needs of Chicago for its cardiac sufferers.

We have in Chicago at this time seven or more cardiac clinics for adults and children—some excellently equipped, some not so completely. The first need of any special clinic, especially a cardiac clinic, is an adequate social service department. In order to do anything with out-patients, one must first know home conditions and adjust them to the needs of the patient, be that patient mother, father or child. In adjusting home conditions we come in contact with the schools, with day nurseries, homes for the friendless, with the employer, with the employment bureaus, with the Relief and Aid Societies, with practical housekeepers, in fact all agencies which have to do with social re-adjustment. The social worker makes these contacts; but suppose there is no contact to make, and suppose each social worker tries to work the problem out alone. There is no need for me to repeat that "In union there is strength". The first call then for our Association is the co-ordination of all the agencies concerned, and especially the union of all the cardiac clinics, including the social workers. It is in the cardiac clinics that the needs for other agencies first became manifest and it is by a union of the cardiac clinics and the existing organizations that these needs can be brought before the public and eventually fulfilled.

Our Chicago Association is, as I have said, young. Our first step after procuring an executive secretary was to find out what agencies we already had in Chicago that could help us in our fight against heart disease. We knew that very few agencies were known; we are now convinced that very few agencies exist in Chicago. Why were only eleven out of the 344 discharges sent to convalescent homes? Chiefly because there are in the whole State of Illinois only 242 year round convalescent beds for all conditions. Does that bring home the need? Why did only five cases out of the 344 report at the existing cardiac clinics? The chief reason (there are many others) is that there are too few social workers to follow them up and see that they return; there would be more workers available for those who could be helped if we had some place to send and care for those who cannot be helped, in other words a hospital for chronics, or better a hospital for Heart Disease.

When we started our association, every one of us realized that a perplexing problem was the employment of the cardiac and we hoped to co-operate with the Bureau for the Handicapped. But there is no longer any Bureau for the Handicapped, and it is up to us to arrange for the proper employment and for vocational training when needed for our own cases. The Illinois State Employment Bureau has a handicapped department with which we can co-operate at present. A majority of cardiacs can work and they can work steadily if they have the proper job or office. In this line more can be done with children, and the earlier we know that a child has heart disease the better it is for that child. The child can then be trained for a suitable occupation and can become a useful, self supporting citizen. For this, we need examination of our school children and examination with the child stripped to the waist. We also need vocational guidance, so that the child, become a man, will not have to seek a job as a laborer on the streets as 88 of the 194 patients did. Whether we should have special schools for cardiac children is still a disputed question. They are carrying on some investigations on this subject in New York where there is a difference of opinion. We may have some facts bearing on the subject in Chicago where we have a special class for cardiacs at the Spalding and one other Public School. At present we need a school or shops where the cardiac who has too strenuous a job can learn a new trade by which he can support himself and family without a breakdown. Then, too, we need some way of lightening the mother's burden in the home. The cardiac mother should not do her heavy work; but who is going to do it for her? There must be a bureau equipped to send some one into the home to relieve the mother of the work she should not do.

All this of course has to do with the relief of heart disease. In a way it is also prevention, that is, prevention of a breakdown of the patient who already has heart disease. So far as the patient goes, he is not concerned about his heart as long as the heart muscle does its work; and if we handle the cardiac properly we are preventing real invalidism. Further, much can be done in the way of actual prevention if the situation is handled adequately.

Most of the cases of heart disease which occur in youth are due to acute articular rheumatism, and the rest are due undoubtedly to other infectious diseases; a large number of the cases of heart disease beginning in those above forty are due to syphilis. We hope that the active campaign being waged by the various Public Hygiene Associations for venereal diseases will have its effect on preventing the increase in heart disease. We also hope that the campaign for combating heart diseases will decrease the incidence of this disease in the young. In the report previously mentioned it was hinted very strongly that the patients did not remain in the hospital long enough. That is true not only of cardiacs but also of those suffering from infectious diseases. We do not at present have a long enough convalescence for our acute diseases, chiefly because we haven't room enough in our hospitals for our acute cases and because we haven't enough convalescent homes. We stated in the beginning that patients with heart disease occupied a very large proportion of beds in our hospitals. If we had a place for our cardiacs there would be more room in our acute hospitals; we consequently could keep our infectious disease cases for an adequate time and prevent some cases of future heart disease. Thus we have not a vicious but a beneficient circle.

It is well known that rheumatism, the greatest cause of heart disease, follows most frequently an acute tonsilitis, as does scarlet fever. We hope, then, to prevent heart disease by removing the tonsils in those subject to frequent attacks of tonsilitis. Some also hope to prevent heart disease by removal of teeth, but I cannot, from what I have observed, subscribe to that. Naturally bad teeth need proper care no matter where found.

From these facts, you must see that Heart Disease is a Public Health Problem from all points of view. I cannot close without telling what we hope will be the final outcome of our education of the public.

We hope to have what I choose to call a cardiac centre. Here in some pleasant spot with large acreage, conveniently near transportation, we shall have, first, a Heart Hospital. In another part of the grounds will arise a Convalescent Home, in close contact with which will be our workshops, where our cardiac if necessary may learn a trade. Nearby will be an adequately equipped gymnasium and parade grounds so that we can build up the muscles, and incidentally the heart muscle, before sending our patients out to work. In this way we can tell by proper supervision how much our patients can stand and advise future employers and doctors just what the patient can do. We shall, perhaps, have a separate hospital and surely a school for the children so that we can start them out upon a proper vocation for cardiacs. Scattered throughout the city will be a sufficient number of cardiac clinics from which we shall receive and to which we shall refer our patients. These clinics will be adequately manned with doctors, nurses and social workers, and our Association for the Relief and Prevention of Heart Disease will be the centre and unifying group of all these activities, of all the numerous outside agencies which are or will be formed and to the great public which will then be educated.

THE VITAL CAPACITY DETERMINATION

George Schiff, Northwestern University Medical School, Chicago

The vital capacity of the lungs is the volume of air which can be expired after the deepest possible inspiration.

Hutchinson, in 1846, invented a spirometer and pointed out its extreme value in the diagnosis of early pulmonary tuberculosis. Until recently, however, the value of the vital capacity determinations was not appreciated, and it is safe to predict that it will not be long before the vital capacity will be an indispensable part of the complete physical examination.

Before the vital capacity determination can be of any practical value, it is essential to have:

1—a method and technic which is simple and accurate, and at the same time which is not time consuming,

2—a normal standard for comparison,

3—a knowledge of the various factors which may influence the vital capacity.

METHOD

A spirometer built according to the specifications described by Peabody permits great accuracy and is best adapted for use with children and adults. The adjustment of a self-recording dial is of great advantage, since the entire attention may be given to the proper performance of the test. The subjects stand or sit upright in bed or on a chair, and breathe in and out as deeply as possible through a rubber or glass mouthpiece, the nose being closed by a tight clip. No corrections need be made for temperature, pressure or water tension.

It is not difficult to obtain satisfactory determinations of the vital capacity in adults, and even children respond with surprising intelligence and ease. Care is taken always to explain to the patients the desired object, and it is necessary to urge them to breathe as deeply as possible. Strict attention should be paid to this point, for otherwise the volume of the respiration will be low and will not represent the true maximum of respiratory exchange. The first attempt is often unsatisfactory, but the second or third attempt will invariably give reliable results. The observations are made rapidly, and consume from three to five minutes for each patient.

VITAL CAPACITY OF NORMAL ADULTS

The approximate normal vital capacity of an individual must be known before readings are of much significance in the diagnosis or prognosis of disease. The normal vital capacity for men and women of average physical fitness has been computed by Dreyer and others who used the height, weight, chest measurements, stem length or surface area as the basis for their calculations. The normal vital capacity varies considerably with such factors as obesity, age, occuption and previous physical training and experience. An athletic person or one who plays a wind instrument or takes other strenuous exercise will have a greater vital capacity than an inactive person. All these factors must be taken into consideration. A vital capacity below 15% of the normal may be looked upon as being of pathologic significance.

The recent work tends to confirm the original observation made by Hutchinson of the relationship between the vital capacity and height, and of its tremendous variability, although it is more constant than compared with weight. Lungsgard and Van Slyke contend that chests measured according to certain formulas and found to agree in size would more nearly have the same vital capacity than would persons of the same height, a contention which is denied by Peabody. Christie and Beams, using the "linear formula" of DuBois, have demonstrated that the surface area and not the height or weight or chest measurements is by far the most constant and exact standard for comparison. This confirms the observations made by Dreyer and by West. From observations on 290 normal men and women, Christie and Beams conclude that "a female from 20 to 30 years of age, with a body surface of 1.4 to 1.5 square meters, has a vital capacity of 2,700 c. c., and for each gain of 0.1 square meter in body surface the vital capacity goes up about 175 c. c. A male from 20 to 30 years of age, with a body surface of from 1.6 to 1.7 square meters, has a vital capacity of about 4,000 c. c., and with each gain of 0.1 square meter the vital capacity goes up 350 c. c. From these data, we can conclude that a normal male between the ages of 20 and 30 has a vital capacity of 2.5 liters per square meter of body surface, and that a normal female between 20 and 30 has a vital capacity of 2 liters per square meter of body surface.'' The maximum respiratory exchange remains practically constant up to 50 years, after which there is a gradual decline—greatest between 50 and 60 years, and reaching 50 per cent of the normal at 85 years.

RESPIRATORY DISEASES

I. *Tuberculosis.*

Meyers, studying the vital capacity in tuberculosis, found a direct relation between the extent of pulmonary involvement and the degree of the lowered vital capacity.

On the basis of roentgen-ray examination, he classed the cases as follows:

- I. Suspected cases in which roentgen-ray examination was negative.
- II. Tuberculous cases.
  - A. Peribronchial with unilateral and bilateral involvement.
  - B. Parenchymatous
    - 1. Unilateral with
      - a—the disease confined above the first rib or an area of similar size.
      - b—With the disease extending below the first rib but not involving more than one lobe.
      - c—involving more than one lobe.
    - 2. Bilateral.
      - a—Disease confined above the first rib, or an area of similar size on each side.
      - b—Disease extending below first rib, on each side but not involving more than two lobes.
      - c—Involvement of more than two lobes.

In thirty suspected cases in which the roentgenograms showed no evidence of disease, the mean vital capacity was 102 per cent of the normal, the range being 82 per cent to 122 per cent of the normal.

In thirty-nine cases showing unilateral peribronchial tuberculosis, the average vital capacity was 97% and the range from 81 to 121% of the normal.

Seventy-one cases of unilateral and seventy with bilateral parenchymatous tuberculosis revealed by the stereo roentgenograms were grouped according to the extent of involvement. The vital capacity of the groups was found to decrease as the extent of the disease increased, the average being 74%, and the range from 26 to 122% of the normal.

On the basis of physical examination, in ninety cases showing no evidence of tuberculosis or in which a definite diagnosis was not made, 90% gave vital capacities within normal limits, while variations of 70% to 90% occurred in the remaining 10%.

In 172 cases showing varying degrees of pulmonary disease, the vital capacity was found to be decreased in proportion to the extent of involvement. The vital capacities of 30 cases, showing pulmonary cavities by the roentgen-ray, ranged from 31 to 109% of the normal, the average being 64%. Nine cases of spontaneous pneumothorax showed vital capacities averaging 49%, the range being 32% to 58% of the normal.

III. *Bronchial Asthma.*

Peabody, Wentworth and Barker, and others have reported vital capacity readings in patients suffering from bronchial asthma, and found that in some cases the lung volume was considerably decreased, and in others, it was normal.

Meyers, reporting 20 cases in which the readings were taken at various times during and between the attacks, found the vital capacity was reduced tremendously during the attacks, in some cases to 20% of the normal, which quickly returned to the normal as the attack disappeared. In four cases in which the disease had extended over a period of years, the vital capacity did not return to normal limits after the disappearance of the asthmatic attacks. In these cases, physical and roentgen-ray examinations revealed definite evidence of emphysema, which apparently was sufficient to account for the reduced lung capacity.

IV. *Pneumonia.*

In pneumonia, Meyers found the vital capacity to be very low from the beginning, being reduced to 50% or less in most cases. This marked reduction from the beginning of a case of pneumonia, he points out, is almost diagnostic. The lowest vital capacity was observed on or near the day of crisis. From this time on, if the patient recovers, the vital capacity gradually increases through convalescence. An increase in the vital capacity is noted almost immediately after the crisis, but does not return to normal for many days. The amount of pulmonary consolidation bears no relationship to the vital capacity, as is true also of the relationship between consolidation and dyspnea, as pointed out by Means and Barach. They also point out that the dyspnea may increase after the crisis, with no evidence of alteration in the anatomic processes in the lungs. This, however, does not hold true for the vital capacity, as an increase is noted almost immediately following the crisis. The test, therefore, is a valuable aid in the early diagnosis of pneumonia. In a case of unresolved pneumonia, the vital capacity remained almost stationary for a period of ten days following the crisis. In another case, in which the tubercle bacilli appeared in the sputum, the vital capacity remained stationary over a long period of time.

Peabody and Wentworth suggested that the reduced vital capacity present in patients convalescing from pneumonia may occur in any severe acute infection. Peabody and Sturgis studied the effect of fatigue and general weakness on the vital capacity, using patients suffering from pernicious anemia. In none of these cases, without a lung or heart disease, was the vital capacity reduced more than 26% below normal. In another series of cases, attempts were made to fatigue the muscles of respiration by taking the vital capacity every fifteen seconds for ten minutes. Contrary to what might be expected, the vital capacity was as great at the conclusion of the experiment as at the beginning. The investigators conclude that "general muscular weakness and fatigue of the muscles of respiration are not important factors in causing the reduction of the vital capacity of the lungs, in heart disease."

V. *Pleural Effusion.*

In a group of cases which include hydrothorax, pneumothorax, hemothorax, and empyema, the vital capacity was found to vary between 74% and 42% of the normal. The vital capacity seems to depend upon the amount of fluid or air in the pleural cavity, and there is a close relationship between the tendency to dyspnea and the decrease in the vital capacity.

DISEASES OUTSIDE RESPIRATORY TRACT

I. *Nephritis.*

In eight cases of acute nephritis with no history of dyspnea, the vital capacity was within normal limits. In chronic nephritis, without evidence of heart disease, and without a history of dyspnea, the vital capacity was high, and within normal limits. In cardiorenal cases, dyspnea was a prominent symptom, and the vital capacity usually was decreased in proportion to the intensity of the dyspnea.

II. *Hyper-Thyroidism.*

Dyspnea on exertion is a common symptom complained of by patients with Graves' disease. This may be due to nervousness, but usually indicates cardiac weakness. The decrease in the vital capacity corresponds to the tendency to dyspnea.

III. *Paratyphoid Fever.*

Meyers, studying the vital capacity in acute diseases outside the respiratory tract, found only 15% of the cases in an epidemic of paratyphoid fever, with vital capacities below normal. In more than half of these cases, the reduced vital capacity could be explained on the basis of complications, such as pleurisy or lung involvement.

From these observations, we may conclude that the vital capacity may be of value in suggesting pulmonary complications in diseases outside the respiratory tract.

VITAL CAPACITY OF THE LUNGS IN HEART DISEASE

It has long been known that the vital capacity of the lungs is frequently decreased in heart disease. Peabody and Wentworth confirmed this fact by making 224 observations on 124 patients, and showed in a striking manner that the clinical condition of the patient, and more especially the tendency to dyspnea, varied directly with the degree of diminution of the vital capacity. They subdivide the cases into four groups, basing their classification on the degree of diminished vital capacity.

Group One consists of cases with a vital capacity of 90 per cent or more of the normal. Very few of these patients complained of any symptoms referable to their hearts. Many of them entered the hospital for other diseases, and the cardiac condition was discovered in the course of the routine examination. The vast majority of the patients in this group were able to work without much restriction. Only two of 25 patients were prevented from working on account of their cardiac condition. It is evident that cardiac patients, with a vital capacity of 90 per cent or more of the normal, are almost always in a good state of compensation. They do not suffer from dyspnea after exertion, and if they are prevented from performing their usual task, it is usually on account of cardiac pain or other disturbances.

Group Two consists of cases in which the vital capacity is 70 to 90 per cent of the normal. A history of dyspnea on moderate exertion was a symptom usually given by these patients, but the majority could work and lead a satisfactory, though somewhat restricted life.

It may be said, in general, that cardiac patients with a vital capacity of from 70 to 90 per cent of the normal may have marked heart lesions, but usually are able to lead satisfactory, but restricted, lives. Almost all of these patients give a history of dyspnea, and have a distinctly limited cardiac reserve; they may be regarded as border-line cases in which the activities must be somewhat limited, but in which, under favorable circumstances, there is little evidence of decompensation.

Group Three consists of patients whose vital capacity is 40 to 70% of the normal. The characteristic feature of this group is the much less favorable clinical condition than those with a higher vital capacity. Dyspnea on moderate exertion was always complained of, and usually was the most prominent symptom. All patients whose vital capacity was 40 to 45 per cent of the normal were in bed. Some of them were slightly dyspneic when completely at rest, and others upon the least exertion. With the vital capacity of from 40 to 60 per cent of the normal, patients were rarely dyspneic while in bed, and most of them could walk slowly without becoming short of breath. When the vital capacity was between 60 and 70 per cent, the patients usually could walk fairly comfortably, and could even ascend the stairs without distress. Of the 67 patients comprising this group, 7 per cent could do light work, 33 per cent were up and about, and 34 per cent were in bed at the time of the examination.

Group four consists of patients whose vital capacity is 40 per cent of the normal or less. The patients of this group were compelled to remain in bed, and practically all showed signs of decompensation. Many were dyspneic when absolutely quiet, and others on the slightest exertion. In 8 patients whose vital capacity was below 30 per cent, extreme dyspnea and orthopnea were noted. The lowest vital capacity found was 17 per cent. There was a close relation between the clinical condition and the vital capacity, and as these patients improved, there was a corresponding rise in the vital capacity. Patients whose maximum respiratory exchange falls within this class during their first period of decompensation may improve so that they are able to return to a fairly normal life, but the occurrence of such a low vital capacity in the later attacks makes the prognosis unfavorable. Few patients who have at any time fallen into this group have shown great clinical improvement, and the mortality is more than 50 per cent.

It is evident, then, that there is a close relationship between the clinical condition of cardiac patients and the vital capacity of the lungs. If the maximum respiratory exchange be known, one can tell with considerable accuracy what the functional condition of the patient probably is. Decompensated patients show a low vital capacity which rises with improvement, and the extent of the increase corresponds to the degree of clinical improvement. When the vital capacity remains constant, the patient's condition remains unchanged. A rapidly rising vital capacity after a period of decompensation indicates a favorable prognosis, while a failure to rise more than a small amount or the maintenance of a continuously low vital capacity is indicative of a less favorable outlook. Slight changes in the vital capacity of ambulatory patients may be of a great significance. Peabody and Wentworth illustrate this by the case of a stained glass worker "who has a double mitral disease and auricular fibrillation. When in his best physical condition, his vital capacity is 2,600 c. c., or 65 per cent of the normal. At such times, he can walk slowly without discomfort, and can do a little light work. May 1, 1916, he came to the outdoor department, stating that he felt poorly and found that he was getting out of breath more easily than usual. His vital capacity was found to have decreased to 2000 c. c., or 50 per cent. He was given digitalis and told to go to bed for a week. At the end of this time on May 19, 1916, he reported again, to say that he was as well as before his upset, and his vital capacity had risen to 2600 c. c."

Determination of the vital capacity has been of service in correcting false impressions derived from the histories of certain patients. Neurotic women may complain of shortness of breath, which is apparently out of proportion to the physical findings in the examinations of the heart, and the vital capacity may be so high as to afford no explanation for such tendency to dyspnea. When the suspicion exists that the sympton is due to nervousness, the patient may be tested by walking rapidly and by climbing stairs. No abnormal dyspnea will result and the determination of the vital capacity will serve to confirm the physical examination. A few patients underestimate their respiratory discomfort on exertion. The vital capacity is lower than one would expect from the history. Exercise tests will demonstrate the patient's reserve is much less than he has stated, and here again the vital capacity determination is a helpful check on the history. In other cases, in which the history of dyspnea seems out of proportion to the results of physical examination, the vital capacity may be low. In these patients, the course of the disease will confirm the value of the history and vital capacity, and shows that the physical examination gives an inadequate conception of the patient's reserve.

It is important to appreciate that changes in the vital capacity of the lungs are an index of the clinical condition only in-so-far as the cardiac weakness shows itself chiefly by producing dyspnea. This is frequently but not invariably the case. Certain patients with cardiac disease are restricted in their activities by the occurrence of palpitation or by pain rather than by becoming short of breath. The vital capacity of the lungs has no direct connection with palpitation or pain, and in cases in which these are the presenting symptoms, it does not bear any relation to the condition of the patient.

The cause of the decrease in the vital capacity of the lungs in heart disease has never been adequately explained. In advanced cases, it is due in part to pulmonary edema, pleural effusion, hepatic enlargement, and similar other factors, but in many cases, the vital capacity is decreased without any physical signs which can account for it, or with physical signs which are insufficient to explain the extent of the decrease. Siebeck suggests that this decrease in the vital capacity may be due to an engorgement or overfilling of the pulmonary vessels, and a consequent diminution of the elasticity of the lungs. Drinker, Peabody and Blumgart produced pulmonary congestion and a subsequent low vital capacity in cats by compressing the pulmonary veins at their entrance into the left auricle. From these experiments, it appears that the vital capacity may be reduced by encroachment of the dilated capillaries on the alveolar spaces, which air could occupy under normal conditions, or the lung may be rendered less elastic through increased vascularity.

In conclusion, it may be said that we have in the vital capacity determination a test which is simple and easily performed, and at the same time, gives important information concerning the functional condition of the heart and the lungs. As an aid in diagnosis and prognosis, and to indicate the efficacy of treatment, it merits, I believe, the serious consideration of the medical world of today.

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PSYCHOLOGY AND EDUCATION PAPERS

THE BUSINESS OF SCIENTIFIC CURRICULUM MAKING IN SECONDARY EDUCATION

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I. *Four factors involved in reconstructed secondary education.*

For a decade or more, an increasing interest has been manifested in the technique of curriculum formulation in secondary education. There is now no indication that this interest will wane in the near future. It has been waxing stronger during the last half decade. *Scientific curriculum making is slowly but gradually becoming recognized as a gigantic and important school business worthy of the attention of educational experts, and of the most competent school administrators and of other school practitioners.*

This stupendous project of reorganizing our secondary schools so that they will function most satisfactorily in the midst of new problems,—social, economic, industrial, and political,—involves many factors. One of these factors has to do with a re-statement and re-evaluation of general and specific objectives of education as a whole, extending from the end of the first six years of the elementary school to the end of the first two years of college, namely, the junior college. We have as yet outlined but the preliminary array or draft of these objectives.

A second factor has to do with the reorganization of our traditionally and accidentally made 8-4 educational ladder into some form of a non-8-4 adjustable educational plan. This plan is now represented most widely by the idea and spirit expressed through the junior-senior high school movement of America. And though fifty per cent of junior high schools may at the present time represent largely camouflage reorganization, the other fifty per cent have, to say the least, caught up the spirit of the need of the adjustment of aims and materials taught to the present-day social demands of the learner.

A third factor has to do with the significant psychological problem of the adaptation of subject matter, offered and taught, to the capacities of different groups of pupils possessing varying abilities and achievements. *Up to date, we have made comparatively a very meager beginning in the matter of the presentation of subject matter to that group of pupils who possess exceptional ability in our schools.* The wide use of general intelligence tests and of educational measurements within school subjects has assisted considerably in helping educators to sense this problem. The task is not more than half completed, however, when pupils have simply been grouped according to capacities or abilities, for the administration of subject matter so that each pupil in any group may use up all of his potential ability is a problem which is as yet far from being solved under our line-of-march, lock-step practice.

A fourth factor has to do with the nature or types of reconstructed subjects and the corresponding subject matter to be offered throughout the whole six years of the so-called junior and senior cycles of secondary education, including, in time perhaps, also the first two years of college.

The mere enumeration of these four factors brings into bold relief four challenging problems in secondary education,—problems suggested in crude form as early as the time of Plato of the Ancient World, and continued in clearer form during the later days of Comenius of the Modern World, but now transferred into the midst of new settings infinitely more complex. To some persons the above factors or problems will appear to be but the platitudinal statement of educational aim, organization, method, and subject matter, respectively, of the past history of education. But they represent much more than this. What is the best way out and ahead? Is one educational move better than another? In the matter of formulating objectives, we have made our largest progress at the present time in secondary education. These are not wholly satisfactory measured in terms of finality.

II. *The Redetermination of Educational Objectives.*

Curriculum construction and the determining of educational objectives are inextricably bound together. The matter of scientific curriculum making has not as yet been carried very far ahead. But we have made an encouraging beginning. In the past, tradition and formal discipline have been the two outstanding criteria used for justifying the inclusion of certain subjects in the program of studies as a whole, or in different curricula. Both of these criteria have now been reduced to the minimum. Every secondary school subject, at one time or another, has been let into the list of offered subjects either on one or both of the above grounds or counts, namely that of tradition, or of mental discipline. But the point of emphasis has now been shifted so as to include a complex of objectives involving cross-sections,—not mere sectors,—of the whole of an individual's experience at different stages of his in-school and post-school careers.

Through such cross-sections of meaningful experience, an attempt is being made through the presentation of school curricula to summarize and interpret the activities of modern civilization and all of its dominating phases,—scientific, social, civic, linguistic, literary, vocational, aesthetic, moral, and religious. *Modern curricula should represent a series of surveys of the whole of the experiences of civilization at varying pupil levels throughout the six or more years of secondary education.* Spinning wheel customs were different from those which we find in our own aeroplane days of multiplely-interrelated interests of one sort or another. *Curricula that once represented simple experiences must represent now complexes of many interests, ideas, and ideals.*

In the midst of differing environmental conditions and the varying problems of one community from one generation to another, or the varying problems within the same generation, a reliable method of procedure in determining present day worthy educational objectives is to be found through making an analytical survey of all of the activities involved within a given time, area, or community, which bear upon the educational experience of the learner.

Seven objectives have been outlined by the N. E. A. Committee in the "Cardinal Principles of Secondary Education", published by the Bureau of Education, namely: (1) Health, (2) Command of fundamental processes, (3) worthy home membership, (4) vocation, (5) citizenship, (6) worthy use of leisure and (7) ethical character. Professor Bobbitt has added two objectives to this list, and contends, furthermore, that it is possible to break up these general objectives into a long list of specific or particularized aims. One of the committees of the North Central Association, representing unit curricula, has outlined four objectives which represent a composite of those outlined by the N. E. A. Committee. Professor Inglis outlines three. Professor Charters combines ideals and activities as essential in the construction of curricula. Professor Bonser evolves all curricula for elementary education out of the world experiences which have come to have meaning for the pupil. Professor Snedden believes in the sociological determination of objectives. The Illinois High School Conference adopted a fourfold set of objectives having to do with health, wealth, association, and esthetic experience.

So far there have been several profitable outcomes of this attempt to redetermine objectives. These aims of education are less vague than were most of those which appeared in the past history of education. In the next place, there is a distinct consciousness that the analysis of the activities in which pupils do and will and should engage, cannot be ignored when making curricula. In the third place, it is recognized that certain objectives, whether they be three, or four, or seven, or nine or more in number, should be regarded as common or universal for all individuals at certain stages of their educational careers, no matter what may be their later vocations or occupations. *No subject matter can be justified per se, apart from the pupil's psychological and sociological needs.* Curricula, when outlined apart from consciously recognized common and universal objectives in the junior high school years of a pupil's schooling, represent an enormous waste of time and effort.

III. *Junior-Senior High School Curricula in the Making.*

The previous remark with reference to the necessity of agreeing upon certain common and universal objectives is applicable especially to the three-year junior cycle of secondary education. Out of the score of arguments which have been made in defense of the junior high school idea or spirit, the reorganization of subject matter is one that is of relatively large importance. The growth in the number of junior high schools has been so phenomenal that in many, if not in most instances, real curriculum reconstruction has not yet been accomplished. On the other hand, there are several large cities, and a number of individual schools, that have modified the nature of the content very materially.

Such modification is inevitable if once it be granted that the subject matter should be related to the objectives outlined. Furthermore, it means the elimination of certain non-functioning materials from certain subjects, as well as the addition of other phases than the mere traditional subjects. Dismissing for the moment the debatable issue as to whether the secondary school should have an inflexible curriculum or differentiated curricula, there is large agreement to the effect that at least *the first two years of the junior high school should offer a common body of knowledge which serves as a time of exploration and adjustment for the pupil.*

To determine upon the proportionate amount of time, if any, to be given during each week to English, general mathematics, general science, introductory social studies, health, or physical education, industrial arts, home economics, music, art, guidance, occupational studies, and school activities, is one phase of the curriculum making problem. To determine upon the nature of the larger units of subject matter and their sequence to be offered under the above named subjects in the light of a half dozen or more accepted common objectives is another important phase of curriculum construction.

The above enumerated subjects represent a composite list taken from several typical junior high school programs of studies. One city suggests a percentage distribution of curricular time such as follows in the so-called general curriculum of the junior high school:

	B	A
Health (gymnasium work, hygiene, safety education)..	16.6	16.6
Auditorium (centralizing, integrating, curricular activity of the school)........	6.6	6.6
Social science (history, civics, elementary economics, and sociology)	16.6	16.6
Exact science (mathematics, general science)..........	23.3	20.0
Languages (English, foreign languages).............	16.6	13.3
Vocational (Shops, mechanical drawing, home economics, commercial)	13.3	20.0
Fine arts (art, design, music).......................	6.6	6.6

The adaptation of subject matter to the individual differences of pupils is worthy of consideration in the junior high school cycle as well as in the senior cycle and will be referred to again under the next section.

However, before leaving the topic of curriculum construction with special reference to the junior high school, one suggestion is worthy of further consideration. *One almost unpardonable sin committed by the traditional curriculum formulator was that he planned separate compartment programs of studies for the elementary, secondary, and higher schools, respectively, and so unduly vivesected the pupil's learning process.* Another sin of almost equal proportions and closely related to the first was that of the mere duplication and repetition of subject matter on non-increasing psychological levels. *In the remaking of the curricula of secondary education, there should be no abrupt demarcations represented between elementary and secondary schools, or between secondary schools and junior colleges.* Education should be regarded as a unit in the large, divided for convenience of administration, into sub-units. This leads naturally to the statement that each pupil should be well trained in a sequential order in two or more subjects throughout the secondary school. In this way the principle of progression and sequence can be utilized in the organization of subject matter. One outstanding limitation and weakness of the program of studies of the junior high school at the present time is that in the minds of many persons, it merely represents a mass and maze of the so-called enriched curriculum materials which have accumulated in such fields, for example, as general science and social studies. The arrangement of this material in sequential order, both within the junior high school and in the transition to and beyond the senior high school is essential to real success. For instance, what certain experimental schools are attempting to do in the sequential arrangement of two or more years of history is necessary also in the social studies other than history, and so on through the round of the other school subjects which are taught in both the junior and senior cycles of secondary education.

IV. *The Adaptation of Subject Matter to Individual Differences.*

It is obvious that the adaptation of subject matter to the different and varying abilities of pupils is as much, if not more, a problem of methodology than curriculum making. It is equally evident, however, that the curriculum, when considered apart from the child, is of little consequence. *Our practice, too frequently, has represented the curriculum versus the child, or the child for the sake of the curriculum, whereas we are now convinced that the curriculum must exist within the child, or for the sake of the child.*

Perhaps the most ready single means for detecting the varying abilities of pupils is through the use of intelligence tests. Through the distribution of these psychological scores, it is possible to classify pupils somewhat reliably into homogeneous groups. As many other means as feasible,—educational measurements, teachers' marks and estimates, etc.—should be used to assist in classifying as accurately as possible the pupils within such groups.

As already indicated, the formulation of subject matter and the presentation of the same are inseparable. In practice, method and material are seldom, if ever, found separate. So far, two large plans have cared for most pupils in recognition of individual differences. In the first place, pupils have been grouped into sections having varying abilites, and have been allowed to cover a larger amount of ground in a shorter length of time. The measure in the past in the main has been the time unit which has been true very largely up to the present. In the second place, pupils in a limited number of school systems have been allowed to progress on the basis of the mastery of certain units of subject matter. In this instance, the chief unit of measure is achievement, not mere time. Promotion is based on merit, not the number of weeks in school. What has happened in most instances however, after pupils have been homogeneously grouped, is either the length of time has been shortened during which the work could be done, or the quantity of subject matter to be covered has been increased. That is, we have merely penalized the student for his brightness by asking him to do more work on exactly the same mental level as that on which the previous work has been done. Relatively speaking, little has been done in the way of real progress to change, not only the method of presentation for the superior group of pupils, but little has been done to change the actual quality of the content of subject matter offered.

The problem of the exceptional pupil is only partially solved when we have allowed him merely to finish in a shorter length of time because of his native brilliancy. He ought not only to be allowed, but to be given the opportunity through the formulation of appropriate subject matter, to use up as nearly as possible all of his mental capacity just as is the more mediocre or slow pupil driven to do in the mastery of the ordinarily outlined material. *Superior pupils have as much right to have an opportunity to use up on suitable materials all of the ability they possess as have the pupils nearer the other end of the distribution curve of native ability, who are compelled to work up to the limit of their capacity in order "to pass".*

The outline of materials in terms of quality has as yet been done very meagerly, and should be kept in mind as a part of the project in the scientific construction of the program of studies as a whole. It is, of course, likely that even with this material of a higher qualitative type to be mastered than that found in the usual program of studies, the especially capable student will still be able to do the work in less time than the mediocre student can do the work outlined for him.

To summarize, it is important that curricula in part be constructed so as to meet the common needs of all groups. But within the scope of secondary education, some attention should be given also,—much more than at present,—to outlining materials for those pupils who possess superior or exceptional ability. And this is no simple task of a few weeks or months. It involves the research and investigation of a decade of time, more or less. The emphasis which has been given more recently to individual instruction versus socialized and group recitations is, no doubt, an honest attempt to face the problem of adaptation of subject matter to individual differences of pupils. *Curricula on the whole have been made for the pupils who have about a medium grade of intelligence. As a consequence, we have attempted during a great deal of the time to reduce all pupils to a similar level of achievement, pulling down those having exceptional ability and intelligence, and pulling up those having unusually low ability and intelligence.*

V. *The Determination of Curriculum Content through Experimental Research, and through the Investigation of Competent Committees.*

Experimentation carried on through a period of four or five years at one time represents one reliable method of procedure in attempting to determine the nature of the content of curricula. In social studies, for example, this can be done as well as in other studies, such as natural science, mathematics, and so forth. In social studies, objectives should be agreed upon as far as is possible in advance of the experimentation carried on. One important general objective or purpose can well be that which has already been suggested by various committees, namely, enabling individuals to live and get along agreeably and successfully with one another. If once this objective be agreed upon, then all subject matter outlined and taught should point to this purpose and other purposes and sub-purposes, equally worthy of realization. Material as traditionally outlined in history and other social studies is not wholly satisfactory in the light of the purpose of the above sort.

Furthermore, it is essential to agree upon tentative large units of subject matter best suited to the realization of these newly stated social purposes. A dozen, more or less, of such units made up by selecting the content from a variety of sources in the general field, extending from ancient times to modern, will constitute a more satisfactory curriculum pabulum, which will be superior to that which has been offered in water-tight compartment fashion. This is true especially in relation to the first three years of secondary education. Gradually more intensive work built upon the earlier larger units of subject matter can be outlined for the last three years or less of secondary education. This method of approach in social studies is but one example of what can be done in other secondary school subjects. The use of this larger unit of subject matter for the earlier approach in secondary school subjects constitutes a fundamental aspect which should be taken into account in our newer technique of curriculum construction.

More experimental schools than now exist should be established in different sections of our country, and endowed for the purpose of carrying on scientific curriculum experimentation and construction in secondary schools. At the present time only a limited number of such schools exist in widely scattered areas. There is no more important and worthy desideratum just now in our attempt to reconstruct secondary education in America than the matter of experimental research in relation to secondary school curricula.

The Bureau of Research, which has been established recently within state universities and in state teachers colleges, can do considerable to bring the gravity of this problem of curriculum construction to the attention of progressive school people through statistical study and investigation of present practices in curriculum formulation.

A limited number of schools have attempted a tentative reformulation of all their subject matter taught. The cooperation of educational experts and of public or private school officers in curriculum making, when well guarded and guided, should become an increasingly wide custom in the American secondary school system. More experimental schools should be created for the specific purpose of testing out the most satisfactory curricula. And, again, the plan of curriculum formulation which enlists the interests and efforts of a whole teaching staff in cooperation with an educational expert should be encouraged.

Within the last decade, it has become the custom here and there for school boards and superintendents to invite in educational experts to cooperate with the regular teaching staff in making over the total program of studies offered. Obviously, one sensible procedure in such a situation is to make a survey of the activities, industries, enterprises, interests, and needs of the community involved. This includes the interests of patrons as well as of pupils. Another aspect of this procedure is the analysis and re-study by the teaching staff of all the materials offered by them in the light of widely accepted general objectives and corresponding specific sub-objectives in harmony with the psychological and social needs of pupils in respective communities. The presentation of such material will be superior to that which is ready made, handed down from too many generations back. We have now come to the time when we can well afford to committeeize the persons who are masters in one field or another throughout the country, and who are competent to work out the different courses of study to be offered within the program of studies and in the curricula of our secondary schools, and delegate to them the power to outline representative curriculum materials.

Each community in the main must work out its own curriculum salvation. Only those aspects of the curriculum will be uniformly standardized which apply to common and universal objectives. Toward the end of the secondary school period, considerable leeway will be necessary, both for the adaptation of subject matter to meet individual differences in terms of capacities and aptitudes of pupils, as well as leeway in the adoption of curricula differentiated enough to apply to all of the varied interests of different communities.

LEARNING CAPACITY—AN IMPORTANT FACTOR IN EMPLOYMENT ADJUSTMENT

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We have heard much of late concerning the "human factor" in industry and in commerce. We have been concerned about the "square peg" in a "round hole" and the "round peg" in a "square hole" and faulty reasoning has sometimes led us to accept conclusions not well founded in fact. It is well known that jobs do shape themselves to the interest, capacity and peculiarities of individuals filling them, and it is also recognized that individuals do adjust themselves to the requirements of their jobs. Difficulty has arisen from the fact that these adjustments have not always gone forward with desired rapidity or because they have not been carried to the desired level of accomplishment.

If one were to follow a new employe from employment induction through the early stages of advancement to positions of more and more responsibility he would find, if both employe and job opportunity were of a high order, almost constant demands for adjustment along the following lines:

The employe finds certain things to do which require more or less skill, tasks which can be done well and quickly only after motor controls have been established. Some of these adjustments are very simple, others involve periods of practice before the necessary controls are perfected. The manipulation of office or plant machines and the skillful handling of materials ordinarily require such capacity. The constant shift in present-day plant and office practice necessitates a modicum of such development on the job as well as through preparatory training if the worker is to be employed regularly.

There is a second type of adjustment which necessitates the accumulation of information. This involves the learning of codes, the memorizing of routes or schedules, the details of manufacturing processes or the bringing together of information along any one of many lines. In any event the employe finds it necessary to read, to observe, to discuss, and to take on information from many sources. The speed of acquisition and the facility shown in reproduction for use become important factors in determining the value of an employe in particular positions.

While it is important that workers generally possess capacity for taking on skills and for making motor adjustments, and while it is important that in certain positions they respond quickly to demands for related information, it is even more important in the most responsible positions that occupants use such skill and information in new and unusual combinations. Capacity for and habits of independent action become a fundamental consideration in the advancement of workers to positions of major responsibility. Planning industrial or business development, planning a sales or publicity campaign, readjusting a production schedule, all of these activities are in large part dependent upon power of independent thinking. Without such ability so-called planning becomes mere copy work, resultant from or dependent upon precedent be it good or bad. Herein lies the distinction between the so-called routine worker and the worker who makes possible progressive and constructive development through the creation of improved devices and through the suggestion of improved practices. Facility shown for achievement in this field is one of the requisites for success in many of our sales, organization, and research fields. Coupled with other abilities, this capacity is fundamental for all responsible administrative positions.

There is still another capacity or ability, which connects itself so closely with ability to learn that it should be classified with the above learning levels or capacities. I refer to the ability to make personal adjustments; adjustments to one's work, to one's surroundings, and to one's associates. This has to do with the worker's attitude toward the task to which he is assigned and the facility shown in meeting new and disturbing situations. It also involves that combination of factors which enter not only into association with other individuals but the management of individuals and groups of individuals. It is this ability which enters into real leadership as contrasted with mere management. The successful leader makes his personal adjustments readily and shows capacity for fair but effective dealing with his associates. While this ability is desirable for all workers, it becomes fundamental for foremen, managers and others who have to do with groups of workers. It is just as fundamental for successful practice in any position which requires contact with the public such as is necessary in secretarial or sales work.

If we accept the general thesis that learning capacity along the lines indicated is an important factor in employment adjustment, are we not justified in assuming that information concerning such capacity would be valuable at the point of employment or even more valuable at the point of special vocational training? If valuable in this connection, how may such information be secured? There are at least two major approaches which promise helpful returns, school ratings and psychological tests.

There are opportunities for rating in connection with the regular school activities which have in the past been utilized only in part. Is it too much to expect that every young man or young woman who comes to employment after the completion of our public elementary, secondary, or college courses will bring as a by-product something approaching a complete appraisal of learning capacities and learning habits? Is it not also desirable that school contact through curricular and through extra-curricular activities result in corresponding appraisal of personal qualities which are of importance in employment? The following records which have been supplied from the files of the University High School indicate the kind of information to which I refer:

A. A problem case—

"Has difficulty in working for any period of time without direction. Cannot organize his work and finds trouble working through a problem when once it has been analyzed and organized in cooperation with the instructor.

"Does not read with any high degree of understanding. A great deal of his reading is cursory and needs to be interpreted for him by another.

"He is easily discouraged in the face of any situation which obliges him to think, but works well in a situation where the work is routine and goes smoothly with a minimum of thought. Is very fond of talking but seldom has much to say. Is noticeably backward in discussing problems of vital importance in connection with his work."

B. A high grade student—

"A quiet, conscientious worker of a deliberative and investigative turn of mind. Has the ability and the initiative to think a problem through independently.

"He is economical in the use of his time and seldom is obliged to revamp poor work; that is, he seldom has poor work to revise. He is a very consistent performer. He is going along in the same quiet efficient way at this time that he was last October.

"His ability is respected by the boys with whom he comes in contact and he is not without influence among them. He seems to possess all the elements which enter into the making of a serious minded, effective citizen."

Cumulative statements such as these mean a great deal more than do grades of "A", "B", or "C" in shopwork, drawing, mathematics or history. They are significant especially in the employment of young workers who have before them an extended period for adjustment.

In addition to such a statement we should be interested in bringing together a more complete measure of specific abilities such as speed and accuracy in typewriting, rate and comprehension in reading, and corresponding scores for accomplishment in other subjects where standard measures are available. Such factual evidence could be interpreted in terms of promise in lines of work requiring corresponding ability.

In addition to any measures of capacity in terms of accomplishment in the regular school subjects and in extra curricular activities there should be ratings from phychological tests which would cover as completely as possible the learning abilities indicated above. Such returns should be combined with measures of capacity in school subjects to give a rather complete picture of the students' learning capacity and learning habits. This would mean a rearrangement and supplementation of such tests as the National, Otis, Turman, and other standard units now in general use.

While it is assumed that established correlation of abilities relieves the necessity for testing in minute detail, it is hazardous to expect that a mere index number, I. Q., mental age, or other similar device will ever take the place of the picture which is presented through a more complete analytical record.

The making of anything approaching a satisfactory record of learning and personal qualities would necessitate the administration of a number of special abilities tests either during the preliminary training period or at the point of employment. As a matter of fact such supplementary testing may be carried forward most effectively just prior to and during the period of early employment, especially in the case of employes inducted through a well organized vestibule or other corporation school. Such schools closely approximate conditions under which work is to be performed and make possible pointed measurement and effective observation.

As employers become more and more interested in the individual workers as a factor in the reduction of unit costs of production, we come to be aware more keenly of the specific factors which make for or against satisfactory accomplishment. If jobs were few and well defined the necessary analyses might be made promptly and effectively. That the actual problem of analysis is a difficult one is indicated by reference to the Federal Census which catalogs occupations under 572 main headings with some 12,000 subheadings. This widely distributed employment field, complicated as it is by the lack of uniform terminology or classification, has led many employers and some psychologists to despair of helpful classification of job and corresponding employe requirements and possibilities. Does effective employment service call for a complete catalog of these thousands of jobs coupled with a corresponding catalog of thousands of potential workers in order that detailed matching of workers and jobs may be carried forward? It is obvious that for the present such practice would be impossible of administration.

It is a well known fact that for a large number of jobs the learning requirements are almost identical. Beyond this point satisfactory service becomes a matter of interest and personal adjustment. Even here there are to be found large numbers of positions which tend to group themselves. Such is obviously true of junior office, sales, assembly, and other large sections of productive labor. Barring the element of work surroundings and the resultant demands and opportunities for personal adjustment, positions within certain group classifications require capacities very much in common. If Mr. Pound in his extended treatment of employment conditions did nothing more, he did succeed in pointing out the fact that jobs may be classified on a horizontal as well as on a vertical plane: that a worker of given ability may operate a machine in a fish cannery, in a fruit or vegetable canning plant, in a meat packing establishment, and without serious inconvenience, adjust himself to production requirements in a plant manufacturing automobiles, all within the space of a few months. If this means anything to educators and employers, it must mean that attention should be centered upon training and production capacity rather than upon specific trade opportunity and requirement.

Is it not, then, for our less mature workers, a matter of reducing employment requirements to *learning demands* just as we are now classifying instructional materials for mastery by students of varying interests and capacities? Such groupings would make possible effective testing practice in the four major fields of learning rather than in innumerable small units. There is the further advantage that such an adjustment of testing practice for purposes of employment service would lead to more effective classification for training purposes. Training and tests could be made to supplement each other in bringing to the employment office the information most needed in selecting and in assigning workers to positions for which they are best suited and in which they find their greatest opportunity for service. The combined practice would also inevitably result in a more exacting appraisal of training materials and methods than has yet been attempted.

It should be expected that a more complete classification of school and testing returns on the basis of learning capacity, coupled with corresponding employment returns, would in the end lead to the establishment of a common denominator for vocational education and employment; a common denominator in terms of capacity, interest, and opportunity which represent the important variables in employment.

THE SELF-ANALYSIS DEVICE AS AN AID IN GUIDANCE

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The brief treatment of the subject of self-analysis herewith presented has grown out of the writer's experience in the development and use of self-analysis materials at Bradley Polytechnic Institute, supplemented by a rather thorough study of prevailing systems in use elsewhere. It is not the purpose of the present paper to evaluate the different angles of self-analysis in its relation to guidance, comprehensively. A limited background of practical experience, however, seems sufficient justification in raising certain questions with respect to prevailing conceptions and practices with respect to administration. In this brief experience the writer finds sufficient enthusiasm for self-analysis, conservatively used, to impel him to make certain criticisms which are in no sense meant to be unkind.

The self-analysis blank is a device which aims to arouse and utilize the interest of the individual in the analysis and solution of his personal problems. Since the principles of vocational guidance recognize that the individual himself must ultimately make educational and vocational choices, it can be seen readily that any device or plan which in any way stimulates and directs self-activity, and brings the individual to a realization of his personal responsibility, is valuable.

It is not the purpose of the present paper to deal with the historical side of analysis in any of its phases. It should be pointed out in the beginning, however, that in so far as content and technique of blanks and forms are concerned self-analysis makes no wide departure from the general subject of "analysis" or "rating". Self-analysis differs from other types of analysis, in the main, only in the methods of administration. The same blank is sometimes used by students and employees in rating themselves, and by teachers, foremen, etc., in rating those whose responsibility they share. A discussion of the minor differences as to form between self-analysis blanks and other types of analysis blanks would avail little. The psychology and motives back of the two, however, are widely different. The present paper will consider only the problems involved in self-analysis.

A survey of printed matter on the subject of self-analysis reveals a chaotic status. Random and disconnected efforts over a wide field have resulted in no very uniform conception as to objectives, nor how such objectives should be reached. There is practically no standardization of terminology either in education or in business and industry. There are as many plans and forms as there are men with ideas. In the trial and success methods by means of which the many projects have been carried on, however, many helpful schemes have been revealed. Such schemes have aided in stimulating more serious introspections and observations on the part of those being rated, as well as to give less arbitrary and more wholesome points of view to those in charge of administration. Along with the saner administration of systems of self-analysis is the malpractice of those who have no clear purposes in mind, and who interpret results with a degree of finality which is wholly unwarranted. Among the latter class are those who for mercenary motives reduce to absurd formulae series of hypothetical principles which they sell to an unsuspecting, yet concerned and needy clientele. Such faddists as the phrenologists, physiognomists, etc., are typical of this group.

Items which may be classed under the heads of "disadvantages" and "advantages" of self-analysis, with certain modifications and additions, will be taken up in order. The disadvantages in the use of self-analysis fall naturally under two divisions,—first, the disadvantages inherent in the blank form; second, disadvantages which result from arbitrary and careless use of the blank. Preeminent among the disadvantages of the first order is the introspective nature of any reactions secured. The introspective process does not yield objective or highly accurate results. This cannot be considered so definite an objection where results are not to be taken at their face value. Since such direct use of results of self analysis is one of the less important uses, it may be felt that the introspective nature of the self-estimate should not be pressed as a definite disadvantage. One important reason for so classifying it, however, is given in the paragraph which follows.

Self-bias of the student is a characteristic which prevents the utmost frankness and which undoubtedly gives colored results. *Two rather careful and important studies of college juniors in this connection are indicative. The findings of these separate studies agree in all essential details. They may be summed up as follows:

1. Error in the judgment of the self is much greater than in the judgment of others. The tendency is for the junior to think he is as he should be. There is a tendency for him to think his fellow-junior is not what he should be. He places himself above the "typical" junior.

2. In the case of undesirable traits there is a constant tendency for the junior to underestimate himself; in the case of desirable traits (beauty excepted) there is the constant tendency for him to overestimate himself.

3. One who possesses a trait in high degree is a better judge of that trait than one who possesses such trait in low degree.

It has been the writer's observation that certain individual students who possess certain qualities in excellent degree are willing to place themselves somewhat below the point on the scale where they should be, to avoid being thought of as egotistical. There is always the danger of interpreting individual cases on the basis of group data, rather than to deal with each case separately. The general tendency toward overestimation, however, should not be ignored. We usually think of exaggerated egotism as typical of the adolescent youth, and, to a certain degree, wholesome. If such egotism persists to the end of the college course, as it seems to do, we should begin to inquire as to how far the college

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* Knight and Frazen, "Pitfalls in Rating Schemes". Journal Educational Psychology, April, 1922.

L. C. Cogan and Others, "Experimental Study of Self-Analysis". School and Society, July 31, 1915.

is responsible for enhancing a characteristic which, apart from the period marked by lack of rational experience, has false values. This consideration becomes all the more serious in view of Cattell's findings that the tendency is for scientific men neither to underestimate nor everestimate themselves. It appears that the experience which brings individuals in contact with the real work of the world eliminates to a certain extent the tendency towards overestimation. Is it consistent, then, to inquire how far the institution which turns individuals out at the close of its period of instruction, egotistical and self-centered to an irrational degree, represents the real work of the world? While there is insufficient data for sweeping conclusion, still the studies referred to above are sufficiently indicative to warrant our raising several questions which can be answered only by the results of further experimentation. If the self-analysis blank can reveal conditions such as described above, it will be to this extent an advantage rather than a disadvantage. When dealing with individual cases the tendency of the individual, especially the individual with mediocre or inferior ability, to overestimate himself, should be held in mind. Self-rating on character qualities should be discounted in the case of the majority of students.

Another disadvantage of the blank form is the suggestiveness of terminology. In expecting the youth to represent his interests and abilities in terms which we specify we can easily defeat our own purpose. Our idea of simplicity of terminology may not be simple for the individual who is asked to rate himself. The opposite extreme of so presenting the form that the complacent individual can easily check a few words, phrases, etc., without thinking the situation through is quite characteristic of many blanks. It is easy for the novelty of the device to come in for prime consideration, rather than the experience of the individual concerning which a response is desired. Illustrative of such tendencies we find the practice of suggesting long lists of school subjects from which the individual is asked to check those he has found most interesting, those which he particularly dislikes, etc. Long lists of antonyms, phrases, etc., are presented, the rater being asked to check those which he likes, dislikes, which more nearly pertain to him, etc.

In a recent self-analysis blank designed for use with college freshmen at Bradley Polytechnic Institute, the writer included a list of school subjects from which the student was asked to check the three in which he found most interest. He was asked also to indicate in which fourth of his class he ranked while pursuing the courses checked. After brief experience the latter part of the scheme was abandoned because of its complexity. In the revised blank which is being used the present school year the list of school subjects does not appear. The student is asked to list the three school subjects in which he found most interest, in order of interest; also to list the three he disliked, or which gave him most difficulty, in order of undesirability. No subjects are suggested, the student being expected to remember those subjects which stand out in his experience, independent of any list. One reason for making the revision, as is implied above, is the feeling that the suggestiveness of the many terms—the elaborateness of the list—would take the interest of the indifferent rater off at a tangent. The possibility of selecting those subjects with high attention value on the list is an item to be considered in the case of the semi-concerned or unconcerned individual. Society, moreover, regards certain subjects as being more dignified and respectable than others. Favorite teachers have certain subjects which are their hobbies: these subjects are accepted by student admirers as being important independent of personal reaction toward such subjects. There arises the reasonable question as to whether the indicated response is the real choice of the rater, or whether he has indicated a preference which is rather in accord with criteria suggested above. It was felt that to have the rater assume responsibility for thinking thru the situation, and for making his own selection without having a list before him would give results which would less likely be colored by factors which are foreign to his real convictions. A second reason for making the indicated change is the difficulty in presenting a list of subjects sufficiently inclusive to represent the varied curricula of secondary schools. This disadvantage is discussed at greater length in a different connection.

While efforts are being made to remove suggestiveness from terminology, and so to present lists, questions, etc., as to require more analytic thinking, it still remains that the rater finds complex and over-suggestive situations before him. Frequently there is little aid given by way of explaining the blank form, or in trying to have the subject in a proper frame of mind before self-rating is attempted. This criticism is not made with the feeling that lists of terms referred to are wholly bad. We cannot accept even the best self-analysis schemes without approving such lists. Efforts should be directed, however, to a further simplification, and amplification, of form.

The vague and general nature of descriptive terms and qualities used presents a further disadvantage, or limitation, of the usual self-analysis device. This vagueness and generality seem to result from two sources. Emphasis on the idea of formal discipline seems to be the basic explanation. As applied to the attempted analysis of character these general terms were enhanced by enthusiasm for various phrenological and physiognomical schemes in evidence in the early history of the rating movement. Certain terms in general usage are so general that they are meaningless. Objection to the use of other common terms is not in their generality, but in the evident lack of agreement as to meaning. The following lists of character qualities, taken from self-analysis blanks of the usual type, may be taken as sufficiently representative. The lists quoted from the Rugg Scale and from the New York Department of Labor Bulletin represent more recent efforts toward simplification, and toward more concrete terminology:

From Scale used in U. S. Army for rating officers and candidates for officers' training camps.

1. Aggressiveness
2. Appearance
3. Competitiveness

4. Control of Emotions
5. Initiative
6. Integrity
7. Health
8. Judgment
9. Openmindedness
10. Organizing ability
11. Perseverance
12. Sense of humor

From "Analysis of Interests and Ambitions", used at Bradley Polytechnic Institute.

1. Punctuality
2. Perseverance
3. Leadership
4. Interest in work
5. Self-confidence
6. Tact
7. Reliability
8. Temperament

From Rugg, "Scale for Rating Teachers". (Adapted also for students.)

1. Skill in teaching
2. Skill in mechanics of managing class
3. Teamwork qualities
4. Qualities of growth and keeping up-to-date
5. Personal and social qualities.

From scheme suggested in "Employment of Women in Five and Ten Cent Stores", N. Y. Department of Labor. (For more specific objective.)

1. Appearance of counters and shelves
2. Filling of counters and shelves
3. Supply of paper and cord
4. Merchandise displayed for selling
5. Order of under-counters
6. Proper place for price cards
7. Registering of money before wrapping
8. Politeness toward customers

Members of the faculty at Bradley Institute rated students on the general character qualities provided in the self-analysis blank used. On several of these qualities there was very little agreement among faculty members. This agreement was less for certain qualities than for others. An interesting observation is that in the case of certain outstanding students there was fairly close agreement as to the possession of a quality in certain degree, upon which there seemed to be little or no general agreement in estimating the students as a whole.

Efforts toward generalizing situations which cannot be generalized are seen in the more modern tendency of stating situations such as "Would you rather be in a crowd?" or "Would you rather be alone?" "Do you like to stick to one job for a long time?" or "Do you like to change jobs often?" The writer's examination of analysis blanks filled out by high school seniors revealed to him the futility of attempting to generalize such likes and dislikes as those suggested. One student stated that he liked to be alone at times. Another stated that his remaining on the job depended entirely on the nature of the job. Certain versatile students are so stimulated as to be able to go beyond the provision of the blank, as was intended doubtless by the makers of certain of those blanks most worth while. One is inclined to question, however, the value of responses made by the majority who most probably accept the situation as presented in the blank, and respond to one of the two alternatives for the sake of system and regularity. Such indefinite questions cannot take into account the varying conditions under which different types of work are done; neither does it give to the individual a fair opportunity for stating his complete relationship to his crowd or group.

The apparently necessary limitation of scope of the self-analysis blank makes it distinctly incomplete as an opportunity for indexing preferences and abilities along all necessary lines. It is impossible to have a list of school subjects which is sufficiently inclusive to be representative of the varied curricula of secondary schools, without making this section of the blank cumbersome and unwieldy. Among those who first filled out the Bradley blank including such a list were two or three students whose preferred subject was not included in the list.

This observation served as justification for the revision referred to previously. It is plainly impracticable, if not impossible, to include a list of all possible professions and vocations which furnish a sufficient range for any large group of individuals in expressing their vocational likes and dislikes. One can only appreciate this limitation in attempting to arrange and use such a list. In leaving blank spaces for filling in any such vocation or profession in which the individual might express chief interest, but which is not given in the list, there is the danger of having the rater feel that any such "filled in" occupation is of minor importance.

Dr. Miner, formerly of Carnegie Institute of Technology, has suggested what seems to be a happy solution of the difficulty outlined above. In his blank entitled "An Analysis of Work Interests" he has included a list of activities which apply to several related occupations. These activities and characteristics are presented in groups. This makes possible an all-inclusive list. It places a somewhat larger portion of the burden of analysis upon the rater himself in that he finds it necessary to think of any occupation which he may have in mind in terms of the qualities listed. While the element of suggestion and lack of earnestness will so enter as to partially invalidate the process, still there seems to be no simpler or less suggestive way of getting necessity for such considerations before the rater:

* "Select the three Kinds of Activities listed below at which you think you would do best and at which you think you would be contented to work permanently. Place the figure '1' before that group which you would place first for yourself. Place '2' before your second choice, and '3' before your third choice.

"Remember the unpleasant features of the work and the conditions under which it would be carried on. Consider also whether you would have the necessary health and strength, whether you can get the necessary training, and whether this occupation will give you the opportunity to utilize your good traits and follow your interests.

* Taken from "Analysis of Work Interests", published by Carnegie Institute of Technology.

"Any occupation will involve a number of these activities, but number only those three groups which appeal most to you. Sometimes it is well to begin by excluding those you dislike. It may help you if you will also compare yourself with others of your own age.

( ) Growing plants, as in farming, gardening, greenhouse, etc.

( ) Care of animals, as in stock raising, care of horses, etc.

( ) Operating engines, as locomotives, automobile, steam plants, etc.

( ) Operating machines, as in manufacturing, using linotype, etc.

( ) Installing equipment, as electrician, plumber, gas fitter, etc.

( ) Construction work, as in building, concrete work, bridge construction, etc.

( ) Delicate muscular movements, as dentist, surgeon, instrument maker, etc.

( ) Discovering and repairing defects, as jeweler, automobile repairman, etc.

( ) Transporting Activities, as railroad operation, express, mail, etc.

( ) Meeting and Directing people, as secretary, floor manager, conductor, etc.

( ) Teaching in school, shop, etc.

( ) Welfare work, as in social settlements, industrial plants, Christian Ass'n.

( ) Advisory Service, as physician, lawyer, consultant, banker, analyst, etc.

( ) Organizing People, as in societies, in work gangs, industrial and business concerns, etc.

( ) Influencing People Directly, as in selling, preaching, campaigning, etc.

( ) Influencing People Indirectly, as in advertising, writing, newspaper, etc.

( ) Organized Planning, as in business, managing institutions, in developing engineering projects, etc.

( ) Scientific Work, as in laboratories, in museums, in research, etc.

( ) Recording and Systematizing Records, as in office work, stenography, bookkeeping, library work, etc.
( ) Entertaining People, as musician, actor, speaker, etc.
( ) Artistic Skill, as in decorating, window dressing, millinery, costuming, printing arts, etc.
( ) Artistic Creation, as in writing, designing, composing music, etc.
( ) Field of Activity not on this list and described as follows:"

It is hoped that thoughtful consideration of the type rendered by Dr. Miner will enable us to overcome several obvious limitations of present blank forms.

The most serious drawbacks in the use of self-analysis are not due to the form of the blank, but rather to the improper mental attitude of those doing the rating, and woeful lack of proper objectives on the part of many who are responsible for administration. The state of mind of those putting in writing their life history, their ambitions and ideals, and their character qualities is not such as to secure accuracy, and in many instances, sincerity of statement. Unless a great deal of precaution is taken there is the natural feeling that the record is an indictment to be used against the raters if at all unfavorable. Such questions as, "Will this be counted on my grades?", "Will anybody else see results?", etc., were not uncommon among college freshmen. The degree of seriousness with which most students fill out the blanks indicates that there is much in their minds which they dare not express. This feeling is the more common where the use of self-analysis is a requirement. In this connection a psychological test record of a very brilliant girl is recalled. Not understanding the reason for very unusual and inconsistent answers to several exercises the young lady was called in for a consultation. It developed that she had accepted the test as a challenge,—that the test was made up of a series of catch questions; therefore she must be on the defensive from the very first moment. She would decide upon the answer which appeared to be correct, then would indicate the opposite response with an "I'll show you" attitude. It should be added that this young lady was a sophomore in college, and an unusual student both from the standpoint of scholarship and attitude. So serious was she concerning her scholastic work that she could not afford to be caught napping. This suggests the necessity of going beyond prescribed formulae in preparing the minds of the individuals for a favorable reception of test and analysis materials,—something which the teacher who is not of the proper temperament, and who is not especially trained, cannot do,—the theories of many who would reduce to mathematical formulae the analysis of human character, to the contrary notwithstanding.

* Mr. Earl B. Morgan in an excellent article on interviewing calls attention to the fact that many people do not represent themselves as they are when they apply for positions. The college student especially is ill at ease and artificial. This artificiality camouflages the real self to such an extent that a great deal of "sparring" is oftentimes necessary before the real qualities of the individual are revealed. There is the constant danger that the self-analysis record will not be a complete blue-print, or a correct blue-print of the individual. Subjectively, the individual will miss the point of self-analysis, going away under an illusion if such an artificial mental attitude predominates. These dangers become all the more apparent where self-analysis results are interpreted literally and used objectively. Self-analysis is the more sinned against, perhaps, in this tendency which is not at all unusual for those untrained in personnel problems to consider it a formula, the working thru of which, irrespective of limitations which have been pointed out, will do the individual good,—and will give a fairly accurate picture of his personal qualities. This attitude apparently is the result of no very definite understanding of individual differences. This evil can in part be overcome thru the recognition that the interpretation of self-analysis results, and the interviewing which must follow, should be the job of an expert who understands his responsibility.

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* "Interviewing for Selection". Industrial Management Magazine, April 1, 1921.

Treatment of advantages and disadvantages or limitations has been taken up in reverse order because of the writer's enthusiasm for the advantages of self-analysis where conservatively and sanely administered. The final impression should be one of faith and confidence in a proper self-analysis device. There are many arguments in favor of self-analysis. First, it helps to place responsibility for important evaluations where it belongs,—upon the shoulders of the individual himself. A large portion of that "getting by" attitude which is obvious at most school levels is due to that spirit of rebellion which the student feels toward the system which places so little personal responsibility upon him. Self-analysis is an effort to have the student or employee analyze his own case. The rater should not have to be told his weak points by the interviewer. In consistently passing thru the experiences provided for in the blank the rater's weak points may be revealed to him. Illustrative of such benefits, the following example from the writer's experience is offered: Three young men desiring clerical work called at a placement office. It could almost be seen at a glance that none of them was suited for office work of any sort. After a courteous reception they were requested to write brief letters of application, describing that type of clerical work for which each felt himself best suited. The interviewer continued his work with other cases, noticing the progress of the three applicants incidentally. After a few minutes each applicant had decided that he didn't care to attempt clerical work. None had gotten far beyond the salutation in his crude attempt at writing the letter of application. The interviewer was free to aid the individuals after they had partially analyzed their respective cases.

Self-analysis should cause the rater to feel responsible for courses he is pursuing, especially on the higher school levels, and for indicated vocational preferences and choices. Many college students can give no consistent reason for being in college except the vague impression that college training is held to be the most adequate preparation for larger responsibilities. A larger percentage of students are even more helpless when asked to justify certain courses they are pursuing, above others. In the first blank used at Bradley Institute the question, "In what department are you enrolled at Bradley?" was deemed sufficient to secure a definite response. Tabulation of responses to this question revealed several instances where the student couldn't name a definite department. For irregular or special students to find difficulty in responding to this question was not considered unusual. For regular students to have difficulty, as several did, indicates manifest ignorance of college curricula and department organization. There occurs to the writer an instance of a college entrant's being in a dilemma as a result of two widely divergent objectives, this being typical of several cases coming under his observation. The student, as a result of his own selection, had two alternatives before him,—a course in business administration and the course for teachers of manual arts subjects. Coming from a small high school, he was face to face with the responsibility of choosing one of these widely variant courses within a twenty-four hour period. The matriculation machinery of the college was not designed to meet his need, or the needs of others in a similar situation. Some college agency must accept this serious responsibility. If self-analysis can reveal conditions which make special machinery necessary it will have performed great service. The pathos of this situation suggested the inclusion in the Bradley analysis blank of the following directions: "State three reasons for electing the course which you have checked", and "State three reasons why you think the vocation or profession which you have indicated is the best one for you". It is hoped that there may be encouraged a greater feeling of personal responsibility for life-career choices, and for courses elected and followed.

The self-analysis record will be suggestive of the problems which must be approached in the interview. There is usually an indication of unity or lack of unity in the rater's plans and habits. Brief description of two contrasting cases recently observed in analysis blanks handed the writer for evaluation are significant. CASE No. I was a high school senior, a young man twenty-two years of age. He expressed preference for electrical engineering as a vocation. His record of reading habits revealed the fact that he was not interested in such current magazines as "The Scientific American" and "Popular Science", a musical journal being the only technical journal in which he expressed interest. He was interested in no club or social activities except as revealed by his membership in a young people's society of the church in which he was a member. He had no hobbies which were in any way connected with his vocational preference. His incidental occupational experience gave no evidence of a background suggestive of his vocational preference. His lack of leadership ability, absence of affiliation with social groups, and his over-age indicated that his ability was ordinary. He indicated his enjoyment of a book, "The Life of Edison", which was probably the basis for his vocational choice.

CASE No. II was a high school senior, a young man eighteen years of age. He indicated salesmanship of mechanical appliances as his desired vocation. He had been employed during several vacation periods in a wholesale house which handled mechanical appliances. He read "The Scientific American" and "Popular Science". As one of his hobbies he liked to "fool around" the physical laboratory at odd times and after school hours. He had elected scientific subjects as a major interest. His success in dealing with others was indicated in his position of leadership in several high school organizations. As a final response he indicated that he had already secured employment with the firm for which he had worked during vacations.

The first of these cases reveals an evident lack of consistency which is highly suggestive of unwarranted objectives. In the second instance the unified and consistent series of reactions give a record of an individual who has largely handled his own case. In the absence of personal contact experience with these two students it would be dangerous to take the analysis blanks as sole criteria for dealing with them; nor is this a necessary function of self-analysis. As an aid, the information secured will point out in advance of any interview which may be found necessary or advisable, certain of the outstanding problems to be approached and dealt with, indicating the possible points of contact. The saving of time which accrue to both the interviewer and the interviewed is no small item. Where provision is made for periodic checking-up,—that is, giving opportunity for the rater to record changed and additional points of view from time to time, the self-analysis system falls heir to the advantages of the cumulative record.

One advantage of self-analysis which should not be overlooked is its value as a test of ability and of certain educational essentials. It indicates the individual's efficiency in meeting new situations. It could be inferred with considerable reason that CASE No. I would fall rather low on the mental scale for his group, while CASE No. II probably would fall rather high on such scale. It should be understood that all judgments based on self-analysis results should be tentative and elastic. The general tendency for records to be indicative of ability, however, is plain.

In presenting the following general outline of content for a self-analysis blank, no wide departure is made from several blanks already in use. The chief purpose of the present paper has been rather to raise certain questions with respect to the form in which essentials are presented, to question certain methods of procedure in administration, and to emphasize certain good features already employed by the more conservative and constructive enthusiasts of self-rating. Summaries on each general item submitted embody the principles already set forth. The following general divisions would seem essential for a comprehensive self-analysis device for college freshmen. With slight modifications they could be adapted for any school or industrial level:

1. Personal items,—age, sex, home address, school address, etc.

2. Family record,—nationality, religion, social, occupational, financial.

3. Education,—Schools attended, grades completed, subjects liked, subjects disliked, permanency or change of interests, course being taken up and why, etc.

4. Past vocational experience,—important jobs held, those liked and those disliked, and why.

5. Rating in character qualities,—those held to be of universal importance. In certain instances those making for success in particular job, school course, etc.

6. Outside activities,—clubs and organizations, social and literary activities, athletic and recreational activities, hobbies, reading habits, etc.

7. Indication of vocational likes and dislikes. Vocational preference or choice, with justification.

Responses to items "1" and "2" will furnish that sort of routine information necessary in any sort of counseling. Information pertaining to religion and financial status must be secured tactfully, where such information is necessary. The financial status of the family can perhaps best be secured indirectly through such items of information as "occupation of father", etc. Most individuals will not resent requests for personal information of this character if they have confidence in those in charge of administration and are "sold" to the advantages of the effort.

Content which should come under "item 3" has already been discussed at some length. A record of interest in school subjects should extend over the entire school period. The student should be permitted to have access to his record from time to time for the purpose of making note of any change of interest which he may have experienced. He should always feel responsible for courses pursued to the extent of justifying himself to his own personal satisfaction, and to the satisfaction of those of his advisors who are seriously interested.

Item "4" should provide suitable opportunity for listing all jobs of importance held: any preference for, or dislike of, any particular kind of work should be noted.

With respect to "character qualities" it should be added that the best modern practice points toward greater simplicity with respect to number and character of qualities used. The qualities used should be stated in terms which are understood easily, and upon which there should be as much agreement as possible. There should be as little overlapping of meaning of terms selected, as possible. The number of such general qualities should perhaps not exceed five or six. A larger number necessarily involves more overlapping of meaning, and increases the complexity of the device. In stating the degrees of each quality, the increasing use of adjectives rather than numerals would seem justified. Each degree of general quality should be defined clearly, frequent use being made of simple, illustrative examples. All this should be done cautiously, with the idea of increasing complexity as little as possible. Where the analysis pertains to the relations of the student to some particular department, the qualities should be selected according to what is most important in such department.

Item "6" should place emphasis on activities such as are not emphasized sufficiently by most educational institutions. Information secured should bring a wholesome message as to what is not being done with respect to extra-curricular activities, to educational authorities. Perhaps thru contacts as a result of investigations in this regard the personnel department can "sell" iself to students as it could in no other way. Information as to reading habits will prove helpful.

Importance of serious thinking with respect to proper selections of life-career has been discussed. Any machinery for stimulating thinking should be as clear and simple as possible. Dr. Miner's contribution in this connection is doubtless the best yet proposed. The machinery should provide means for the student to justify any vocational selections or preference stated. His own responsibility should be kept clearly before him.

Advantages of self-analysis have been presented with the assumption that self-analysis systems will be administered, and results used properly. Responses secured cannot be accepted at indicated face value. The device becomes dangerous rather than helpful when used in any other than a supplementary way. Self-analysis cannot be said to be scientific. The best that can be done is to "cast bread upon the waters", with hopes for as large a return as possible. Individual human character, so many are its variable qualities, baffles any sort of complete quantitative or qualitative determination. As a formula self-analysis cannot be a success; as a means of summing up hints and indications to be faced in the interview, it may be helpful. Perhaps the greatest value of conservative self-analysis, that of subjective effect on the rater, cannot be appreciated because it cannot be measured.

THE IDEAL ASPECT OF PSYCHOLOGY

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Since I was introduced to the subject of Psychology thirty-five years ago great changes have occurred in its fundamental conceptions and definition. In some respects there have been unexpected expansions and in others equally startling limitations. I have no doubt but that both have added much to the general interest in the subject. During this time the definition of Psychology has changed many times. At the earlier date we defined it as the "Science of the Soul"; later we defined it as the "Science of the Mental Life", the "Science of Consciousness", the "Science of Human Behavior" and more recently as the "Science of Behavior."

The first change in definition grew out of the acute observation of David Hume, who asserts that no matter how carefully he introspected he never found anything to which the term "soul" could apply. He always found himself conscious of a content but never of a so-called container. The subsequent observations of philosophers have confirmed Hume's position and have made the substance theory rather unpopular. That change in metaphysical conception has made the original definition of psychology quite inadequate. A second reason for the changes is found in the separation of psychology from its parent, philosophy. It has taken the course of the other sciences which have proceeded to an intenser study of their subject matter by abstraction and self limitation. The psychologist proceeds oblivious of what other people are doing in other fields, unless it be in the field of biology, for which psychology seems to have a special affinity. In some cases it appears as though psychology is little more than a study in physiology. The third reason is found in the disposition of the scientist to have objective criteria for measurement. Consciousness is too subjective and too individualistic to be the subject matter of science. Science must have objective data which can be subjected to experimental investigation and mathematical measurements. And still another reason is found in the pragmatic tendency of the age. The tendency of pragmatism is to discard all theorizing that cannot be turned in for its cash value, apparently forgetting that science is generally called upon to work out consistent theory before it attempts to make practical application of it. I am not underestimating the method of the pragmatist. I interpret the meaning of "satisfactoriness" as used by Professor Dewey to mean the successful vindication of an hypothesis by the careful consideration of all pertinent facts. In the history of science the theoretical stage always has preceded its practical application.

I certainly am not opposed to the application of psychology to the practical affairs of life. For twenty years I have been offering courses in General Psychology to which I have added courses in Genetic, Experimental, Educational, Social, Abnormal, Religious and Applied Psychology. I am not born a prophet, but I can foresee with considerable clearness how the results of the psychological laboratory will greatly augment the efficiency of the people who will accept its offer. That applied psychology needs objective standards is beyond dispute. It certainly is fascinating to study the behavior of people, to ascertain individual differences, to watch modifications resulting from a learning process, and to observe to what extent changes depend upon environmental conditions. The changes which have occurred in industry due to the application of psychological discoveries to the task of the worker fully justify the enthusiasm which the practical psychologist has for his limited specialty.

This great achievement in applied psychology, however, should not blind us to other psychical facts which are no less obvious. For forty years I have made a study of the psychological basis of ethics and religion. I am thoroughly convinced, as every student of the subject knows, that religion and ethics are not objective systems formulated and turned over to man for his pledge of allegiance. And yet the phenomena of religion must be reckoned with. I do not find religion to be primarily fidelity to an institution but loyalty to personal ideals which have a psychical basis. I am fully aware of the contention that these problems must be turned over to the philosopher for final settlement. I am not opposed to this division of labor in the field of research, but I do object to the dogmatism of the psychologist who sees in the psychical field nothing beyond his self-imposed limitations.

Functional psychology has many points of advantage. I was one of the first to use Prof. Angell's psychology in my class room. I think it an excellent method of studying psychical processes. According to this theory, the psychical stands for the readjustment of the organism to sensory stimuli in accordance with retention traces of previous experiences. The retention traces are the product of the sensory stimuli, the motor responses and the sensory consequences growing out of the motor responses. The association centers retain these experiences and later, even without an external stimulus the whole process may be set in operation. The cerebral rehearsal of this previous experience becomes a check and determines the response when the original stimulus is again experienced. This accounts for the complex mechanism of the mental life. The value of this procedure cannot be discounted. The adjustment of the organism will always be a pressing problem, but it does not exhaust the meaning and function of the psychical.

Psychology has done well to abandon the sterile conception of a soul substance, but it would be unpardonable recklessness to abandon the concept of psychical energy, or a psychical life. Whatever the metaphysician will say ultimately about life it will always be recognized by its striving toward ends. Darwin made his great contribution to the thought of the world when he pointed out that life proceeds according to law and that these laws are not mathematical or mechanical. Living organisms do not merely adjust themselves to what is but are selective of the parts of the environment to which adjustment is made. Insects and animals with more definitely organized instincts make their own environment, as is seen clearly in the ant, the bee and the bird. In human behavior we must reckon with impulses that make for spiritual goods, such as literature, art and science, and becomes the urge to social, political, ethical and religious ideals.

Dr. Prince has done some excellent work in the study of multiple personality. His striking conclusion is not the mystery of multiple but the achievement of unitary personality. Instead of looking at the ego as a unity with various faculties, he considers it to be a composite structure built out of psycho-physical dynamic mechanisms, called instincts, each having within itself its own driving force. Each instinct is a dynamic mechanism striving toward an end. The ends differ and often are in conflict wth each other. Personality, as Professor Angell points out, possesses intrinsically tendencies to unify and organize these instinctive tendencies into a consistent and harmonious whole.

Let us now take up the study of the psychical life in greater detail to see what ideal tendencies it discloses. Instincts are more or less definite mechanisms of behavior. They serve the purpose without previous training to adjust the organism to its environment. They may be explained mechanically, as the result of open synapses in the cerebro-spinal system. They may be explained genetically by referring to the evolutionary process by which they came into being. They doubtless arose because they have survival value for the organism. While it is true that the mechanism of instinct requires a stimulus to set it going, the resulting action is not in the strict sense a mechanical product, because the response looks forward to the good of the organism. The end is often quite remote. The bee gathers wax and constructs its cell in order to store up its honey. The food instinct impels to the immediate gratification of hunger, but it serves a remoter purpose in storing up glycogen in the muscles, nerves and liver for future use when the relations between the organism and environment become strained. The mastery impulse strives immediately to overcome a present obstacle to the well-being of the organism, but a remoter end appears in the feeling of satisfaction growing out of the consciousness of its own superiority. It lies at the root of the problem solving disposition. When coupled with the social instinct it expresses itself in the potent urge to social excellency. Doubtless the highest forms of satisfaction are not found in the hedonic consequence of sensory stimulation but in the consciousness of difficulties mastered. Even the sex instinct, while it consists of an immediate impulse towards the object of its love, has a remoter meaning in the perpetuation of the race and the foundation of the one of the most important social institutions, the home. Again, consider the instinct of curiosity, which, starting with a manipulatory disposition for the purpose of discovery, when stimulated by an object, a noise, or a taste, is nevertheless an urge to far reaching explanatory research. Simple as it may appear in the animal or in the young child, it is the dynamic that moves the scientist to unravel the mysteries of nature.

There can be no doubt that the discoveries of the scientists have had great practical value when applied to the affairs of everyday life. I am the last man to quarrel with the pragmatist at this point, but I am convinced that the great urge felt by the scientist is not primarily practical utility. It was rather a more consistent and harmonious organization of experience. It was the interest of the knower in the thing to be known. At any rate I cannot see what great practical difference it would make to the multitude of earth's toilers whether the "Nebular Hypothesis" of LaPlace or the "Planetesimal Theory" of Chamberlain and Moulton will ultimately prove true. And yet the Chicago men have worked long and hard that they might organize astronomical facts into consistent and harmonious relations to each other. Man has the conviction that the universe is knowable and feels a strong impulse to know it.

The hostility of nature to man and his enterprises is apparent to all. We need no Schopenhauer to tell us that from the standpoint of human interest nature must be reconstructed. Nature does not adequately shelter man from her own inclemencies. Little of the food he eats is allowed to remain in the form in which he finds it. The swamp and marshes are not compatible with the cultivated tastes of the artist. The landscape gardener does not adjust himself to what he finds, but aims to reconstruct and transform what he finds into similarity to his artistic ideal. The artist is creative, and true creation starts with the ideal which it aims to embody in a concrete form. Artistic creation can be explained only by assuming that the psychical life has ideal tendencies.

We may proceed to study the percept from the standpoint of its mechanism. We may say that it is the product of sensory experiences, which leave retention traces in varying degrees of complexity. When subsequently any one of the particular stimuli that figured in the original is experienced, it tends to reproduce the whole complex of previous experience. There is, however, another aspect to perception. It has an important function for the organism. At any time when a stimulus is experienced the organism anticipates the experiences associated with it, thus enabling the organism to make favorable adjustments to consequences which it anticipates. In the strict sense of the term the percept is an ideal construction, perhaps never an adequate construction, for the organization of sensuous experiences, and functions as a plan for action.

The higher forms of thought disclose more clearly their teleological aspects. Thinking starts with a felt need. The thinker recognizes the need of something not possessed. The possession of the longed for becomes the pressing problem. The solution of the problem consists in the dramatic rehearsal of all possible suggestions and the final adoption of the suggestion which carries with it the best evidence of its adequacy. In a genuine thought activity the problem is a new one and the solution also must be novel. It always requires a readjustment of the mechanism of the past with reference to a future or ideal contingency.

I think a study of the facts we have fragmentarily pointed out thus far lead us to assume that the psychical is a life proceeding to organize its experiences into a consistent and harmonious character. It not only preserves the memories of the past but also makes a forecast of the things that are yet to come. It is impelled by the conviction of a causal interrelationship of all phenomena of experience and is impelled to recognize that its conduct must be consistent with rational ideals. I do not ask that we accept the theory of a soul substance, nor am I prepared to argue the theory of the vitalist. But I do ask that the psychologist be true to the facts which his subject presents. The psychical life is fundamental. It will not allow itself to be made a mere instrument for the adjustment of the organism to its environment. It will not yield itself to the status of an efficiency machine. It has ideals of its own and thus becomes the foundation of philosophy, sociology, education and religion. These subjects are commanding the respect of the world because they are the natural and legitimate outbudding of the psychical life.

FURTHER DEVELOPMENTS NEEDED IN TESTS FOR MENTAL MEASUREMENT

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The practical or clinical psychologist of today makes much use of the terms *intelligence, mental age, intelligence quotient*. He is asked and expected to settle certain social and educational problems on the basis of these terms, and what is vastly more important, the fate of individuals who at some points of social adjustment are atypical. The authors of scales of mental measurement ask us to assume for the most part that these terms indicate something fixed, innate, and relatively unchangeable. Much in the way of mathematical proof has been adduced to justify the assumption.

To the conscientious psychologist, holding the fate of some definite individual in his hand, there comes the wonder as to just what these terms mean. Shall he send a delinquent child with a certain I. Q. to the home for the feeble minded, and another a few points higher back to the privileges of social liberty? Shall he place this child in the room for special defectives in the school, and recommend another no farther advanced scholastically for residence with his normal fellows? Are I. Q.'s in themselves a safe guide to decision? What does the I. Q. represent? Do the terms *intelligence, mental age* and I. Q. cover the same ground fundamentally as their authors would have us believe? These questions are being asked here and there with the accompanying element of doubt implied in most questions. The answers, both on the part of the doubters and the apostles, have always come in the form of more mathematical statistics. In my opinion the answer can not be deduced from this source, but from analysis of tests themselves and the relation of their character to the various known factors of growth and development.

The term *intelligence* is capable of two constructions of meaning and is used so loosely in the literature of mental testing that the reader can only guess at times which it is intended to mean. This point must be cleared up before we can proceed, and tests of mental ability must be analyzed and related to the various phases involved in the definition of intelligence. The various phases of development which may enter into the concept *mental age* must be enumerated before that term can be definitely understood. If this were done one of four problems, the problem of the upper limit of development, could be defined in an understandable way. At present, with one person maintaining that it is at sixteen and another at thirteen or some other point, one can only ask, "What do they mean?"

At the risk of seeming very much more certain about these points than I am, I shall enumerate the various factors which may be involved in the use of the terms under discussion. In the first place, there is that very necessary machine, a nervous system. The complexity of its development and interrelations of cellular connections correlate with the complexities of behavior. Intelligence in this sense indicates *possibilities* of complexities of behavior or adjustment. In our thinking and use of terms it must be contrasted sharply with the *forms* of its expression which may relate themselves wholly or in part to the physical or cultural environment and to training. We should know, or strive to know, whether our tests measure this innate quality, or measure in addition to it something due to training or which could not be expressed without a certain definite training. For example, the civilized child who has learned to read has expressed this innate quality in a certain *form* which is the result of formal training. The savage who learns to read the meanings of the signs of life in the forest about him has expressed it in another *form*, which is, perhaps, as much the result of a definite training. If these two factors are differentiated clearly in our use of the term intelligence we simplify and make definite the *problem* of the upper limit of development, tho not necessarily at once the answer to it. Donaldson, in his "Growth of the Brain," expressed a wonder about this problem with the same lack of clarity of definition. He observed that about eighty percent of brain growth in all of its aspects is completed at seven years of age and that the other twenty percent is distributed thruout the remainder of life. He observed, too, that the adult is apparently an entirely different creature mentally than the child of seven, and he was led to ask whether this small percent of growth might not be of such difference in quality as to bring about this result, forgetting the effect of training which, in standardized and formal ways, begins at seven. The further researches of Donaldson and his students indicate that brain growth ceases at a much earlier age than seven.

If the term intelligence connotes this innate capacity related to neural growth, then development ceases at this early age and not at thirteen or sixteen. If intelligence connotes the results of training and formal education in addition to innate structure, then it probably ceases only with senility. The average child of thirteen has, for example, a certain knowledge of mathematics, namely arithmetic. In high school he makes a readjustment of this knowledge to fit more complex forms, algebra and geometry, which in turn are capable of further readjustment into the more complex forms of college mathematics. He has a certain rather simply organized body of historical knowledge, United States history, which is further evolved into high school and college history. He has certain vocabularies which are increased quantitatively and qualitatively by the new terms of the new sciences and literatures of the higher schools. When our psychologists declare that mental development of the race stops at a certain point as measured by certain scales, would it not be well to analyze those scales before assuming that fifty percent of the race is innately inferior? Might we not ask how much of the test is the result of formal training which for the greater part ceases at thirteen? More mathematics will not help us here. This attitude is supported by Freeman and others who have maintained that the flattening of the curve of mental growth at the adolescent period is due to the character of the test and not to a phase of development.

The problem of *maturity* of development at any age is a variation of the problem of *limit* of development. That there is a quality due merely to having lived at all, which we may denominate maturity of development at any age, seems certain. It is a correlate of certain phases of physical development. It is shown in the case of the child over six who can sit quietly in school as contrasted with the younger child who can not do so; the child who can give a concentrated attention to work as compared with the young child who is more easily diverted and disorganized. How is this factor shown in our mental age scales as apart from the qualities due to formal teaching? It is a very important one in the case of many children who constitute school problems, children who in many cases are not retarded seriously, or are even bright according to test results, but who in the first grade are slow to learn to read or fail at various points above the first grade to adjust effectively to the conditions of school work. Some of the tests measure this factor, but they are not followed out consistently for all ages. It is the assumption of the author of the scale most in use, the Stanford Binet, that the I. Q. at certain values measures this factor, but there are involved in the I. Q., also, tests which measure formal training, and with the lack of the results of this training mixed with the other results we cannot know what the final mathematical statement does mean.

The problem of what qualities distinguish the dull child as opposed to the definitely subnormal or moron child is confused also by the scale in general use. Terman associates the diagnosis of dullness with an I. Q. of eighty to ninety. But what constitutes the mental quality of dullness disassociated with this mathematical term needs to be explained. The tests which require formal training for their performance at certain ages may make the final diagnosis doubtful. I should like to suggest that certain qualities of reaction to tests of reasoning ability or learning ability should be taken as the criterion of dullness rather than the I. Q. statement. I am accustomed to make this diagnosis for the child in school who does not fail with the tests, but who needs to be taught their meaning in certain instances, or given more than the standard amount of time in others, or more than the standard number of trials in still others. Needless to say, these variations in performance from the fixed normals are faithfully recorded, since a record of an examination which records only failures and successes according to the fixed standard is of little value in the analysis and d i a g n o s i s of most cases. Apropos of this point I may remind you that one reviewer of the Stanford Revision stated as the highest form of praise of it that it had been made "fool proof". In my opinion this is a very dubious praise. To the thoughtful observer the complexities of mental growth, the interrelation of its various factors, to say nothing of the effect of emotions, attitudes and the various phases included in the Freudian type of psychology, are too great to be intrusted to the judgment of a person mechanically trained in the administration of a scale of averages. These facts are being admitted constantly by psychologists and psychiatrists, but in actual practice much of their diagnoses are derived from a mathematically and mechanically derived I. Q. obtained through the testing made by relatively untrained persons.

Another factor in mental development is the effect of a foreign language or an illiterate cultural environment which cannot be evaluated from an I. Q. rating. I wish to define the term illiteracy in this sense as a deprivation of the products of culture, rather than a lack of ability with the mechanics of reading. The home which does not possess books or access to books of the sort current in modern life, or does not take a newspaper or magazines, provides what I wish to call an illiterate environment. There are thousands of such homes in our cities and in many country districts. This condition of illiteracy is extreme in the remote country districts of the South from which so many negroes are coming to our northern cities, bringing with them the great problem of adjustment to our city school system. In connection with this problem I do not wish to be interpreted as considering lightly a test which makes use of language or thinking through language mediums. The highest form of mental activity, namely abstract reasoning, can be carried on only through this medium. However, in order to use it for such a purpose one must have much training and experience with the medium itself. To one always accustomed to the cultural environment, all language forms of expression seem to carry a parallel meaning. For instance, most verbs and nouns do so; they are related directly with what they are intended to express. But certain forms of expression do not. A definite example of this in the scale is that absurdity of the ten year group, ''An engineer said that the more cars he had on his train the faster he could go''. To our minds, trained or accustomed to the forms of logical expression, this seems to connote a meaning which is correlated with the words used to express it as in the verb *run* with a definite act, or the noun *house* with a definite object. But to the child from a foreign environment this is not the case. Often have I seen the puzzled expression when the child is asked to consider the terms, ''the more—the faster'', to be cleared up instantly when the examiner changes to the statement, ''The engineer said that when he wants his engine to go faster he puts more cars on the train.'' Many of the words used in the various tests as well as the vocabulary test are common only in cultured environments. The child from an illiterate home or a foreign language parochial school does not know them. In analyzing a reaction to any one of these tests the examiner needs to separate the underlying fact of mental activity which the test may bring out from the understanding of forms of expression used in the test. This kind of analysis and adjustment of the tests to suit conditions has not been welcomed generally by authors of scales of mental ability.

In meeting the criticism of the suitability of his vocabulary test, Terman cited data from a number of Italian and Portugese children, with the following conclusion: ''The fact that these children had learned another language before learning English is reflected in their inferior vocabulary scores for three or four years after entering school. After that, however, the vocabulary catches up with the mental age. After the mental age of twelve years, these children are practically on a par with their fellow pupils of the same mental age level who have known no other language than English". In this conclusion a number of the factors here discussed are confused. A mental age without the vocabulary test is still almost as largely a test of vocabulary knowledge. However, one of the factors involved in a mental age rating is that of the innate qualities of intelligence, including thinking or reasoning ability. The child from a cultured environment, with opportunities for learning language expressions, who makes a certain low score may not be at all comparable with the child from an illiterate environment who makes the same score. Only an analysis of the tests and the relation of this analysis to certain qualities of reaction not taken account of in the standards set for scoring, and these in turn to environmental factors, can be of help in the diagnosis of the essential differences of these two types.

Another factor of mental development which needs to be taken into account at times is the effect of disuse of the mental faculties in certain ways upon test reactions. This problem is related especially to the negro child who has attended school not at all or but very little. His life, except for the farm work required of him, has been one which has been organized with reference to impulse alone, and not at all with reference to the set requirements of school with its attendant mental disciplines. One is impressed with the fact that these children seem to have no consciousness of their inner mental processes or of methods of their control. Their mental life is objective. An example of this difference may be found in the process of counting backward when compared with counting a row of objects. The child of four or five counts objects, but has not arrived at that state of mental development which enables him to make the counting series a matter of conscious control of certain mental processes with no outside objective relation. It is possible that this factor was involved in the cases of well-to-do farmers and business men reported by Wallin, who made scores which would technically justify a diagnosis of feeblemindedness. The question presented is, Is this ability of conscious subjective control of mental processes one which may be developed by the working conditions of the school?

Another factor involved in a few of the tests is lack of experiences of a motor and spatial type necessary to the development of the imagery underlying certain tests. One of the tests which requires such experience is the ball and field test which is difficult for our city children to realize. In our poor and crowded sections many children have had no experience with a space so large that every part could not be seen readily. To ask them to consider such a one and at the same time to call it *a field*, of which they have never heard, is to assume a body of experience which they have never had and a resultant imagery which they do not possess. The children in the outlying districts, near what they call "the prairie", have not this same difficulty, nor those who live near the market garden sections and know about the onion fields. Another test which relies upon such a type of imagery and experience is that absurdity, "I know a road which is downhill all the way to the city and downhill all the way back home". Our Chicago children have no imagery or experience with a country road; they do not know the term. They never saw a hill, for we have not one in all Chicago. There is no such thing for them as going from their house to the city. A variation of this test involving the same idea but appealing to a familiar background of experience may take the form, "A boy said, 'My room is on the top floor of the building. I go downstairs to get to the street and downstairs to get back again.' " I am accustomed to ask children who fail with this test from apparently some other reason than general inability to think or plan or reason if they ever saw a hill or know what it is, with always a negative answer. One boy said, "Yes, by the Grand Trunk tracks at Forty-seventh street". This place is a slight decline covered with tracks, used for switching, I am told. With only this imagery as a back ground, what could this boy do with the test?

As has been intimated, the factor of schooling is important in test results. The fact of a child's having learned to read or not before the age of 8 years will tend to modify 10 of the 26 tests between the 8 and 12 year groups, inclusive, with respect either to the actual subject matter of the tests or the vocabularies involved. Academic training varying from grammar grades to college will modify 8 of the remaining 18 tests of the scale.

In summing up, let me say that the most pressing need now is that analysis of tests which will enable us to know what it is that we are testing in a given case. Our knowledge of the result can be valid only in so far as we know what our tests are. I have not mentioned here the influence upon test scores or mental development of sensory defects, certain generalized motor disabilities such as spastic paralysis, poor nutritional condition, poor health or attitude and temperament. Each one of these points could be elaborated into a long discussion. In taking my examples from the Stanford Binet scale, I do not mean to say that that is the only one concerned. Performance scales are involved in their own way. I do not at all think, either, a performance scale can take the place in all respects of a scale testing ability with language forms. The higher grades of intelligence can not be tested with any performance scale yet devised, though such scales may be used to test wide ranges of innate intelligence. The very general movement toward the development of group scales is a false economy in the development of mental testing. What we need is more intensive work on the side of analysis of the character and quality of tests themselves and the conditions underlying their application.

A RADICAL EDUCATIONIST IN EARLY ILLINOIS

R. F. Swift, Illinois College, Jacksonville

Higher education has been chiefly the possession of a limited and favored class. Its character has been determined largely by the desires, the needs, and the traditions of such a class. Knowledge, perhaps for this reason, has been regarded as knowledge of things which do not interest the masses of men. It has been, one may say, characteristically aristocratic and remote from the daily life of the lower classes in society. Some educators believe that class distinctions and the traditions of social status have determined what type of education and knowledge is valid. Hence knowledge about the normal activities of the masses and education for such activities have been regarded as unworthy of the name. Such, we are told, was the Greek conception and it has persisted until this day.

The tendencies in modern democratic societies seem away from this view of knowledge and education. Knowledge about the activities of the common man is regarded by many today as equally valid with the knowledge of the nature of the universe and of man's destiny. Knowledge is instrumental, not contemplative. Education therefore is most successful when most intimately associated with the daily pursuits of the learners. It is an instrument of control, not a beatific vision. The classical tradition has lost its supremacy largely because it has seemed to have no sufficiently vital function in the normal activities of the masses of men. The various classes of society are winning the battle for the right of special types of education based upon special needs and occupations. Higher education is no longer limited to preparation for leisure or for the few professions.

The purpose of this paper is to call attention to an early advocate of this view of knowledge and education.

Jonathan Baldwin Turner began his career as a pioneer in building the civilization of the Middle West in the third decade of the last century as a professor in Illinois College. He gave his life to the cause of securing for the agricultural and the mechanical classes a preparation for their occupations comparable to that given in the colleges of that day for the "learned" professions. He was a man of vigorous and positive mind, of broad culture, and of splendid intelligence. He was a radical, not only in education but in religion and in politics also. Although himself a product of the classical tradition in education, he criticised it severely because he saw that it was in practice a class education. His criticism and his constructive work showed that he had a deep sympathy with all classes in society and that he saw the problems of the early west. Not the least of his services was the perfecting after years of experimentation of the Osage Orange hedge which made small farms possible and proved the practical effectivness of his social vision.

Professor Turner thought that the system of colleges then existing was too restricted with respect to the classes which were benefited, that the preparation they gave was valuable mostly for the few professions only, and that there should be colleges which would do for the agricultural and the mechanical classes what the existing colleges did for the traditional professions. He saw the beginning of the realization of his program in the establishment of the University of Illinois.

Knowledge, he held, must function in the everyday pursuits of life if it is to be of value, and education must provide this knowledge not merely for one class but for all classes. The industrial classes *(Address at Griggsville, May 13, 1850) lacked the means of bringing the abstract truth in their occupations "into effectual contact with the daily business and pursuits" of life. Truth as taught in the colleges was concerned with a very different world than that of the industrial classes. He advocated therefore a development of the science of the various industrial pursuits. The industrial classes "want, and they ought to have the same facilities for understanding the true philosophy, the science, and the art of their several pursuits and of applying efficiently existing knowledge thereto and widening their domain which the professional classes have long enjoyed." They

* All quotations from "The Life of Jonathan Baldwin Turner" by Mary Turner Carriel.

could not get this in the existing colleges for it was not regarded as valid as knowledge or as education.

How were they to get such an education? First, there should be a National Institute of Sciences "to operate as the great central luminary of the national mind". He thought we possessed this in the Smithsonian Institute. In addition each class should have its own university, with subordinate institutions. Each department should conduct annually a series of experiments. This, he thought, would be a means of good to all classes, would "evolve and diffuse practical knowledge and skill, true taste, love of industry, and sound morality".

This view naturally involved criticisms of the assumptions of the classical tradition in higher education, in particular, the validity of the claims made for language study and the doctrine of mental discipline. Education, he thought, should be liberal. But he doubted the effectiveness of mental discipline even for the professional classes. His view of mental training is a good example of realistic thinking. He said, "No inconsiderable share of mental discipline that is attributed to this peculiar course of study arises from daily intercourse for years with minds of the first order in their teachers and comrades, and would be produced under any other course if the parties had remained harmoniously together". His definition of mental discipline would be difficult to improve. "The most natural and effectual mental discipline possible for any man", he said, "arises from setting him to earnest and constant thought about things he daily does, sees, and handles, and all their connected relations and interests". This is at once a defense of the value and the validity of knowledge concerned in the so-called practical concerns of life and a criticism of the looseness characteristic of much present-day education, for it involves earnest and constant thought as well as a vital relationship to daily pursuits or concrete problems.

Professor Turner thought it absurd "to educate the man of work in unknown tongues, abstract problems and theories, and metaphysical figments and quibbles". He knew the sensibilities of the orthodox, however, and thought that some might regard "the theories of such a course of education as too sensuous and gross to be at the basis of a pure and elevated culture". He thought not, however. Such objects of study were as important as any, "unless, indeed", as he said, "the pedantic professional trifles of one man in a thousand are of more consequence than the daily vital interests of all the rest of mankind". Such men as Socrates, Franklin, and Kossuth derived their education from their connection with the practical pursuits of life. "What we want from schools," he said, "is to teach men . . to derive their mental and moral strength from their own pursuits." The difficulty of providing schools and a literature suited to the wants of the industrial classes would be met by the methodical application of science.

This view that the knowledge possessed by the workman is real knowledge, that the source of all knowledge is the normal activity of human beings, and that education, even in the schools, is best derived from intimate connection of the individual with life activities and occupations, is familiar doctrine. I thought it might be of some interest that they were verified in the life and thinking of Professor Turner, who developed them in intimate contact with the conditions and problems of a new country and who came by them through earnest and constant thought about things which a pioneer daily does and sees and handles.

ON THE ORIENTATION OF AN ANIMAL IN A PROBLEM-BOX

RUTLEDGE T. WILTBANK, KNOX COLLEGE

It is stated by Thorndike in his "Animal Intelligence"[1] that in learning to open the door of a problem-box a cat gradually associates the successful movement with the sense-impression of the interior of the box, so that the cat comes to perform the act as soon as it is confronted with the sense-impression. The particular impression with which the movement is associated is that of the button or other devise fastening the door on the inside. "It makes little or no difference whether the box from which a cat has learned to escape by turning a button is faced north, south, east or west. * * * * * * * The cat will operate the mechanism substantially as well as it did before."[2]

That these statements of Thorndike's,—to the effect that the animal's orientation is to the sense-impression of the interior of the box, and that the changing of the position of the box does not make any substantial difference in the successful adjustment of an animal which has already learned to turn the button,—are not always true, and perhaps never true, is indicated by the following experiment.

A cat was allowed to learn to open a problem-box which throughout the learning remained in the same position, facing the east. The box was then turned through 180 degrees, and the animal reintroduced into it. The cat went through the pawing motion of turning the button, but on the east side of the box, although the door and the button were now to the west.

The original learning, when the door was to the east, required twenty-eight trials. Two days afterwards the cat showed perfect retention of the habit. It was then that the box was turned through 180 degrees, and the cat put in again, the result being as noted above. All the conditions, including dishes of food equidistant from the four sides of the box, were retained as in the first

[1] Psych. Rev. Mon. Supp., No. 8, 1898, p. 15.
[2] Thorndike: Educ. Psych., Briefer Course, p. 134.

learning, except for the one change mentioned. The animal, in this second part of the experiment, went directly and immediately to the east side, where the door had been; and, after making eight or nine button-turning movements where the button had been, engaged in random movements until after three minutes and forty seconds it turned the button. Upon the next trial it at once directed its movements toward the button in its new position, and with hardly any superfluous motion. After this the box was placed in other positions—namely, 90 and 270 degrees from the original one, and the cat went directly to the door and button, performing the correct act.

The experiment was repeated with another cat, and the findings set forth above were corroborated in all essential respects.

The experiment shows that an association can be formed between the button as a stimulus and the appropriate movement, but that this association does not come about until the box has occupied several different positions. The original orientation, when the box was facing east, was with other, no doubt external, features of the environment rather than with the sense-impression of the interior of the box.

The results of this experiment accord with Carr's findings relative to the orientation of rats in a maze.[3] The maze was covered with a canvas top about two feet above the glass, flaps extending all the way down on the four sides. There was a peep-hole, and the interior was illuminated with an electric light. A group of ten rats learned the maze thus covered; then the cover above was turned through ninety degrees, and the rats reintroduced. No disturbance in the habit resulted. After this another group, of seven rats, learned the maze with the same canvas cover, except that one side of the cover remained open. Then the cover was closed on this side, and opened on another. Five of the seven rats were disturbed by this new condition. In six trials the total number of errors per rat ranged from nine to fifteen.

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[3] Jour. of Am. Beh., 7, 1917, pp. 265f.

This indicates that the adaptation, of five animals at least, was not to the interior of the maze only, but to the larger environment as well.

It is the purpose of this paper but to point out that the cats concerned in the experiment did not respond merely to the button, but were affected by other conditions besides the interior of the box. The question as to what feature or features of the larger environment affected them is left open. It may be conjectured, nevertheless, that in the case of the cat, as pretty certainly in the case of Carr's rats, the direction of the light was the main if not the sole factor. The door of the box, in our experiment, in its original position faced a window twelve feet away, there being no window on any of the other sides of the room. Another possible factor was the position of the experimenter, which remained the same, irrespective of the changes in the position of the box.

The bearing of this experiment on the question of animal intelligence (meaning by "intelligence" conscious analytical capacity with the purposeful adaptation of means to ends, or the purposeful adoption of such means accidentally discovered) is plain. Heymans[4] has recently rejected the problem-box experiment as furnishing any material bearing upon this question. He asserts that it is unreasonable to expect the cat to analyze a situation so terrifyingly new, into which it has been thrust forcibly; and that man in a similar situation would have some past experience with locks and bolts to fall back upon, which the animal lacks. But after twenty or twenty-five trials there was no sign of fear on the part of these cats; and their actions in going to the side where the door had been, and making the turning-motion there, seemed, to say the least, unintelligent.

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[4] Zeit. f. Ang. Psych., 21, 1922, pp. 84ff.

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 scientific 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. Each national member, except life members of the Academy, shall pay an admission fee of one dollar and an annual assessment of five dollars.

Local Members shall be those who are members of the local Academy only. Each local 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. 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, and who have not paid as much as $20.00 in fees to the Academy.

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 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. All other officers 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.

They 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, Vice-President, Secretary, Treasurer, Librarian, and the president of the preceding year. To the Council shall be entrusted the management of the affairs of the Academy during the intervals between regular meetings.

Article VI. Standing Committees.

The Standing Committees of the Academy shall be a Committee on Publication and a Committee on Membership 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 Committee on Membership shall 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 Publication.

All members shall receive gratis the current issues 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 being sent 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 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.

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.

LIFE MEMBERS.

*__Andrews, C. W.,__ LL. D., The John Crerar Library, Chicago, Ill. (Sci. Bibl.)
*Bain, Walter G., M. D., St. John's Hospital, Springfield, Ill. (Bacteriology.)
Barber, F. D., M. S., Illinois State Normal University, Normal, Ill. (Physics.)
Barnes, R. M., LL. B., Lacon, Ill. (Zoology.)
Barnes, William, M. D., 320 Millikin Bldg., Decatur, Ill. (Lepidoptera.)
*__Bartow, Edward,__ Ph. D., University of Iowa, Iowa City, Iowa.
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TRANSACTIONS

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SEVENTEENTH ANNUAL MEETING

Elgin High School and Elgin Academy

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

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1908

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

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Secretary, A. R. Crook, State Museum, Springfield.
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1909

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

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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.)

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Secretary, A. R. Crook, State Museum, Springfield.
Treasurer, J. C. Hessler, James Millikin University.

1912

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

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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.)

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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.
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.)

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

1916

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

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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.)

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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.)

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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. VANCLEAVE, 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.

ILLINOIS STATE ACADEMY OF SCIENCE

Office of the Secretary

State Teachers College, DeKalb, Illinois

Council Meeting, Urbana, May 19, 1923

President Waterman presided and all six members of the Council were present.

Invitations from Elgin, Decatur, Normal and Bloomington, and Joliet, urging the Academy to hold its next annual meeting in their respective cities, were read, and after thorough discussion it was voted to accept the Elgin invitation. The decision was based on two facts; first, that the Academy has never met in Elgin while it has met in the other cities named; and second, Elgin had extended a cordial invitation a year ago to hold our 1923 meeting there.

The following standing committees were appointed: Committee on Ecological Survey, H. C. Cowles, Chairman, George D. Fuller, Ruth Marshall, V. E. Shelford, W. B. McDougall, R. B. Miller, A. O. Weese, James H. Ferriss, H. S. Pepoon and M. M. Leighton.

Committee on High School Science and Clubs: John C. Hessler, Chairman, F. H. Colyer, C. M. Turton, Harriet Strong, W. S. Bayley, F. C. Bohannan, R. G. Buzzard, F. D. Townsley and H. H. Radcliffe. Chairman Hessler was authorized to add another member to the Committee and to make other changes if desired.

By vote the Committee on High School Science and Clubs was empowered to use funds up to $50. if necessary, to carry on its work.

The President was given authority to have printed a small four page pamphlet, setting forth useful information concerning the Academy and its work, for distribution among members and for use in securing new members; the cost of such a pamphlet not to exceed $30.

The following amendments and additions to the constitution were presented to be acted upon at the next annual meeting:

Article V.—Council. The first sentence to read: The Council shall consist of the President, Vice-President, Secretary, Treasurer, Librarian, and the presidents of the two preceding terms. (This allows for two past-presidents on the Council instead of one.)

Addition to Article V.—At the annual meetings the presiding officers of all the affiliated scientific societies of the state shall meet with the Academy Council for the discussion of policies.

Article VI.—Standing Committees. Add to this article a Committee on Affiliation. Also add to this article,—The Committee on Affiliation shall consist of five members, chosen annually by the Academy.

By vote the President was empowered to appoint a temporary committee on Affiliation to serve this year and work among the County Academies and other scientific societies of the state, with a view to securing the affiliation of their members with the Academy, so that all may cooperate in the interest of science.

The following Committee on Affiliation was appointed: W. S. Bayley, Chairman, H. J. VanCleave, F. R. Jelliff, Clarence Bonnell and W. G. Waterman.

Council Meeting, Urbana, November 17, 1923

President Waterman presided at the meeting. All six members of the Council were present.

Treasurer Schulz presented four names for membership. It was voted that the names be accepted by the Council and presented at the annual meeting of the Academy.

By vote the Secretary was instructed to invite the Illinois Division of the Mathematical Association to meet again with the Academy at the next annual meeting.

The date of the annual meeting to be held at Elgin was set for May 1, 2, and 3, 1924. However, the President was empowered to change the date to a week earlier or later, if it was found that these dates conflicted with some other large meeting of a scientific nature.

The Treasurer submitted the following report:

Balance on hand May 1, 1923	$459.97
Receipts from May 1 to Nov. 17	392.30
	852.27
Expenditures, May 1 to Nov. 17	294.30
	$557.97

Dr. Bayley reported progress for his Committee on Affiliation of local scientific societies.

It was voted that the following plan concerning the affiliation of local scientific societies should be recommended to the Academy at the annual meeting:

Affiliated Societies

Local Academies of Science and similar Scientific Societies in the State, other than High School Science Clubs, may become affiliated with the State Academy by an affirmative vote of three-fourths of the members of such society, when confirmed by vote of the members of the State Academy at their annual meeting.

Members of such affiliated societies may become members also of the State Academy without initiation fee, by paying annual dues to the treasurer of the local society sufficiently large so that the local treasurer may send to the treasurer of the State Academy one dollar for each member, except for life members of the State Academy, or for those who are also members of the A. A. A. S.

The Secretary presented a communication inviting our Academy to send a delegate to a commemorative meeting to be held in Philadelphia, December 6, 1923, in honor of the centenary of the birth of Joseph Leidy, one of America's greatest naturalists.

The Secretary was authorized to appoint as our delegate to the above meeting some Academy member residing in or near Philadelphia.

By vote the President was empowered to appoint a Program Committee for the annual meeting, to consist of the President, Secretary and one or more other members. This committee is to have charge of the selection of papers to be read at the annual meeting, and to plan other features for the program.

It was voted to present the following amendments of the constitution at the annual meeting for action:

Article IV.—After the word president, substitute for vice-president,—a first vice-president, a second vice-president.

This provides for an additional officer, a second vice-president.

Also add to Article IV. the following: The second vice-president shall be a resident of the town in which the next annual meeting is to be held, and shall be appointed by the Council as soon as the next meeting place has been decided upon.

Council Meeting, Elgin High School, May 1, 1924

The Council met with the Local Committee of Arrangements at the High School Building, Elgin.

Final arrangements for the Annual Meeting were discussed and all plans completed.

New names were presented for membership. The list of names was approved by the Council, and it was voted to recommend the Treasurer's list of new members to the Academy for election.

A letter from the British Association of Science was read, in which an invitation was extended to our Academy of Science to attend the Science Convention to be held in Toronto, August 6-13, 1924. It was recommended that the incoming Council appoint delegates to the Toronto Convention from among those members of our Academy who were planning to attend.

Annual Business Meeting, Elgin High School, May 2, 1924, 8:45 A. M.

President W. G. Waterman presided, and, after calling the meeting to order gave a brief report concerning the printing and distributing of the leaflets on the work and aims of the Academy. A copy of the leaflet had been sent out previously to each member of the Academy.

The Treasurer submitted the following report:

REPORT OF THE TREASURER FOR THE YEAR 1923-1924.

RECEIPTS.

Balance on hand, May 1st, 1923		$459.97
From Local Dues		130.00
From National Dues		332.50
For Reprints		176.61
For Transactions		21.00
Total		$1,120.08

DISBURSEMENTS.

Reprints, Printing Bill		$156.20
Collected for A. A. A. S		32.00
Refund Dues		13.00
Expense of President's Office		56.35
Expenses of Secretary's Office		351.26
Expenses of Treasurer's Office		48.74
Secretary's Salary		150.00
Total		$807.55
Total Receipts	$1,120.08	
Total Expense	807.55	
Balance on hand	$312.53	

The report was accepted by vote and referred to the auditing committee.

The Membership Committee, through its Chairman, Clarence Bonnell, reported that 34 new names had been approved by the Council for membership. After reading the list of candidates a vote was taken electing them to membership in the Academy.

The Librarian, A. R. Crook, handed in the following written report:

Librarian's Report 1923-1924

Since the museum has been moved to attractive quarters in the magnificient new Centennial Building, opportunity has been offered for the first time in many years to make accurate count of the volumes of reports still on our shelves.

The number of each of the sixteen volumes remaining is as follows:

Vol. I	71
Vol. II	604
Vol. III	559
Vol. IV	516
Vol. V	506
Vol. VI	230
Vol. VII	456

Vol. VIII	415
Vol. IX	1470
Vol. X	313
Vol. XI	357
Vol. XII	270
Vol. XIII	350
Vol. XIV	369
Vol. XV	542
Vol. XVI	400

The large number remaining of Volume IX is due to the fact that officers at that time thought that these volumes would be useful in spreading a knowledge of the good work which the Academy is doing. If members of the Academy will let the librarian know where these volumes may be useful, copies will be sent.

The sales of such volumes as have been published by the Academy have totalled $34.50 as indicated below:

April 17, 1923, McClurg Company, Chicago, 8 volume @ $1.50 each	$12.00
June 4, 1923, H. Garman, Uni. of Ky., Volume VI	1.50
Jan. 31, 1924, Insular Experiment Station, Rio Piedras, P. H., Volume X	1.50
Jan. 31, 1924, Minn. Uni. Library, Volumes VI, VII, VIII, IX, X, 5 volumes	7.50
April 3, 1924, Wisconsin Uni. Library, Volumes I, II, III, IV, V, VI, VII, VIII, IX, X, 8 volumes	12.00
Total	$34.50

This total has been forwarded to the treasurer.

The major portion of the expenses of publishing our volumes is met from the museum's publication fund. While there are reports which the museum desires to publish, yet the thought of the chief is that there is no better way of carrying out the work of the museum in its purpose of diffusing scientific knowledge, than in publishing the Transactions.

It is to be hoped that the time will arrive when the legislature will appropriate sufficient funds to bring out not only the Transactions but other museum publications.

Respectfully submitted,

A. R. Crook,

Librarian.

Report was accepted.

Chairman John C. Hessler, of the Committee on High School Science and Clubs, gave a report on the year's work as follows:

Report of the Committee on High School Science and Clubs, May 2, 1924

The work of the committee for the year 1923-1924 has been limited to two projects: (1) The preparation of a program for the section of High School Science; and (2) The making of a census of High School Science Clubs in Illinois.

The section meeting this afternoon will, as the program indicates, consider Science Clubs and the "Humanizing of High School Science". The thanks of the committee are extended to the men and women who have consented to contribute a share of their time and interest to this program.

The census of High School Science Clubs was made through a return postal-card questionnaire of 12 questions. The cards were addressed to 645 High Schools of the state. Up to the present time 153 replies have been received, two of them letters which go into details more specific than the space on the cards permitted. This means that about 500 of the 645 schools addressed made no reply whatever. Of the 153 replying, 105 reported no Science Clubs whatever; 16 reported no clubs at present, but manifested interest in the possibility of forming clubs; while 32 reported clubs at work. When it is remembered that last year's committee sent out 625 eight-page pamphlets, in which the desirability of High School Science Clubs was stressed, and in which suggested programs for a year's work were given, the progress of the High Schools of the state in taking up science from the amateur, as distinguished from the curricular point of view, does not seem very rapid. This ought not to surprise those who know the High Schools of the present day and the appalling number of extra-curricular activities that occupy the student's interest and time. It is barely possible that, as a result of the number of these activities already existing, a great number of the pamphlets and postal cards sent out did not reach the teacher of Science at all, but were diverted to the waste basket in the administrative offices of the school. This explanation would account for the "lost battalion", nearly 500 schools in number, from which no replies whatever were received.

The committee chairman recommends that the work go on, and that the Academy take special pains to interest itself in, and if possible to cooperate with, those High School Science Clubs already in existence, as well as to encourage the formation of clubs in those schools in which the census reveals an indication of interest in such clubs.

In conclusion the chairman desires to read a portion of a letter received from a teacher vitally interested in Science Clubs:

"Science clubs started in the school five years ago as an experiment in the General Science classes. Chemistry Clubs were organized a year later; then followed the Botany and Zoology Clubs. All members of the class are members of the club, as the club meets during the recitation period. In this way not only the bright and interested student, but also the student who needs the incentive of club activity is reached. We find this a strong point in favor of such an organization.

There are 16 General Science Clubs with meetings every two weeks. The president of the club, elected for a semester, presides over the meeting. The program consists of simple experiments or talks on subjects relating to science in everyday life.

In Botany, Zoology, and Chemistry the same plan is followed, with variations to suit the particular need. The president and secretary are directly responsible for the program. Each student takes part. Talks on current topics, reports of outside lectures or conferences, biographical sketches, and talks on topics bearing on the subject and of general interest make up the programs. The two Botany Clubs superintended tree planting on the school grounds lately. In one of the Zoology Clubs a lively discussion of the proposed Game Reform Law took place. Each of these clubs meets twice a month.

Each of the three Chemistry Clubs meets once a month, but has a two-period session when experiments performed require the time. Critics are appointed, and a general discussion follows the talks or experiment. Two years ago a member wrote a short play for the club. This year the clubs are working on a pageant to show important epochs in the history of Chemistry.

In each of the various clubs the teacher takes no active part. He may ask or answer questions, or guide the trend of the discussion. All of the clubs with the exception of the General Science Clubs have taken excursions to plants near by or in Chicago. Moving pictures have also been obtained for use in club meetings.

The Radio Club is an after-school organization. Any one in school may join, providing he is passing in his work."

Respectfully submitted,

John C. Hessler,

Chairman.

The report was accepted.

The Secretary reported that Vol. 16 of the Transactions had been published and sent out to all members, and about 400 copies remained in the Librarian's keeping. Also reported that such reprints of the Galesburg papers as had been ordered were now in the press and would soon be issued. Report was accepted.

Chairman W. S. Bayley, of the Committee on Affiliation, reported progress, and stated that the Committee had attempted to secure a census of the Scientific Societies of the State, but was unable to do so. It was difficult to locate any scientific societies not already affiliated with the Academy. Members were urged to notify the Committee if any local scientific societies were known to them. Report accepted.

The following plan for affiliating local scientific societies was presented in two parts.

PART I

Local Academies of Science and similar Scientific Societies in the State, other than High School Science Clubs, may become affiliated with the State Academy by an affirmative vote of three-fourths of the members of such society, when confirmed by vote of the members of the State Academy at their annual meeting. Voted to adopt.

PART II

Members of such affiliated societies may become members of the State Academy without initiation fee, by paying annual dues to the treasurer of the local society sufficiently large so that the local treasurer may send to the treasurer of the State Academy one dollar for each member, except for life members of the State Academy, or for those who are also members of the A. A. A. S. Voted to adopt.

AMENDMENTS

Several amendments to the constitution were presented as follows:

(1) An amendment to Article V, allowing two past-presidents, instead of one, to sit with the Council. The article as amended in the first sentence reads as follows: The Council shall consist of the President, Vice-President, Secretary, Treasurer, Librarian, the retiring President and his immediate predecessor.

(2) An addition to Article V.—At the Annual Meetings the presiding officers of all the affiliated scientific societies of the State shall meet with the Academy Council for the discussion of policies.

(3) An addition to Article VI, providing for a Committee on Affiliation, consisting of five members chosen annually by the Academy.

(4) An addition to Article IV, providing for the selection of a second vice-president.

Said officer may be a resident of the town in which the next annual meeting is to be held, and may be appointed by the Council each year when the next meeting place shall have been decided upon.

The above amendment and additions to the constitution were separately adopted by vote.

The Illinois Nature Study Society of Elgin applied for affiliation with the Academy, and by vote such affiliation was granted.

The President appointed the following committees, to report at the business meeting to be held at five o'clock in the afternoon.

Committee on Nominations.—A. R. Crook, Chairman; H. C. Cowles, Mary M. Steagall, L. E. Hildebrand, J. C. Hessler.

Committee on Resolutions.—W. S. Bayley, Chairman; F. R. Jelliff, F. M. Colyer.

Committee on Auditing.—W. H. Packard, Chairman; G. W. Boot, C. M. Turton.

A motion was passed that a Committee on Conservation be added to our standing committee. By vote the incoming Council was empowered to appoint such a committee on Conservation for the coming year.

A letter was read from the British Association of Science inviting our Academy to send delegates to their meeting to be held in Toronto, August 6-13, 1924. It was voted that the recommendation of the Council, in session May 1st, that the delegates be appointed by the incoming Council, from among those who were to attend the Toronto meeting, be accepted.

Adjourned to meet at 5:00 P. M.

Business Meeting, Elgin High School, 5:00 P. M., May 2, 1924

President Waterman presided. Report of committees called for.

W. E. Packard reported that the Auditing Committee had examined the books and accounts of the Treasurer and had found them correct. Report accepted.

W. S. Bayley, for the Resolutions Committee, reported as follows on the death of members during the year:

It is with sincere regret that the Academy records the passing away during the past year of the following members:

Mr. C. B. Caldwell, M. D., Lincoln State School and Colony, Lincoln, Ill.

Mr. Theo. O. Edgar, M. D., Dixon, Illinois.

Mr. J. H. Jones, Evanston, Illinois.

Mr. L. H. Hyde, M. D., Joliet, Illinois.

Prof. Alexander MacGillivray, Ph. D., Urbana, Illinois.

Mr. Chas. F. Millspaugh, M. D., Field Museum, Chicago, Illinois.

Resolutions accepted by vote.

Also the Committee presented the following resolution of thanks to all persons and organizations in Elgin who had helped in any way to make our meeting a success:

Resolved that the State Academy of Science herewith expresses its sincere appreciation of the kindness and hospitality shown its members, during the annual meeting, by the citizens of Elgin.

That it is especially grateful to Mr. Carl F. Gronemann, Chairman of the Committee on Arrangements, and to all his assistants, who have rendered such efficient service; to the Mayor of Elgin for his cordial address of welcome; to the Board of Education for the use of the High School building; to the Elgin Academy and Junior College; to the Superintendent of City Schools; to the High School and Elgin Academy Officials, teachers and students; to the Boy Scouts; to the Chamber of Commerce; to the Elgin Press for its helpful notices and write-ups; to the Illinois Nature Study Society of Elgin; to the Merchant's Association; to the Elgin Watch Company; and to the Elgin Scientific Society, all of which have aided so greatly in making the 1924 meeting of the Academy of Science a gratifying success.

W. S. Bayley,
F. R. Jelliff,
F. M. Colyer.

This resolution was adopted. Copies were sent by the Secretary to all in Elgin concerned in making our meeting a success.

A third resolution was presented concerning the practice of polluting the streams and rivers of Illinois, and recommending reformatory action by the State legislature. Following is the resolution:

WHEREAS it is the common practice of many Illinois cities to discharge raw sewage, and of numerous corporations to empty factory and even chemical waste into the streams of the state, thus polluting and poisoning and rendering them unfit for domestic and, when excessively charged, even for industrial use, depriving farmers of their right to the use of said streams for stock and other purposes, and preventing the public from enjoying them for bathing and other pastimes, and

WHEREAS such abuse of the streams is killing the fish and aquatic life, and imperiling waterfowl; and

WHEREAS in the case of the larger streams such practices of pollution are making said streams offensive for navigation; and

WHEREAS the gradual diminution of other sources of water supplies for municipalities, farms and industries makes the preservation of our streams as possible sources of supplies imperative, therefore be it

Resolved that we will support the State Waterway and State Health authorities in their efforts to encourage or compel municipalities, corporations and individuals to abate the public menace created by the discharge of sewage, waste and other filth into the streams of Illinois.

Resolved that if the present law is not sufficiently stringent for this purpose, or is not applicable to municipalities, we favor the passage of such further measures by the State Legislature as will secure reformatory action.

Resolved that we favor the study and consideration of the question in the commercial bodies and schools of the State, so that the people may be led to comprehend that the present practice of stream pollution is a crime against themselves, and so that they may, therefore, be persuaded to assume the expense of providing a remedy.

Resolved that we favor the appropriation by the Legislature of a sum sufficient to enable the State Waterway Board to make a detailed survey of the streams of the State with a view to recommendations that will meet the present dangerous situation.

Resolved that we commend Decatur, Elgin, Champlain, Urbana and Springfield for the forward steps they have taken to provide sanitary drainage districts.

Committee,

W. S. Bayley,
F. R. Jelliff,
F. H. Colyer.

This resolution was adopted.

The Committee on Nominations reported as follows:

Nominations for Officers for 1924-25

President—W. G. Bain, Springfield.
Vice-President—C. H. Smith, Chicago.
Secretary—C. F. Phipps, DeKalb.
Treasurer—W. B. McDougall, Urbana.
Librarian—A. R. Crook, Springfield.

Nominations for Committee on Membership

B. K. Richardson, Springfield, Chairman.
W. H. Packard, Peoria.
J. H. Bretz, Chicago.
T. E. Savage, Urbana.
Miss Alice Patterson, Normal.

Nominations for Committee on Affiliations

W. S. Bayley, Urbana, Chairman.
Mrs. Eleanor Smith, Joliet.
M. H. Leighton, Urbana.
W. G. Waterman, Evanston.
C. A. Shull, Chicago.

Nomination for Third Member of Publication Committee

L. E. Hildebrand, Kenilworth.

The report of the Nominating Committee was accepted, and the Secretary was empowered to cast the ballot of the meeting for the officers and committees nominated. This was done and the officers and committees named were declared elected.

The Treasurer reported five new candidates for membership, and they were duly elected.

Meeting adjourned.

The papers presented at the general meetings and section meetings were very much enjoyed by the members and visiting friends. As nearly as could be calculated there were from 150 to 200 Academy members present and possibly as many visitors. The total attendance at the section meetings Friday afternoon was about 200, but this number was much increased by visitors at the general meetings. There were 73 papers presented in the 7 section meetings and 3 General Sessions. The Academy was welcomed by Mayor Earle R. Kelly on Thurday evening in a very cordial address.

On Saturday, May 3rd, many members and friends met at the High School to participate in the field trips. One group visited the Elgin Watch factory and were shown through the various departments and had the details of making a million watches a year explained. After the tour of inspection the Watch Company's Astronomical Observatory was visited where it was learned how accurate time is obtained from the stars every night.

A second group, led by Dr. M. M. Leighton and Dr. Paul MacClintock, visited interesting regions of glacial deposits near Elgin.

The third group, led by Dr. H. C. Cowles, made a study of plants and trees in Trout Park. The White Cedar swamp was of especial interest, since it is a relic of the glacial age and has no counterpart elsewhere in the state.

All these groups met at noon in Trout Park where they were served a bountiful complimentary luncheon by the Illinois Nature Study Society of Elgin. This courtesy was much appreciated by the members.

In the afternoon the Geology group continued its exploration of the glaciated regions, and the Botany group visited Hill's famous Evergreen Nursery at Dundee.

Concerning the Elgin meeting as a whole, many of the members voiced the opinion that it was a gratifying success, and that it was one of the best the Academy had ever held.

C. Frank Phipps,
Secretary.

PAPERS PRESENTED AT THE GENERAL SESSIONS OF THE GALESBURG MEETING

PLANT COMMUNITIES OF GLACIER NATIONAL PARK, MONTANA.

W. G. WATERMAN, NORTHWESTERN UNIVERSITY

GEOGRAPHY AND GEOLOGY

Glacier Park is located in the northwest corner of Montana, extending from the east front of the Rockies across the Lewis and Livingston ranges. The east front of the mountains rises abruptly from the Great Plains, as a result of the formation of the great Lewis overthrust fault which pushed the mountain strata out over the great plains formation in places as far as fifteen miles. This front or escarpment has been trenched by many streams which flow down from the plateau and find their way northeastward through the St. Mary's river to Hudson Bay or through the Milk River into the Missouri. The continental divide runs south along the crests, first of the Livingston and farther south of the Lewis Range, and the waters from the west side of the divide flow eventually into the Pacific Ocean. These streams in their lower valleys have developed narrow flood-plains, but they rapidly become steeper and their head waters are located in mountain ponds and springs on an average not more than 8 or 10 miles west of the plains. The mountain sides are very steep and are covered by slides of gravel occasionally broken by horizontal ledges formed by the protruding edges of the strata of which the mountains are composed. These strata dip gently in both directions toward a central valley between the two ranges, forming a great syncline. They are generally almost horizontal, though occasionally crumpled into many short wavy folds.

Near the summits of the mountains on protected ledges and in saucer-shaped depressions are located the glaciers from which the park gets its name. They are mostly small and decreasing in size, but they produce characteristic ridges of clay and gravel known as moraines, and their melting supplies the streams which cut narrow gorges down the mountain sides. Where two glacial valleys start opposite each other on the divide, their heads have cut the ridge down and a saddle or pass has been formed. On an average the valley floors have an elevation of 4000 feet above sea level, the passes 6000-7000 feet and the mountain summits 9000-10,000. There are only six mountains in the park above 10,000 feet and of these the highest, Mt. Cleveland, is 10,500.

PLANT COMMUNITIES OF THE VALLEYS

The dominant plant formation of the region is the Rocky Mountain conifer forest which is found in the river valleys and on the lower slopes of the east side of the divide. The forest of the central valley and of the west slopes is similar but has an admixture of many of the species of the Pacific Coast.

The vegetation of the Great Plains adjoining the east front is of the grassland or prairie type. This consists chiefly of several species of grass with some herbaceous dicotyls, including a prickly pear cactus, and the shrubby sage-brush. In the river valleys, cottonwoods and willows fringe the streams and in smaller valleys and gullies thickets of shrubby willows, alder, and aspens are generally found. On the rolling hills adjoining the east front, aspen thickets are found and on the summits of the hills there are occasional stands of scattered stunted conifers.

In the ponds and marshy spots scattered over the prairie and along the stream valleys are characteristic aquatic communities. In most localities are the usual swamp communities including cattails, arrowhead, water-plantain, water smart-weed, and also such unusual forms as the pincushion plant, the owl-clover, and several genera of the evening-primrose family. Many of the depressions are strongly alkaline with such halophytic plants as salt-grass, shad scale, and the alkali buttercup.

The conifer forest (Fig. 1) is found at its best in the river and lake plains in the deep valleys of the east front. Here the trees grow in close stand to a height of 60 or 70 feet, and there is a dense mesophytic undergrowth of shrubs and ground plants. The chief trees are the lodgepole pine, the Englemann spruce, the Douglas fir or false hemlock and the alpine fir. The low trees and shrubs include the mountain ash, mountain maple, the service-berry, the buckthorn, the buffalo-berry, the deerbrush, the snowberry, and honeysuckles, with blueberries, gooseberries, and raspberries. Among the ground plants are such characteristic forms as the queencup, the rattlesnake plantain, the baneberry, the pyrola, the bishop's cap, and several ferns. Occasionally rounded shoulders or knobs, usually on the north side of a valley, show very xerophytic conditions and have a vegetation resembling that of a pine barren. The trees are chiefly lodgepole and lumber pines and poplars, and they have a stunted growth and open stand. The chief shrubs are blueberries, mountain spray, and deerbrush, and the ground plants include bergamot, harebell, fireweed, beardtongue, stonecrop, and a xerophytic selaginella.

PLANT COMMUNITIES OF THE MOUNTAIN-SIDES

On the valley sides the soil rapidly becomes drier than that of the flood-plains, the trees are not so tall and have a more open stand, and the undergrowth becomes more xerophytic. The forest also becomes discontinuous, with alternating patches of shrubby thickets or of mountain meadow. In the thickets, alder and willows predominate, with elder and red osier dogwood and stunted specimens of mountain ash, mountain maple and service berry. The mountain meadows consist of a dense ground cover of grasses and herbaceous plants which are famous for the variety and bright color of their flowers. Among these are paint brush, columbine, bear grass, mariposa lily, beard-tongues, louseworts, larkspur, Jacob's ladder, shooting star, spirea, stonecrop, saxifrages, sulphur plant, bistort, wild onions, lupines and other legumes, and several showy composites. Where there is plenty of water in the soil, as along the mountain streams, will be found the globe flower, little elephant, pasque flower, anemones, and hydrophytic saxifrages and mosses.

Farther up the mountain side the plants get more and more stunted. At timberline the conifers form extensive thickets of trees not over 3 or 6 feet tall. Above timberline there are no trees and the ground plants grow in clumps with a very open stand. All have short stems and many show the cushion habit, but the flowers are still brightly colored and generally full size. Characteristic species are the mountain dryad, mountain pink, several saxifrages, red and yellow stonecrops, dogtooth lily, cinquefoil, mountain sorrel, mountain forget-me-not, and wild candy tuft. These plants continue in very open stand as far as any gravelly soil can be found. Among those which are found at the highest levels are the dryad, mosspink, a saxifrage, a hedysarum, a dandelion, and chickweeds. On the bare rock surfaces there is a profusion of lichens, predominantly greenish-gray, but also black and white, brown, lavender and even yellow and red.

PLANT COMMUNITIES OF ALPINE PARK.

Near the summits of the mountains, small level tracts are occasionally found which may be called mountain parks. These contain slight depressions in which snowbanks accumulate and frequently remain until late in the summer. The vegetation of these parts resembles the tundra of the arctic regions interspersed with scattered clumps of stunted conifers. (Fig. 3.) In the drier portions of the tundra, the main groundcover consists of grasses and sedges with such characteristic flowering plants as the red and white heathers (*Phyllodoce*), the shooting star, the Rocky Mountain laurel, the dwarf willow, the alpine speedwell, fringed gentian, Indian warrior, and rock cress.

The snowbanks have a different and a very characteristic vegetation. In the early part of the season, the dogtooth lily grows around the edges of the snow, even coming up through the snow and blooming before it has melted away. When the snow has completely melted, the bottom of the little hollow is found to contain not the dogtooth lily but the alpine spring beauty. The conifer clumps are usually found on the shallow dry soil which overlies rock ledges and they follow the outlines of the buried rock ridges. The species include fir, spruce, the white-bark pine, and the Rocky Mountain juniper.

On the sides of the parks near the mountain slopes, the rock ledges often protrude through the scanty cover of soil and here the plant communities are quite different.

Fig. 1. Conifer forest in stream valley. Mountain meadow in foreground.

Fig. 2. Flowers in mountain meadow surrounded by conifers.

Fig. 3. Elongated patches of stunted conifers in Alpine Park.—indicators of buried rock ledges.

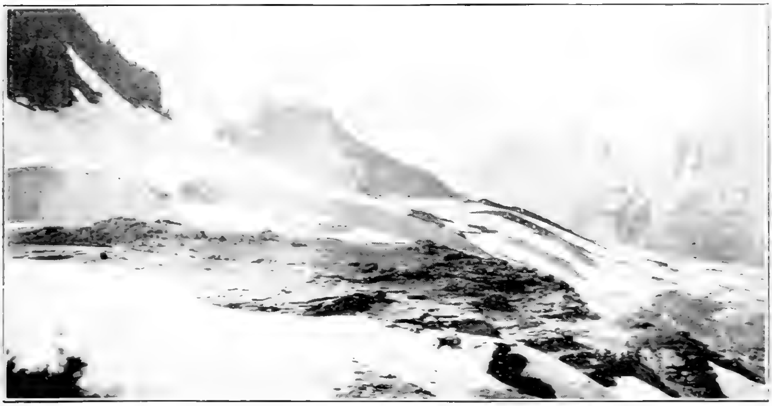

Fig. 4. Moraines and rock ledges surrounding Two-Ocean Glacier.

The outer edges of the rock ledge which are exposed and relatively dry are occupied first by elongated patches of stunted conifers of the species already mentioned. The inner part of the ledge is lower and the scanty soil is watersoaked from melting ice and snow, and in this depression a moisture-loving community develops. The plants here include grasses and sedges, the heathers, and the Rocky Mountain laurel, the globe flower, a buttercup, a cinquefoil, the queencup, a white paint-brush, the meadow rue, the rock-cress, and in protected spots several delicate ferns.

When water drips over the face of the ledge, the projections and pockets in the rock face contain hydrophytic mosses and ferns, and such unusual plants as the mist-maiden (*Romanzoffia*) and the butterwort (*Pinguicula*). In especially cold, wet spots a bit of real arctic wet tundra may be found with sphagnum and the arctic heather *Cassiope*.

Still another type of community is found occupying the clay-gravel moraines around the melting fronts of the glaciers. (Fig. 4.) Here the conditions are extremely hard for plants on account of the character of the soil, and the exposure and the absence of moisture on these dry, clay ridges. The first plants to appear after the retreat of the glaciers are stunted and scattered, as they are able to become established only in the most favorable spots. The first pioneers are usually grasses, with chickweeds, fleabane, alpine beardtongue, the mosspink, and the alpine poppy. The last mentioned is especially interesting and characteristic as it is a true poppy, but only two or three inches high. It has only a few leaves and one orange-colored flower which is perfectly formed and easily recognized as a poppy.

On the older moraines these plants form layer clumps and are found closer together. Other less hardy species come in and scanty clumps of stunted conifers begin to appear. Those are the same species that are found on the dry tundra and on the rock ledges.

PLANT COMMUNITIES OF THE WEST SIDE OF THE DIVIDE

The same general conditions prevail on the west side of the divide, but the plant communities there are interesting because of the presence of many species from the Pacific coastal forests. Among the trees are the western hemlock, giant cedar, western larch, western white pine, and white birch. Among shrubs and ground plants are the yew, the devil's club, the mountain lover, and the Oregon grape. Other plants found chiefly on the western slopes in Glacier Park are the nine-back, the Labrador tea, the bunch-berry and the high-bush cranberry.

The forests of the valley floors are very damp and the heavy undergrowth resembles in luxuriance as well as in species that of the forests of Washington and Oregon. The trees are draped with the bearded lichen and there is a profusion of fungous forms on the rich humus.

In some of the ponds above the head of Lake McDonald are sphagnum bogs which resemble those of the eastern states and Canada. The characteristic feature of these bogs is the floating mat of sphagnum which supports such bog plants as sun-dew, swamp cinquefoil, and cottongrass as well as the Rocky Mountain laurel, the orchid lady's-tresses, the water hemlock, and several club mosses.

MENTAL HYGIENE AS A PROBLEM OF PUBLIC HEALTH

Herman M. Adler, M. D., Criminologist, Department of Public Welfare, Chicago

The accomplishments of medical science in controlling infectious diseases both by prevention and by cure are so well known to the general public that there can be little doubt as to the main facts. In spite of the opposition of a relatively small but determined number of dissenters the science of medicine has gone on in an uninterrupted sequence of achievements. Typhoid fever, small pox, diphtheria, and tuberculosis have all yielded to the medical attack. Even in those conditions in which the etiology and specific treatment are still obscure a great deal has been accomplished in prevention. The average expectancy of life has been lengthened in one generation from thirty-three years to fifty-six years, and predictions are now being heard, based on reasonable assumptions, that the span of life will be further increased to sixty or even the Biblical three score and ten years.

It is natural that such a growing accumulation of knowledge has produced a marked effect on the community aspects of the general health problem. Public Health has developed into one of the most important agencies in the safe-guarding of the community welfare. Hygiene has made it possible for increasingly large groups to enjoy the advantages of close association in cities without the dangers to health which formerly were an invariable accompaniment to concentration of population. This ability to safe-guard health has been felt also on the farms and in industry. It has made possible the management of large armies, the conquest of the tropics and the arctics, the building of the Panama Canal. In addition to the prolongation of life and to the protection of citizens has been the progress made in the reduction of infant mortality.

Medicine has not yet reached the final triumph over disease. In spite of the advances made in cancer, heart diseases, the disease of the respiratory organs, meningitis, syphilis, and tuberculosis, these diseases still exact too heavy a toll. But enough evidence has been obtained to indicate that however difficult the problem may seem at the moment, an ultimate victory is reasonably assured.

It is probable that most of this success has resulted from definite discoveries made often as a by-product of another research. The mere recognition of a danger or of an unsatisfactory state of affairs does not solve the problem. Discontent and rebellion, however justifiable as emotional manifestations, have not contributed much to a solution.

The functions of the Public Health organizations are largely those of applying available knowledge. On account of the tremendous urgency of the problems dealt with there is little time to attempt research. Nevertheless our Public Health Agencies have managed to contribute important new knowledge; thus diphtheria antitoxin was in large measure the result of the Public Health interests of its discoverer, von Behring.

It is natural that Public Health has been forced to concern itself within the last generation with the practical problem of physical health, and the advances in scientific knowledge have been largely in the direction of specific treatment in an increasing number of physical diseases. The advances in laboratory technique have been responsible for the preventive work on a large scale. There is one branch of medicine, however, which has long been recognized as one of the most important, but which has lagged behind the general advance in clinical medicine. This is the field of mental science. Largely due to the complexity of the problem and to the relative inaccessibility of the central nervous system to available methods, there is an apparent discrepancy between our effectiveness in this field as contrasted with the physical diseases. Nevertheless psychiatry and psychopathology have not been inactive, and considerable advance has been made of late, so that now we are in a position to apply, in some degree at least, therapeutic and preventive measures.

It is natural that the first advance should have been made in the recognition and the diagnosis of mental disorders rather than in their treatment and prevention.

This has perhaps contributed to a certain amount of scepticism on the part of those outside towards the practical value of the methods of mental science. It is interesting to note also in this connection that the extension of life and the saving of infant lives, of which medicine is so proud, have served to complicate the problem from the mental side. A favorite comment of journalists on this topic is to the effect that medicine is now saving the unfit, that we are tampering with nature's law of the survival of the fittest and thus increasing the numbers of the unfit who endanger the welfare of the more favored individuals; that all that has been accomplished has been to protect the weak and inadequate without benefit to anyone. I need not examine this argument more closely at this time or point out all the fallacies involved. The struggle for existence and the survival of the fittest may be shown to be still active even in our social organization of today. It is true that since the progress of science is uneven, inequalities may arise and that at a given moment in one or another direction the difficulties may be increased rather than lessened. Nevertheless, it must be perfectly obvious to any fair-minded observer that the sum-total of gain is far in excess of any circumscribed losses. Whatever inequalities of this nature may now exist will undoubtedly be wiped out by the further progress of knowledge and by our increased control over ourselves and our environment, to which we can confidently look forward.

The question that I wish to deal with today is not whether mental science is worth while, but rather are we applying effectively all the knowledge now available; are we dealing with such problems as those just suggested as well as we now are able. Psychiatry deals with mental disorders. From the Public Health aspect, however, it deals less with the mental disorders themselves than with a subsidiary phenomenon, namely, human behavior. Thus a person is not considered insane because his mind is deranged, but because of what he does as a result of such derangement. Every psychiatrist has observed repeated instances of individuals with gross mental disorders who have not been declared insane, who have not presented any major problem to the community or themselves mainly because their behavior was not disordered to the degree which the law specifies is to be considered as a menace to themselves or to the community. To say that medicine and especially psychiatry now have interests, therefore, in behavior is to indicate that medicine has social relations and an interest in the social organization much more far reaching even than the social implications of communicable diseases, which are so well recognized at present. The medical attack, however, is made easier by being confined to a limited part of the problem and is not officially concerned with social problems in general. The medical interests must be based on the problem of pathology, and it is this point which I particularly would like to stress.

There is one other general consideration which I think it is important to note, namely, that the logic of medicine cannot be transferred from the clinical field of physical diseases to that of mental disorders without some modification. The generalization which covers this is perhaps best stated thus: there is no specific relationship between the nature and degree of the organic involvement in the nervous system and the behavior manifestations to which it gives rise.

It is this latter consideration probably to which we must ascribe the aloofness of the general medical practitioner in his attitude towards mental problems. The physician, perhaps merely as a human being, prefers problems in which the sequence of cause and effect can be clearly determined. Where the cause is often so elusive or so apparently insignificant as contrasted with the effect, as it is in mental disorders, both layman and physician refuse to commit themselves.

There is one specific subject in which after a very hopeful beginning a great deal of distrust has resulted. I refer to the subject of feeble-mindedness. When Binet devised his system of tests, which have since become famous, great enthusiasm was manifested because it seemed as though at last we had an accurate quantitative method for determining this important phase of mental disability. An enormous amount of observational material has been accumulated both here and abroad in connection with mental tests in our schools, in the Army during the war, and in industry. The results seemed surprising to many, and talented writers whose imaginations were fired by some of the apparent implications have run wild in their generalizations. Evidence of the danger of too hasty generalizations in this field is furnished by the numbers of books that have come, often from the pens of distinguished writers, in regard to Race questions. Present discussions in regard to immigration often lead to bitter differences of opinion in regard to the possibility of erecting hard and fast rules based on mental tests.

The situation may be simplified in the following way: Intelligence is probably not measured directly by these tests at all, but in the ordinary individual the results of these tests may be regarded as a fair sample of the mental ability of the subject including his intelligence. For statistical use, therefore, the method is probably reasonably sound. We are dealing with the approximate measurement of a quality which is universally possessed by all human beings. It comes under the category therefore of *more or less.* It is comparable to the quality of tallness or shortness, the quality of pigmentation, and to other similar qualities. If determinations are made on sufficiently large groups the results will be observed to follow one or another curve of distribution. There is no evidence adduced so far to indicate that a particular rating on such an intelligence scale will indicate the presence or absence of pathological factors. In spite of repeated attempts to do so, all who have tried to indicate at what point on the intelligence distribution curve for the United States Army the pathological threshhold may be placed have failed. On the contrary during the war it became apparent that a very low rating by intelligence measurement did not indicate *feeblemindedness,* even though the rating was well within that regarded as characteristic of the mentally deficient. Large numbers of men thus rated were found to be extremely useful in various types of labor and employment, and in fact were more satisfactory than those who rated higher. Most of the actual labor involved in the embarkation and debarkation of men and materials, the building of the strategic railway in France, the building of cantonments, the construction of trenches and similar hard labor was performed by men whose rating placed them in the group of the unfit.

If it is true that ten per cent of our general population falls in this classification it is a matter for serious consideration, if we are to consider them because of that mentally deficient and a menace to themselves and the community. There is, however, evidence which will indicate that there are not grounds for alarm. If we regard this matter of intelligence distribution as a matter of *more or less* a generally possessed faculty we must look for something else in order to make the diagnosis of pathology. This latter quality is not subject to the category of *more or less,* but is a matter of *all or nothing.* Like disease or deformity in the physical sphere an individual either is or is not pathological. If he is pathological then it may be a matter of *more or less.* This point of view would therefore vitiate the common belief which is often facetiously expressed in the statement that all men are more or less insane. They may be more or less intelligent, more or less mentally strong, more or less alert, more or less well integrated, but in order to determine whether they are more or less disordered it is necessary to ascertain first whether they are disordered at all or not. Applied to this mental problem, therefore, a person may be highly intelligent or he may be stupid, and it is probable that this is an inherent quality and that there is a maximum beyond which he cannot develop. This maximum is predetermined in his individual make up.

But mere stupidity, however severe in itself, is not a sign of pathology. It will be seen, therefore, that the reliance on the mental tests alone will not determine this point. Positive evidence of some special disability, inherited or acquired, must be obtained in order to identify an individual as feebleminded. This emphasis that I have placed on the importance of the pathological factors must indicate that medicine has a distinct function in regard to this very large and important problem, a function which it has not exercised sufficiently up to date.

The applications of psychiatry as a part of Public Health to the behavior problems of the community are not, however, confined to the group of the feebleminded. Keeping in mind the essential importance of the pathological, it is clear that medicine has developed to the point where it is able to render a service in connection with behavior problems which are even less obviously matters of mental disorder than is feeble-mindedness. In the first place, there has been an extension of psychiatry during the last few years to include a consideration of not only the gross behavior disorders such as criminality and delinquency, but less obvious difficulties affecting the happiness and success of individuals and families. As I have said before, medical science has made it possible to live in large, congested centers of population. We have conquered the physical obstacles and we are now coping with the mental difficulties. There are a great many manifestations of individual weaknesses, of nervous disorders in themselves unimportant, perhaps, but decisive in their effect upon the economic and social life of the individual. Our experience during the war with shell shocked cases, in which the American Army justly deserves great credit, shows what correctional therapy can do in dealing with behavior problems. Shell shock, or more properly, war neurosis, belongs to the group of psycho-neurosis, hysteria, and neurasthenia. Though more spectaclar than the ordinary manifestation of these disorders in civil life it does not differ in quality from the latter. The same procedure which worked so well with the military cases secures favorable results with the others. It is interesting to note, however, that the world has been dealing with these manifestations since time immemorial without recognizing that they represented a medical problem. Disciplinary measures of the crudest kind have always been resorted to in the attempt to correct such behavior. In war time summary court martial, execution, disgrace and imprisonment were always relied upon to achieve results. These same methods in perhaps less summary form are constantly being applied in the field of delinquency and criminality. There is a tremendous work to be done by the medical profession in this field, and it is to be hoped that the public health officials will presently recognize their share in the responsibility.

While a great deal can be accomplished in dealing with the offender a great deal more can be done in the prevention of delinquency. This requires in the first place adequate recognition of the problem as a problem in pathology, and adequate provisions for administering such methods of treatment as our present knowledge supplies.

There is probably no department of our social organization in which more can be done than in the department of education. In education up to now the main emphasis has been placed upon intelligence and the acquisition of knowledge as manifested by the progress of the child through the grades and farther. A closer study of the mental problems presented by any of the ordinary grade schools, or by the high schools, as well as by the universities, such as has been carried out by the Institute for Juvenile Research in this State, especially in connection with the High School at LaSalle, by the Bureau of Children's Guidance in New York, by the National Committee for Mental Hygiene, and other agencies, has shown that many a child or adolescent is acquiring habits which are bound to prove dangerous or at best serious handicaps, on the basis of individual peculiarities or traits which in themselves need not cause such difficulties. A perfect understanding by analysis and examination before the major damage is done, before fixed habits are formed, and before the accumulation of results of behavior present insurmountable obstacles, will often save these children for effective and happy careers.

Finally there is a field in which the application of mental hygiene is beginning to make itself felt both on the treatment as well as on the preventive side. This is the field of industrial relations. Very promising work is being done here in connection with industrial difficulties, by contributions to the management of personality peculiarities and difficulties which have important bearings not only on vocational training but on industrial assignment. Labor very frequently looks askance at any method which suggests that an attempt is being made to cajole the worker into acceptance of unsatisfactory industrial conditions. A great many attempts to ameliorate the condition of the worker through so-called welfare departments have met resistance on the part of union and non-union labor. None of these objections applies to the medical program, which is free from any implications of the sort just mentioned, which are applicable equally to the employer and the employe, and which, as all medical procedures should, has as its main objective the rendering of a service to the individual. It is therefore partisan only in the sense of being for the patient and is not concerned with any partisan struggle.

Time does not allow me to discuss in detail any of these propositions, nor to take up the consideration of many other important subjects directly connected with this topic. It is a waste of time to emphasize the importance or the urgency of the problems presented by behavior disorders. What we are concerned with is the possibility now offered to medical science through psychiatry to render a service in the treatment and the prevention of these behavior disorders with all their associated consequences of social waste, of economic loss, unhappiness and danger both to the individual and to the community. Dr. Frankwood E. Williams, Director of the National Committee for Mental Hygiene, says: "This year in this country there are 250,000 boys and girls of high school and college age, all of whom in five years will be confined in hospitals for the insane." A conservative statement would allow at least an equal number who will in five years come into serious conflict with the law. To this must be added a large number who are hopefully looking to life, who will meet with bitter disappointment and who will meet with unhappiness and unsuccess. A very large portion of these individuals can either be saved from their impending fate or at least benefited by prompt and suitable relief measures. Can there be any valid excuse for inaction in the face of such need?

THE YEAR'S PROGRESS IN PUBLIC HEALTH AND MEDICINE

W. A. Evans, M. D., Health Editor, Chicago Tribune

When you listen to a report on the progress of public health and medicine given before a meeting of this character and made by myself, you expect to hear more about progress in preventive medicine than you do about the second subject. My excuse for slighting medicine in favor of preventive medicine is that I am more interested in public health.

SCARLET FEVER

Two fundamental, scientific facts have been known for some time. The first was that some one or more of the streptococci were concerned in the symptomatology of scarlet fever. As to the causative relations of the streptococcus there were two schools. One held that this strepococcus was the cause of the disease. The other held that streptococci were so nearly obiquitous and caused so many diseases that they could not be the specific cause of scarlet fever. This school held that the specific cause was some unknown organism, but that the streptococci contributed materially to the symptoms. The theory upheld by Bristol that the rash of scarlet fever was an anaphylactic phenomenon for which streptococci was the bacterial cause, lent more support to this side of the question than it did to others.

Dr. Dochez, by the use of certain culture methods, demonstrated the one variety of streptococcus which he claimed could produce the disease, and in that way seemed to establish the primacy of the streptococcus as the etiologic agent and, at the same time, to answer the point made by Jochmann that an organism which was so widespread and caused so many diseases could not be the specific cause of scarlet fever.

Doctors George F. and Gladys H. Dick proved that a certain strain of streptococcus grown from the throats of persons having scarlet fever, when injected into susceptible human beings, produced a disease with the symptoms of scarlet fever. They extracted a toxin from this streptococcus which they used to make skin tests for susceptibility to scarlet fever. The Dick test for scarlet fever appears to take its place alongside the Schick test for susceptibility to diphtheria.

The specificity of this streptococcus for scarlet fever seems established. The use of serum from recent convalescents as a cure for and preventive of scarlet fever was of academic, rather than practical interest. Dr. Dochez used horses to make an antitoxin. His method consisted in injecting agar culture media under the skin of the horse and then innoculating the agar pad in the subcutaneous tissue with the streptococcus. He got a horse serum containing antitoxin in curative doses on a practical basis. Drs. Dick injected horses with toxin from their coccus. They got a horse serum containing antitoxin in weak strengths. They concentrated the serum, getting a serum which seemed curative in 10 c. c. doses. Dr. Blake reported blanching of the eruption and therapeutic cure of the other symptoms of scarlet fever. At the present moment the therapeutic power of the Dick antitoxin is being tried.

With a method of bacteriologic diagnosis established, the Dick test proven and a curative serum and preventive about ready for wide clinical use, it may fairly be said that the fundamental problems presented by scarlet fever have been solved.

MEASLES

Proof accumulates that the measles organism is present in the blood stream in the earlier stages of the disease. The blood serum of persons recently convalescent from the disease produces a relatively short lived, passive immunity when injected subcutaneously. So many confirmations of this observation have been reported that we may say the fact has been established.

The New York City health department has endeavored to collect and keep on hand a stock of this immunizing serum for use in situations to which it is adapted. Recognizing the difficulty in obtaining blood serum from human donors recently convalescent from measles, they have been paying the donors for a serum.

Recognizing the weakness of the passive immunity produced by the injection of serum from convalescents and its short duration, certain French physicians follow the injection of the serum from convalescents two days later with an injection of a filtrate containing the active cause of measles. In this way they claim to produce an active as well as a passive immunity without any considerable illness. The induced immunity, it is claimed, is more potent and endures longer. The observations have not been verified.

The artificial production of immunity against measles has not made much headway in general health department practice, nor will it until some large donor animal replaces human beings as the source of supply of vaccine.

PNEUMONIA

The year 1923-24 witnessed a very great increase in interest in the control of pneumonia. This interest is shown by elaborate and extensive investigations of the disease by the Pittsburg and the Chicago Health departments. As yet, neither has reported. The Chicago Health department will gather data until September 30, and they will begin reporting before Christmas. But the very fact that the communities are manifesting their interest by studies is an advance.

VENEREAL DISEASES

The State of Illinois and the city of Chicago have taken some advance steps in the control of venereal disease during the year. From the administrative standpoint, the adoption of:

(1) Rules and regulations for the control of venereal disease;

(2) Standards of infectivity;

(3) Standard Laboratory Methods;

(4) Standard Clinic methods;

represents a gain. These rules and methods are in operation.

There is frequent complaint of lack of definiteness and detail in health ordinances, orders and rules. The courts have not infrequently criticised such laws on this ground.

The control of venereal diseases in civilian communities in peace times is under the necessity, for the first time, of establishing a firm place in the law as determined by court decisions. Thanks to the definiteness of procedure and conformity to legal requirements of these rules and regulations and standard methods, the Illinois and Chicago Health departments are helping to put the control of these diseases on firm, legal ground.

The method of curing obstinate, chronic, gonococcal infections by the use of diathermy has gained some ground.

SYPHILIS OF THE NERVOUS SYSTEM

The low penetrability of the central nervous system of the newer arsenicals used in the treatment of syphilis has been noted for some time. There are those who hold that the modern, intensive treatment of syphilis results in a higher rate of nerve syphilis than prevailed prior to its use. There is no data on which this question can be settled either pro or con.

Those who claim that there is an increase in nerve syphilis explain the increase on the theory that the membranes and other defensive agencies of the central nervous system react poorly in protecting the nervous tissue against treponema; that early comprehensive treatment prevents these tissues from acquiring power to protect against treponema; therefore, when once this organism gets into the nervous tissues, it is not easily destroyed.

Dr. W. H. Brown and others at the Rockefeller Institute offer tryparsemid as an anti-syphilitic agent with greater power to penetrate the central nervous system. Various reports on the efficacy of this agent have been made. Dr. C. F. Read made the latest of these to you today. The United States Public Health Service published several reports on the penetrability of the central nervous system by various arsenic preparations. Among those with high penetrability, in addition to tryparsemid, is sulpharsphenamine.

INSULIN

The discovery of insulin antedates 1923-24. Insulin is a pancreatic product which represents that part of the secretion which has to do with metabolism. It is pancreatic secretion from which the digestive agents have been removed. I need scarcely say to this very intelligent audience that it is, in a certain sense, a cure for diabetes.

During the past year, progress in insulin experimentation and therapy has gone forward in two directions. First, there has been a considerably promotional effect—philanthropic, professional and commercial—to bring insulin into more general use. Second, much experience—clinical and experimental—tending to show the place of insulin in therapeutics, has been accumulated.

This experience shows that insulin is a remedy for emergencies. Given to a patient in coma, or suffering from acidosis, or in straits from diabetes, it acts like magic. For patients making the long pull—the day in and day out battle to hold diabetes in check and succeeding fairly satisfactorily—it is not indicated.

It appears that it may find a place in the treatment of other metabolic disorders, some of which have not been suspected of having any relation to disease in the pancreas, or to the functioning of that organ.

It is noted that the diabetes morbidity and mortality rates are both apparently on the increase, and the increase has been at its maximum since the use of insulin became somewhat general. The diabetes death rate in 1920 was 16.1; in 1921 it was 16.8. To the experienced person this merely means that the publicity given diabetes and its treatment by insulin has uncovered cases and deaths due to diabetes which would have been overlooked otherwise. The same phenomenon was noticed with consumption, diphtheria, malaria, syphilis and other diseases.

GOITRE

The term is used to denote increase in size or in functional activity of the thyroid gland. Prior to 1923, the prevalence of goitre in the United States, the variation in that prevalence in different sections of the country, and the parallel variation in the amount of iodine in the water of different sections of the country, has been established. 1923-1924 has been characterized by an extension of information and of the application of known facts to treatment and prevention.

That deficiency of iodine in the human body is the principal cause of goitre may be considered to be established. That the supply in the iodine reservoir is frequently deficient because the amount supplied thereto by the drinking water and other foods is insufficient, is accepted.

The reservoir supply may be exhausted by reason of rapid growth in childhood and particularly during pubescence and adolescence, by reason of the demands of the system during pregnancy and during certain infections such as tonsillitis and pharyngitis and by reason of several emotional shocks and strains.

The active principle of the thyroid secretion, a body having great powers over all physiological processes requiring iodine thyroxin, was discovered by an American, Kendall, several years ago. It is interesting that insulin from the pancreas, thyroxin from the thyroid, and epinephrin from the adrenal are all American discoveries.

The year 1923-24 witnessed a great extension of popular interest in goitre. A fair number of American cities report goitre surveys of children in the public schools. In a fair number of places, iodine in some form is given children in schools. This is sometimes given as iodide of soda, sometimes as iodine in the table salt. In Rochester, New York, and Sault St. Marie, Michigan, iodine is being added to the public water supply. In Switzerland, where supplying iodine is more of a government function than it has been in this country, giving iodine in salt has been in vogue.

Plummer has endeavored during the year to differentiate various types of goitre and the effect of giving iodine on each. There has been the beginning of an effort to distinguish between the different types of thyroid abnormality and to determine which will get well spontaneously; which tend to progress toward more serious consequences which are benefited by iodine and which are, or may be, harmed by it.

The tendency is definitely away from classifying all cases of thyroid enlargement as goitre in need of iodine and all cases without such enlargement as being without that need.

CANCER

Statistics show that the death rate from cancer is increasing. This increase is greater than the increase in population forty years and over. Part of this apparent increase is due to greater dependability of the diagnosis as given on the death certificate, and a part of that improvement is due to public education on the cancer question. It has happened with cancer, as with other diseases, that interesting the public in the disease has shown a primary apparent increase in its prevalence. In spite of this apparent loss of ground in cancer, the year 1923-24 witnessed some gains in the fight against the disease.

Operations for cancer have gained ground in that they have been done earlier and, therefore, offer a greater liklihood of permanent cure. The people and the general practitioners are diagnosing cancer in its earlier stages and some of the cases come for operation while just developing. The need of making the diagnosis before pain appears as a symptom is coming to be fairly well known. The use of radiation by radium or X-rays, or both, before and after surgical procedures, has become more general.

The evidence is increasing that cancer of many internal organs, as well as of most surface structures, can be removed with a good possibility that at the end of a five year period there will have been no recurrence.

But the valuable work of the year in cancer consists in foundation work done in research laboratories and in the field of vital statistics. These relate to such subjects as the inheritability of cancer; the inheritance laws of cancer; the tendency of cancer to appear at certain age levels; the tendency of inherited cancers to appear in certain organs; the chemistry of cancer cells; the biology of cancer cells; the effect of different kinds of radiation on the biology and chemistry of cancer cells.

Valuable research work has been done on the chemical and physical irritants which lay the foundations for cancer or which directly cause the disease.

In a very recent paper, Hoffman says: "It may properly be said, however, without fear of successful contradiction, that concerning no other disease is a larger body of facts and observations available for qualified consideration.

"It is my deliberate judgment, arrived at after mature reflection, that it is a fundamental error to seek or to hope to find a single cause responsible for the frequent and increasing occurrence of malignant growths in the human body. It seems likewise an error to look upon cancer as an entity, for the disease, both in its origin and development, varies quite considerably as it affects the different tissues."

Dr. Hoffman then discusses the many contributing causes which may be related to cancer, placing especial emphasis on overeating, too frequent eating, constipation, the refinements of civilization, changes in food, and various irritations and local poisonings.

CARBON MONOXIDE POISONING

The importance of carbon monoxide poisoning has been stressed during the year by Dr. E. R. Hayhurst of Ohio. A very considerable number of fatalities due to carbon monoxide from domestic use of gas stoves, ordinary stoves, and from automobiles, caused the introduction of proposed laws regulating stoves and stove connections to be introduced in the Ohio legislature. These proposed laws did not pass, but they were the forerunners of legislation which will pass either in that legislative body or in others.

Dr. Yandall Henderson and others investigating as a basis for advising as to the ventilation required for the New York vehicular tunnel under North River reported informingly on the proportion of carbon monoxide in the air in the wake of automobiles. He also contributed valuable information on the advantage of adding a small proportion of carbonic dioxide to the oxygen used to resuscitate persons overcome by carbon monoxide.

The United States Bureau of Mines published methods for the quantitative determination of carbon monoxide in blood as well as in air.

ETHYLCHLORIDE

Anaesthesia by means of ethylchloride has had additional trial during the year. The use of calcium and parathyroid preparations in various spasmodic disorders has made some headway.

The year has witnessed progress in the study of sunlight and other forms of light and their application in the treatment of rickets and other diseases.

THE AMERICAN HIGH SCHOOL VERSUS THE ENGLISH PUBLIC SCHOOL

F. H. Crawford, Northwestern University

It was Addison, I believe, who made the remark that it is very melancholy to consider what a little negligence could spoil us, but what a deal of industry and toil is necessary to improve us. That the industry and toil demanded is great, surely none in this gathering is prepared to dispute. But on the nature of the industry and the kind of the toil necessary there will be as many different ideas as there are individuals here present. Indeed, since education first differentiated itself as a special human problem requiring special treatment and special thought, its concrete form has ever been one of controversy.

There has been controversy as to methods of instruction, the proper age for beginning it, the length of continuance, and above all, perhaps, as to the specific nature and proportion of the various subjects to be studied. These individual points of variance are, however, evidences of the real difficulty which lies in differing conceptions of what the education process shall accomplish. The rigidly state controlled education of ancient Sparta had in view the strength and glory of the Spartan State. The monastic schools of the middle ages had a no less definite aim and for them education was a tool by which the work of the Mother Church might be forwarded. Each perhaps owed its success in a measure to the recognition of the ends which it was to serve.

And so today we must define as accurately as possible the ends which we are seeking, else we shall wander far afield e'er we know it. Since I shall confine my remarks largely to secondary education, we may lay aside at once the claims of the specialist. His requirements are so exacting and extensive that they must be left for the universities to satisfy. What then should be required of a system of education in England and America today? These two countries have, I believe, fundamentally much the same educational need, namely, the need by a representative government of an interested, informed and thinking body-politic. This, of course, does not say that each country has arrived at the same stage in the solution of this problem, nor that they will each necessarily arrive at the same or even a similar one. Yet, the general criteria for judging a system for either country will be much the same. Now, an informed, interested, and thinking body-politic would imply some process of education involving first, the imparting of certain quantities of facts, second, the awakening of intellectual curiosity, and third, some attempt to develop independent thinking. If these three elements can be mixed in due proportion, the result should be a type of education suited to the purpose in hand.

But just what constitutes a "due proportion" seems to be the snag. One class lays the greatest emphasis on the first requirement and maintains that any system of education is hopelessly incomplete and narrow which has not given the student a little Latin and mathematics, some acquaintance with English Literature, some German or French, a little ancient and modern history, political government, some manual training or needlecraft, a modicum of chemistry and physics, a bit of bird study, etc., etc., or in fact, which seems to slight any field of human knowledge. They unconsciously proceed on the theory that since no one knows exactly what he is going to do in later life, he should be given such a breadth of useful information that there is bound to be some of it which he can use later on. Needless to say, their program is so ambitious that they do not have much time for the other two requirements. They represent what we might term the adherents of the "fact-education" idea.

Another school, while recognizing the necessity of mastering a certain number of facts, argues that education is not altogether a process of accumulating predigested ideas on a world of isolated facts, but is rather a disciplining of the will and a training of the mind in correct mental processes; that it is a fitting of the recipient of this training to use his mind in solving the difficulties which life presents; that, further, it is an awakening of a craving for knowledge and an imparting of the means for self-satisfaction of this craving. They proceed on the theory that the nature of the facts which one is to need in later life, whether he go on to a university or not, is of so problematical a nature that the best we can do is to insist on the mastery of a few fundamentals, such as English and mathematics. The rest of the time should then be spent, not jumping frantically from one thing to another, but in studying intensively subjects designed to give the maximum of mental training and discipline and at the same time a cultural outlook on life. They hold to what we might consider as the "mind-training" conception of education.

Let us now examine the American and English systems of secondary education, the former being, as I conceive it, an outgrowth of the first viewpoint, and the latter of the second. The mechanical details of the American High School are too familiar to detain us long. The work of the average four years falls into 16 more or less disconnected "subjects", each studied as a separate and unrelated field. As a rule, except for the requirement of three years of English and probably two of some foreign language, (and even this varies somewhat from place to place) the pupil is left to choose pretty much as he likes, so the specified number of subjects are taken and he arrives at the end of the four years with the required minimum of credits. Now from the point of view of the "broad-education" advocates, this system is ideal. By due choice the whole realm of knowledge can be visited in the short span of four years and there is no danger of turning out narrow specialists, for the pupil has never spent an appreciable length of time on any one subject.

It has nevertheless its disadvantages. The individual fields being taught from set text books in set courses come to be regarded as residing in water tight compartments, and the student is never taught and seldom has time to study out for himself the relationships which connect the various fields and join them one with another. As a result, he takes the facts as they are given, memorizes them blindly, or at any rate such ones as he finds necessary and lets it go at that. The idea of reading outside of a text book, in other than novels, has never occurred to him. Furthermore, it has seldom, if ever, been pointed out that such reading is one of the most lasting sources of enjoyment and self-improvement. In fact, the whole atmosphere of the modern high school seems to be that of fitting out the pupils with a cargo of miscellaneous information with should last him until he has reached the allotted three score and ten. Our educators tacitly ignore the necessity or even possibility of continued reading and study once the pupil has left school, and make no apparent effort to train him towards this end. The result, of course, is natural enough. If he is not to read or study by himself when he has finished school, it is obviously desirable to load him up with as much information as the time will allow.

The result of this, also, is only too obvious. Since the world of knowledge has reached the bounds which it knows today, it has become humanly impossible for even a man of unusual attainments to acquaint himself more or less casually with the more important portions of it, even in the course of an entire life time. Yet, what this man of talent finds difficult in fifty odd years, we cheerfully attempt in the case of immature youths in the space of four years. Just at the time when the pupil should be gaining a thorough mastery of his mother tongue, should be receiving that strict mental discipline from which man can benefit only in youth, and should be acquiring those mental traits which will guide his reading and study in later life, just during these four precious years his time is being squandered in a hasty, shallow, sciolistic survey of knowledge. In an attempt to do the impossible we allow habits of carelessness, superficiality and inaccuracy to develop which constant effort in later life is often unable to eradicate.

The average pupil has never learned the elements of how to study. He leaves the high school a poor speller and unable to write a page of English without committing the grossest grammatical errors. In this anyone will concur who has had any experience with freshmen students entering the universities and colleges. Since usually more time is devoted to English than to any one other study, his attainments in other fields must be tragically meagre. And, presumably, the greater share, at least, of those who go on for further education are among the better products of the high school. What level the rest have attained must from inference be very low indeed.

Of course, we must recognize that a unique feature of the American High School is its comparative freedom to all, regardless of financial condition. In some ways this very freedom has defeated its own ends, being responsible in some measure for the deplorable results we have just mentioned. It has brought such an overwhelming increase in numbers and consequent lowering of the general level of ability that standards have been forced to descend. The large classes and the need of keeping each class together have necessitated holding the brightest and most eager back to the level of the slowest and dullest. Our whole system seems designed for the lazy or inept pupil. How much budding genius we are stifling yearly I shall not even venture to guess. It is too solemn a thought. But, since genius or even conspicuous talent is so rare, and its contributions to the welfare of the human race so precious, it is permissible to question whether a poorly trained class of mediocre ability, obtained at its sacrifice, is worth the price we must pay. If we believe with that learned old Frenchman and staunch friend of Thomas Jefferson's, Pierre Samuel du Pont, that "a single day in the life of an educated man of genius is worth more to the world than the labor of a hundred thousand average men for a year", we shall agree that the price has indeed been very high.

Let us now turn to the English Public School, the details of which are somewhat less familiar on this side of the water. It might be well to remark at the outset that the schools, commonly known as "public", included, up until some thirty years ago, nothing but distinctly private institutions. They were consequently residential schools to which the scholars were sent, at a tender age, to remain during the greater part of their youth away from home. This feature I have always regarded as one of the most objectionable arrangements of the older system. During the last thirty years, however, state-aided and municipal schools have grown to a remarkable extent. These latter schools are free for non-resident pupils and have a number of free places awarded on the basis of scolarship and promise for resident pupils. They are not coeducational, the boys and girls attending school in separate buildings. The increasing number of pupils residing at home and studying at school during the day is an encouraging development of the last two decades in both types of schools. The so-called free or semi-free (i. e. schools receiving some state aid) schools have grown to such an extent that today in point of numbers they far outrank the older Public Schools, of which Eton, Rugby, Harrow and Shrewsbury, to mention only four, might be cited as typical. But, despite their relative fewness in numbers, these older Public Schools have, on account of their age, large endowments, and strong traditions exerted a preponderating influence on the development of the newer ones. This influence has been felt not so much perhaps in the exact nature of the curricula, as in the general methods adopted and standards set up. For this reason we shall confine our attention to these former as typifying the standards generally striven towards, even in the smaller and less well equipped institutions.

The study following the primary school covers six years, or "forms", the first of which is entered usually at the age of twelve or thirteen years. This six years the boy devotes to the study of Latin and Greek, the English language and literature, mathematics, one modern language, usually French, history, and, if he so elect, some natural science. Aside from the presence of Latin and Greek, the method of instruction differs most radically from ours in that the pupil studies so few things at a time. Thus, during the first three or four years he may spend practically his entire time on Greek, Latin, English, and mathematics. Then come French and history and more Latin and Greek or mathematics. If he so elect, he may devote less time during the latter part of his course to the classics and take up some one natural science, as physics, or chemistry, or botany. The point is that the pupil studies but a few things at a time, usually two or three, and continues his study of them over a period of years in such a way that he really begins to get into the subject and thoroughly masters at least the fundamentals of it. As the pupils advance, the instruction of the brighter and more apt ones becomes less formal and they are taught to rely upon themselves and in a limited sense to direct their own efforts. Particularly able students may be allowed to spend the last year on two or even one favorite study, and through it all there is a constant insistence on mastery of anything attempted and a desire for thoroughness which cannot be compared with anything with which we are familiar.

Now the product of this system will appear on first sight to be rather narrow in his training to the average American. Let us look at him more closely. He has acquired a good knowledge of the Greek and Latin languages and at the same time a knowledge of these peoples, their philosophy and their history; he, even on the average, has had more mathematics and has it more thoroughly than the average sophomore in our colleges or universities; he can read French with some comfort; he has a good knowledge of the history and literature of the English people, and further, he speaks precise, correct English and writes in a clear, often bright and forceful style. If he has elected some natural science in place of the classics during his last two or three years, he has had usually the equivalent of two years of science of college grade. What is perhaps most valuable of all, he has cultivated the habit of reading and has learned how to study and how to think.

If I have analyzed the situation correctly, the application of the "fact-education" idea has reached an extreme with us from which we must soon return or our secondary education will become little short of a farce. I quite agree that a "broad foundation" is a desirable acquisition, but so far have we pushed the idea that the result has ceased to be a foundation at all. It has become so thin that it disintegrates (if it ever were integral) into a mass of detached units, a hopeless hodgepodge of half remembered and undigested facts. Even in the best schools when such an array of material has to be absorbed in so short a time, much thought or digestion of ideas is precluded.

The process usually descends into one of blind memory work on the part of the better pupils, and of slipshod half-learning on the part of the rest.

Of course, a good memory is an asset in any field of activity and quite indispensable in many. And if the system did nothing but train an accurate and tenacious memory, it would have certain recommendations. Most of us will admit that it does not do this; everything is skimmed over too rapidly and too many things are skimmed for the mind to get a fact hold. But supposing it did do this efficiently, could this be accepted as the rational aim of the educational process? After all, the memory is only the raw material warehouse of the mental factory, and if we spend so much of our time piling material into the warehouse that we cannot even sort it and label it, much less polish and align the mental machinery which is to employ it, how can we expect any results? To use another analogy, it is like providing a vehicle with a tank filled with a mixture of oil, water, and gasoline, and an engine in the form of the rough castings from the foundry. The oil, water and gasoline must be separated and put into separate compartments; the various parts of the engine must be milled, fitted and assembled. Then, and then only, this vehicle is ready to proceed somewhere other than down hill.

Just what our system fails to accomplish the development of the "mind-training" system of education realizes, at least in the main. The dogged insistence on thoroughness which is so characteristic a part of it, and the length of time devoted to each study insure the retention of a large number of connected facts and allow their being organized and more or less digested in the student's mind. The large attention paid to mathematics, and in this to original problem solving lacks its complete counterpart with us, as does also the general types of work usually designated by us as mental gymnastics. We are inclined to become rather impatient when anyone mentions the translating of difficult meters into Greek hexameters or the composing of original poems in Latin. We fail to see what an accurate training is necessary before they can be attempted and hence what a stage of development their creditable execution reveals. The ability to do this must not be regarded, as has been remarked, as a mere virtuosity but as the symbol of an active and well trained mind. They ask, and justly, if the mind is not to be trained beforehand to reason and think how it can be expected to do so at all efficiently once it finds itself confronted by the actual problems and perplexities of life. Then the problems are real and success or failure may be the price of incorrect or faulty solutions.

On the other hand, the artificial difficulties set up for solution in school can bring no loss by occasional failure. They, moreover, give the pupil that healthy exercise in doing hard things, in untwisting knotty problems, and overcoming real difficulties which is of such incalculable value. We have the tendency to make everything too easy, perhaps a bit too sugar-coated, with the result that individuals trained under our system seldom gain, even in after life, the intellectual independence and self-reliance, the seeds of which should have been planted in school days.

Just after the war I saw a letter written by a prominent officer in the English navy on receiving news of the death of his old Greek master back at school. He was commenting on the various things which he had studied while in school and of their relative value in his after life. It seems that he had been put in charge of one of a fleet of nine destroyers and commissioned with the location and destruction of German mines in the British Channel and the North Sea. It was soon discovered that, in order to facilitate the laying of the mines and the marking of their positions, the Germans had taken to laying them in more or less well defined patterns, some rather simple and the rest very complicated. When a newly laid mine field was discovered, either by accident or as the result of search, a dredging process was resorted to until half a dozen mines had been located accurately. The problem of the commander was to take the positions of those which had been located, decide on what pattern the field had been laid and predict where the other mines were to be expected. In case correct conclusions were arrived at, a mine field of several dozen mines might easily be destroyed completely in a few days, whereas, by mere cut and try methods, as many weeks might be required and in the meantime a transport ship and several of their own cruisers might be lost. In this letter, the officer went on to say that one particular year's work had meant more to him in this work than all of the rest of his study; and this was a course in deciphering ancient Greek inscriptions which he had taken with this same Greek master.

Now, on first sight, ancient Greek inscriptions and mine fields appear to lie at the very antipodes of unrelatedness. But it seems that this old teacher of Greek was accustomed to take the more advanced boys, who had their Greek pretty well in hand, and set them to deciphering inscriptions in which endings, odd words, and even lines were deleted. The pupils then were required with their knowledge of Greek life and manners as a background, and their knowledge of the language as a tool to decipher the puzzle. They must then give good reasons for every insertion which had been made. The result was that, far from being a mere puzzle contest, where a premium was put upon lucky guess work, the course developed habits of independent thought and logical reasoning. ''This course'', the officer said, ''was of more value than all the rest put together because it really made us think, and beside it the years spent on Latin, history, etc. were quite wasted.'' He perhaps, however, did not stop to realize that it was the mental discipline acquired in mastering these other subjects which made this particular course of value and that without the habits of thoroughness and accuracy derived from them it could not have succeeded in the first place.

I have not given this illustration as an argument for the immediate introduction of courses in deciphering Greek inscriptions into our schools, but rather to illustrate the fact that in nine cases out of ten it is not the specific things which are studied, aside from the fundamentals, so much as it is the ability to reason and think through difficulties which is of most value in after life.

Now I do not wish to be thought of as holding a brief for the English Public School. It has its faults as has our own. It has a certain tendency to get out of touch with the world and, in the case of the older public schools, tends to foster a class consciousness which we are striving to avoid. In its best form the system is also rather expensive, and hitherto the policy of the local governments has been to enlarge and give financial assistance to private institutions already in existence and to build and equip new ones of their own only when no others were near at hand. In proportion to the aid received from public funds the semi-private schools have lowered their fees so that we have "public schools" ranging from the free Public High School as we know it to the distinctly private schools of the older foundations. I have mentioned the rather unfortunate practice of sending children away from home at a comparatively early age, a practice necessitated at first by the fewness of the available schools and continued now largely because it has become the respectable thing to do. Its gradual decrease is a noteworthy feature of post-war England.

The American system has been conceived on a larger scale and does reach a correspondingly greater proportion of the population. I wish to point out, however, that in our satisfaction at having created a system of secondary education free to all, we are inclined to be blind to its most glaring imperfections.

Since the English public school receives its pupils a year earlier and keeps them a year longer than our high school, we cannot expect to cover a similar field in as thorough a manner. If we are to make the most effective use of these four years, however, we must, I feel, give serious thought to a somewhat radical rearrangement of our present methods. If we once realize that mental discipline is of more fundamental importance than mere memorizing of facts, and that training of the mind rather than attempted acquiring of possibly useful information should be the primary aim of education, the difficulty is half solved.

In the light of this I should suggest that four years might well be devoted to the following:

1. *Latin or Greek.* The mental discipline of study in a foreign language is unsurpassed, and no foreign lan-

guages can give the insight into the structure and use of our own mother tongue as do these root languages of English.

2. *Rhetoric and English Literature.* Accuracy in languages and fluency in his mother tongue should be the first marks of any educated person.

3. *Mathematics.* The rigorous training in exactness, the wide scope for development of originality in problem solving can perhaps be surpassed by no other study.

4. *Physics or Chemistry.* I have selected the exact sciences rather than Botany or Zoology, not only because they are fundamental to later work in any field of science, but primarily for their greater emphasis on exactness and their consequent higher value as discipline.

Time might also be found for a certain amount of history, though I do not consider it as well adapted to the purpose as those above. Moreover, a pupil who has had the vigorous training of the above schedule could acquire all the history he might reasonably be supposed to desire in the reading which the spare time of his first year out of school could provide.

It is quite possible that such a program could only be put into effect by selecting the upper one-fourth in an entering class and furthermore, the success of the whole undertaking would depend upon the training of the teachers who undertook it.

The day may never dawn when the program which I have outlined will find its exact counterpart in any school in this land, but I am firmly convinced that if our much boasted free education is not to become as valueless as it is free, we must return to the principle of fundamentals first; we must demand mental discipline in place of purblind memorizing, must exalt thoroughness above sciolism.

THE GLACIAL HISTORY OF THE ELGIN REGION

M. M. LEIGHTON, CHIEF ILLINOIS GEOLOGICAL SURVEY

The City of Elgin is situated in one of the most interesting glaciated localities of the country. The surrounding landscape portrays in remarkable fashion the architectural work of the great ice sheet. A great deal of study has been given the glacial history of this portion of the State by various workers, including Professors Chamberlin, Leverett, Trowbridge, MacClintock, Goldthwait and others, but there are still details to be deciphered. Notwithstanding the fact that the full history is not known, it nevertheless may be of interest to recite the facts as we now have them in hand, subject of course to the results of future study.

PRE-GLACIAL HISTORY

Before the glacial period, this general area had a markedly different aspect from its present. Before the incursion of the first ice sheet, this was a territory of limestone hills and valleys, mantled with such soil and residual clays as result from the weathering of the Niagaran dolomite. The present valleys, with their erratic tributary development, were not here, but instead a system of valley development of the leaf-like or dendritic form similar to that of the driftless area of northwestern Illinois, although there was less relief. The present topography has come about from a heavy mantling of this old erosional landscape with glacial drift deposited in a series of recessional moraines with intervening belts of ground moraine. The uplands at the present time have an altitude of 900 to 1000 feet above sea level. From the records which we have of well drilling, the bedrock has an altitude of approximately 650 to 700 feet. In other words, if the old bedrock topography were to be restored, a glacial drift which ranges in thickness from 100 to approximately 300 feet would have to be removed. Clearly, the deposition of the glacial drift in the Elgin area has revolutionized the old topography, giving the country a markedly different aspect from what it had previously.

GENERAL HISTORY OF THE ICE INVASIONS

For more than a score and a half of years it has been known that the glacial period was a complex period of ice invasions, rather than a single epoch; that it included five distinct glacial epochs separated by long periods of warm climate, each interglacial epoch being in most cases much longer than the time since the last glacial epoch.

Records of the earlier ice invasions, however, are not to be seen in the Elgin region. Most of the earlier glacial history has been worked out in other parts of Illinois and in adjoining states, rather than in this area. We feel quite certain, however, that this territory was transgressed by at least three different ice sheets, although the full record is not visible here. Old soils separating glacial tills have been penetrated by various wells in this locality at depths ranging from about 40 to 137 feet. These old soils are striking evidence of one or more of the interglacial epochs when the climate became so mild that the ice sheet was melted away and soil making processes were active.

While it can not be claimed that the Elgin area is a type locality of the older drift sheets, it does have the distinction of showing in a way perhaps unsurpassed by any other locality in this or any other state, the late glacial history.

MORAINAL BUILDING

At the time of the invasion of the Wisconsin ice sheet, the basins of the Great Lakes had outlines somewhat similar to their present ones. The concentric arrangement of the moraines about these basins shows that the basins caused the ice to become organized into fairly distinct lobes with radial motion. In the case of the Lake Michigan lobe, the general direction of ice movement was southward, with radial motion towards the east and west sides. In the Elgin locality, the direction of the ice movement was to the southwest. The greatest extent of this ice sheet was to Peoria and Shelbyville on the southwest. With oscillatory changes in climate from cold to warm, the ice front began its recession, but the oscillatory nature of these climatic changes brought about halts or readvances of the ice front so that at different stages of retreat moraines were built along the margin of the ice during the time that it was temporarily stationary. These moraines, named from the outer to the inner, are now known as the Shelbyville, Cerro Gordo, Champaign, Bloomington, Marseilles, Minooka, Rockdale, Valparaiso, and the Lake Border System.

Elgin lies just beyond the outer limits of the Valparaiso moraine. Driving westward from Elgin along the Grant Highway, one crosses two of the outer morainic belts, one of them about three miles west of Elgin, the other about eight miles west. The hummocky character of these belts, their strong undulations, the promiscuous arrangements of hills and depressions are the product of unequal glacial deposition at the front of the ice during two of its halting stages.

The next stage of recession is recorded by the northwest-southeast trending moraine which crosses the Fox River Valley just south of Algonquin. Further recession of the ice took place, during which a great amount of outwash poured forth in the Crystal Lake and Dundee localities, but the moraines built when this high outwash was laid down were later overridden by the ice which made the Valparaiso moraine, thus adding to the complexity of the morainic topography of the Valparaiso system.

THE LAKES OF NORTHEASTERN ILLINOIS

It is a familiar fact that the great majority of glacial lakes of Illinois are situated in the northeastern part of the State, lying chiefly in Lake County, giving that county its name. This territory is genetically a part of the beautiful lake country of Wisconsin, and its origin involves a consideration of most unusual conditions.

Such picturesque bodies of water as Fox Lake, Grass Lake and Pistakee Lake date back in their history to the formation of the glacial moraines of the Valparaiso system, when apparently the ice movement was vigorous, the rate of melting of the ice was rapid, and large portions of the ice became detached and buried and entered into the composition of the moraine for a brief time. If this is true, the present topography is not the original topography that existed when this particular moraine was built. The moraine then had a greater continuity and greater mass than it now has. When the ice blocks melted, these portions of the moraine lost their identity as elevated parts and became basins which are now the sites of these lakes.

The concentration of lakes in this part of Illinois raises the question as to why this should be. It is also to be noted that the moraines of this part of the State have a much greater content of stratified gravel than the moraines of the rest of the State, and that the topography is rougher, more hummocky, and possesses more of the kame and kettle features than the rest of the moraines of the State. All of these features indicate that the drainage from the ice sheet in this territory was much greater than in the rest of Illinois. This was evidently due to two things: (1) The conjunction of the Lake Michigan lobe with the Delavan and Green Bay lobes was such that the radial movement of these ice lobes was opposed to each other, resulting in the ice becoming greatly riven and crevassed, thereby facilitating melting and drainage; (2) The surface elevation at the conjunction of these lobes was lower than that of the summit of either lobe, hence there was concentration of drainage from the surface of any two adjacent lobes. With great quantities of water, therefore, pouring forth from the ice sheet in this territory, the finer materials of the glacial debris were carried away, leaving the coarser materials deposited in the form of sand and gravel hills commonly known as kames, and in the form of outwash plains and valley trains.

What has been said thus far in regard to the lakes in the morainic belts does not apply, however, to such lakes as Crystal Lake. This beautiful body of water does not lie in a terminal moraine; it is surrounded by an outwash plain. It appears to have originated from a detached block of ice, a mile and a half in length and a quarter of a mile in width, having become detached in the recession of the ice and surrounded and buried by the outwash gravels, later leaving a basin for the inundation of the lake water. This general territory in fact is a territory in which pitted outwash plains show a most remarkable development. East of McHenry on the east side of Fox River there is an outwash plain dotted with numerous pits, yet made up entirely of gravel which has a uniform summit level.

THE FOX RIVER VALLEY

The Fox River Valley appears to have had its inception in the period following the deposition of the high outwash plain at Crystal Lake, Carpentersville and Dundee. This is well shown northeast of Algonquin where 160 feet above the present river the outwash deposits lie at the summit of both valley bluffs, the valley itself being sharply entrenched. It is very clear from these relationships that the Fox River Valley was cut subsequent to the deposition of the Crystal outwash plain. It also appears from the contour of the valley walls that the cutting of this valley was rapid and was accomplished by a large volume of water. We do not know the source of this water, because the later moraines to the east obscure the topographic conditions which prevailed at that time, but it is conjectured that the Fox River was an outlet of the Great Lakes, similar to the old Chicago outlet but before the deposition of the Valparaiso moraine.

Following this period of valley cutting, there was a readvance of the Wisconsin ice, and it is to this advance that the Valparaiso system of moraines is due. The ice appears to have advanced as far as West Chicago and within two miles of Elgin, and two miles of Algonquin, a notable moraine known as the West Chicago moraine marking its limit. Two miles northeast of Algonquin this moraine descends into the Fox River Valley within about 50 feet of the valley floor, which fixes the age of this moraine as later than the carving of the valley. From the front of this ice and subsequently from the ice which built the Cary moraine, water poured down the Fox River loaded with sand and gravel greater than the transporting power of the stream, resulting in a partial filling of the valley to a height of 80 to 90 feet, near Cary, producing a valley train which may be traced with decreasing height down the Fox River to Ottawa at its union with the Illinois. The valley train, however, does not exist today in its entirety, but only as remnants of terraces.

In addition to the Fox River valley train, other outwash deposits were made in the form of outwash plains. A remarkable example of this occurs east and southeast of Elgin. Here these enormous gravel resources are being drawn upon for our railroad and highway building, in addition to other phases of the concrete industry, and the topography is being markedly changed by the activities of man so well displayed in the pits of the Chicago Gravel Company.

This gravel outwash occurs at a distinctly lower level than that at Dundee, Carpentersville, and Crystal Lake, and is later in origin than the cutting of the Fox River Valley, whereas the Crystal Lake gravel deposits just mentioned are older. This conclusion is based not only upon the difference in level at which the two deposits ccur, but upon the fact that the higher gravels are found to pass and to continue eastward beneath the Valparaiso moraine for a distance of approximately six miles in McHenry County, whereas the lower gravel plain has its source in the Valparaiso moraine.

THE CLOSING STAGES OF THE GLACIAL PERIOD

After the ice had readvanced to within two miles of Elgin, and built the outer Valparaiso moraine, the climate became such as to cause the recession of the ice by stages, with the resultant building of recessional moraines to the east until not only had the entire Valparaiso system been developed, but also the Lake Border system, and the ice had receded to within the basin of the Great Lakes. From this time forth, the average severity of the climate decreased, the lake levels shifted from time to time as the lower outlets were uncovered by the receding ice or shifted by the warping of the land surface, until finally the North American continent was freed of this active and colossal geologic agency which had so thoroughly revolutionized the topography of the land surface upon which it encroached.

Judging from the freshness of contour of the glacial moraines from the meager amount of gullying which has taken place, except under special conditions, and from the small amount of slope wash which has gone on, it appears that the increasing warmth responsible for the melting of the ice made possible also a rather prompt reinvasion of the plant kingdom followed no doubt also rather promptly by a return migration of the animal life.

We do not know the precise length of time that has transpired since the glacial period, but recent studies seem to show that it has been something like 20,000 to 30,000 years since the building of the outer moraine of the late Wisconsin, which would correspond with the building of the West Chicago moraine which lies just east of Elgin.

PLANT LIFE IN THE ELGIN REGION

H. C. Cowles, University of Chicago

(Paper not handed in for publication)

PAPERS ON BIOLOGY AND AGRICULTURE

SOME RADICAL DEPARTURES ON THE TEACHING OF BIOLOGY

Elliot R. Downing, The University of Chicago

The psychology of science teaching is now sufficiently clarified and the experimental determination of the relative values of method of instruction sufficiently advanced to warrant certain radical changes in our courses of study in biology and the technique of presentation.

All subject-matter should be eliminated from the course that is not socially worth while, and at the same time of prime interest to the pupils. The only justification for the taxation of the people to cover the expenses of the education of their children is that education contributes to the efficiency of those educated as members of the community. Interest is a prime prerequisite. For any educational process is the result of self activity and that is conditioned in its intensity by interest. We know from the studies of Mau, Finley, Trafton, and others that pupils are interested primarily in the activities of animals and plants, their identification and relation to the environment—not in their structure, classification, utility. Further, that the interest is chiefly in birds, insects, and common mammals among the animals, and in wild flowers, trees and garden plants. Our biology should deal largely with these groups and it should be concerned chiefly with behavior and environment relationships.

The subject-matter should be organized in relatively small units, with topic titles that challenge attention, for the mental grasp of High School sophomores is not extensive. The pupil needs to progress by small, well defined steps, so that he may have a constant sense of mastery and not feel lost in the intricacies of a hazy, large subject.

The unit, or a small group of them, should eventuate in a comprehension of a biological law or generalization of major social importance, because in proportion as one gets his knowledge generalized is it applicable to a new situation, and then only as he has had drill in such application. The teacher must therefore spend time in carrying over these biological generalizations into life situations. A few such general laws well selected for their social values, well mastered and applied, are of real value. A mass of unorganized biological detail is useless.

Many of these units should be organized in problem or project form to give drill in accurate methods of scientific thinking, for such ability is more important than the acquisition of knowledge. Some units should be organized with a view to giving an aesthetic appreciation of one's environment, others to give an appreciation of the value of science and of the devoted labors of scientists; some to develop a sense of the lawfulness of nature, and the moral obligation of the student to obey her laws.

The recent experiments of Cunningham, Cooprider, Anibal, and others have shown that as far as the acquisition of knowledge is concerned, the lecture demonstration is more efficient than the laboratory method of instruction, and much more economical of time and material. Science instruction is neglected in the small High Schools because of the unjustified notion that expensive laboratory equipment is essential. The cost of instruction per pupil in the sciences is well toward the top of the list in high school subjects. The writer is convinced that we waste a large amount of time of students in muddling around in the laboratory. Teach them by the lecture demonstration method. Reduce laboratory work to a minimum. Bar the compound miscroscope from the High School biology course, and replace it with the demonstration projection microscope. Omit all dissections by students; such a dissection is rarely instructive—it is futile hash. Use prepared dissections when structure is to be studied, remembering that such studies are to be made only when structure is essential to a comprehension of activities. Omit from the notebooks all detailed sketches and replace them with diagrammatic drawings. Ayers investigation has shown that such drawings are much more efficient in fixing in mind the essential points.

In working out problems and projects, the early work should aim to habituate the pupil to the solution of a problem in the logical way, by following the detailed guidance of the teacher. Gradually the teacher's help should be withdrawn as the student is instructed in the essential steps of the problem solving process. Finally the pupil should be led to work out his individual problem or project unaided.

CERTAIN DIFFERENCES BETWEEN TEXT-BOOK EARTHWORMS AND REAL EARTHWORMS

FRANK SMITH, UNIVERSITY OF ILLINOIS

This paper deals with earthworms of two quite different kinds; those that are found out of doors, in which I have been interested for the past 30 years, and those that are found in text-books, in which I have become interested more recently. During the 30 years that I have been interested in the outdoor varieties I have spent considerable time in collecting species in various parts of the country and have examined a great many collections made by others. This has led to the discovery and description of several new species not previously known, and also has made clear that in almost any locality in the United States there are likely to be several species that may properly be called common. In most of the northern and eastern states, the most abundant forms in random collections brought into school rooms and laboratories would commonly include several species which are also very common in Europe, and they have been introduced wherever Europeans have settled and cultivated the soil for many years. Introduced of course unintentionally, they have thrived at the expense of indigenous forms and to some extent have replaced them in the long cultivated areas. In the Northern tier of states most of the common species belong to the family Lumbricidae, but include several different species of at least three different genera. In the latitude of Illinois and farther south, representatives of other families of earthworms are abundant, and in many cases include the largest of the specimens collected. Anatomically these are very different from Lumbricidae. It is no more reasonable to talk about "the common earthworm" than it would be to talk about the common species of bird or the common kind of fish. It is done in 29 of 47 text-books recently examined.

My interest in the text-book varieties of earthworms has been increased recently as a result of a historical study of the development of our knowledge of Lumbricidae in general. *Lumbricus terrestris,* which includes the largest fairly common species of northern Europe, was the first species to be carefully and also carelessly described by European workers, and naturally was the species adopted by text-book writers of England. Earlier American text-book authors have followed in their footsteps, for the greater part, and this has been feasible since *L. terrstris,* or *L. herculeus* as it was formerly called, has become fairly abundant in our northern states and is supplied by dealers. In most cases this text-book *L. terrestris* is the one which was known a half century ago before the use of the serial section method of anatomical study. It is quite different in some respects from the outdoors *L. terrestris* as made known by more recent investigations, which very few of our text-book authors have consulted.

"The common earthworm" is a variety which is met with very frequently in more recent text-books, but not in collections. As described in a new text-book which appeared within the last year, this variety would seem to be a hybrid form from ancestors belonging to two different genera of outdoor species, which has also acquired some additional characters found in none of them.

In so far as time will permit I wish to deal with three different topics: viz, the calciferous glands, certain blood vessels in the anterior dozen somites, and the position of the nephridiopores, and will compare text-book statements with facts.

I have no disposition to criticize any teacher or writer who decides against the advisability of giving attention to the calciferous glands, but I do protest against the incorrect statements that are found in the text-books that make a pretense of giving information about them. We will first give attention to the calciferous gland of the extremely abundant species *Helodritus caliginosus trapezoides.*

An essential feature is the peculiar modification in the structure of the wall of the esophagus in the somites 10 to 14. In these somites, the muscle layer of the wall becomes separated from the inner epithelial layer, and the space between them is divided into a series of longitudinal chambers which are separated by flattened lamellae that are radially arranged around the lumen of the esophagus. These chambers seem to end blindly at their posterior ends, which are in somite 14, or at the anterior margin of 15. In most species commonly studied in the laboratories, the esophageal wall in somite 10 is evaginated into two lateral pouches, one on each side, often called esophageal pouches, which retain the communication between their cavities and the lumen of the esophagus. The longitudinal chambers with their separating lamellae extend into these pouches between the muscle and epithelial layers for a distance which varies in the different species. Ultimately the cavities of the chambers open into the pouch cavities and a definite communication is established. In one species, and in only one of those commonly studied, *Lumbricus terrestris,* in each of the two somites next posterior to the pouches there are paired lateral swellings of the chambered wall which superficially resemble the pouches in somite 10 in size and form. This results in the presence of three pairs of lateral expansions of the esophageal tube which superficially resemble each other somewhat, and have led to the very common statements concerning three pairs of glands.

These paired inflations of the esophagus are in somites 10, 11, and 12. They are not separate glands, but are simply parts of one glandular structure, developed in the wall of the esophagus in somites 10 to 14. They certainly are not three pairs of pouches or diverticula opening into the esophagus as often stated. Marshall and Hurst's Zoology and a few other text-books that have adopted the statements contained in it are most nearly correct in their statements concerning the gland or glands, but make no mention of the continuation of the gland development in somites posterior to the 12th somite.

We will now consider some of the more common errors found in the text-book statements concerning this part of the worm. A new text-book which appeared in 1923 states that the esophagus begins in the "6th segment and continues posteriorly as a thin-walled, undifferentiated tube to the 14th segment where it connects with the crop and gizzard. Three pairs of calciferous glands open into the esophagus near its posterior end." We have seen that the so called glands are merely parts of a highly differentiated wall, and furthermore that instead of the three pairs alike opening into the esophagus only one pair has such direct openings. In this book "The Common Earthworm" is described without any specific name, but the statement is made that the clitellum is on somites 28 to 35, from which it is evident that the author was writing about an earthworm altogether different from *Lumbricus terrestris,* in which the clitellum is on somites 32 to 37, and one in which there is but one pair of conspicuous enlargements of the esophagus instead of three pairs. The description of the reproductive organs also applies to *L. terrestis* rather than to a worm with the clitellum on somites 28 to 35.

The statements in such text-books concerning the calciferous glands in earthworms are more than a century behind the times, since they include less that is accurate and more that is inaccurate than is found in a paper by a European writer which appeared in 1820. I have recently examined 47 text-books in which earthworms are included in the list of animals studied. In 23 of them the calciferous glands are not discussed. Just 18 of the other 24 state, or imply, that the glands of the three pairs are alike. Only six mention differences of structure. Four give the correct location; five an incorrect location; and the other 15 are indefinite. Five of the 24 books describing the glands do not mention the number, and the other 19 all state that there are three pairs, even though the majority of them do not intimate that *L. terrestris* is the species of earthworm being discussed. The trouble is due to the fact that most authors do not base their statements on their own study of the animals nor on the published results of careful investigations, but chiefly on what they find in other text-books with an ancestry dating back into the previous century. A paper by Harrington in 1899 in the Journal of Morphology contained illustrations and information which supply a basis for correct statements concerning the anatomy of the glands in *L. terrestris,* but Hegner is the only author that seems to have made use of it, and he has incorporated in his account one rather serious error. The general facts of position and form can be seen easily in a preparation made by splitting a well hardened specimen with a razor blade, in a frontal plane, about on a level with the upper rows of seta bundles. Serial sections are necessary for a detailed study of the anatomy.

Another topic in which I have been interested includes the text-book statements concerning the location of the nephridiopores. The nephridia are paired excretory organs of which one pair is found in each of all the somites, except a few at the anterior and posterior ends of the worm. Internally their ducts enter the body wall quite uniformly at the anterior margins of their respective somites, and slightly dorsad of the rows of ventral seta bundles. Approximately one half of the ducts pass directly through the body wall, and their external openings or nephridiopores are slightly dorsad of the rows of ventral seta bundles and hence on the surface of the ventral half of the worm. Since all the nephridial ducts enter the body wall at about the same level it seems natural to expect them to open externally at about the same level, but on the contrary approximately one half of the nephridial ducts follow a course in the body wall which leads dorsad for some distance and they emerge at the surface dorsad of the row of dorsal seta bundles at irregular distances. Marshall and Hurst described the location correctly more than 30 years ago and explained how the irregularity might be readily shown by stripping off pieces of the cuticula from slightly macerated specimens and placing them on slides, a very simple operation. Of 24 text-books making statements concerning the location of the nephridiopores, I find but three that have their statements correct. The others all assign a uniform location.

I will make brief reference to another feature of earthworm anatomy which is the occasion of numerous textbook errors. It involves a part of the circulatory system. The dorsal vessel, posterior to the so-called hearts of which the posterior one is in the 11th somite, is a collecting vessel and receives blood from the body wall and from the alimentary tract through branches of the vascular system in each of most of the somites. This blood flows anteriorly and is forced into the ventral vessel by the hearts. In the anterior dozen somites the dorsal vessel does not function as a collecting vessel. The ventral vessel is in general a distributing vessel and from it blood is distributed to the body wall and alimentary tract. In it the blood flows anteriorly in front of the hearts and posteriorly throughout the remainder of the body. It is a very common assumption by text-book authors that the dorsal vessel functions as a collecting vessel throughout its whole extent, which is not true. Two longitudinal vascular trunks lying one on each side of the alimentary canal, and joining the dorsal vessel at their posterior ends in the twelfth somite, act as the collecting vessels in the anterior somites in place of the dorsal vessel. Only seven of the text-books mentioned make any reference to these vessels, and only one of them makes reference to the posterior connections of these vessels with the dorsal vessel in somite 12. Very few of the authors seem to have known of a very useful paper on circulation in earthworms which appeared in The American Naturalist in 1902 and was prepared by Johnston and Johnson.

A NEW MUSHROOM

W. B. McDougall, University of Illinois

During the past few years I have been collecting in the University Woods near Urbana, Illinois, and occasionally at other places, a pretty little mushroom which very evidently belongs to the genus Marasmius but which so far as I have been able to learn is undescribed. (Fig. 1.) The plant is especially interesting because it always is attached to buried nuts. It is usually attached to walnuts or butternuts of the preceding year but occasionally it has been found attached to hickory nuts.

The substratum that the mushroom makes use of seems to be the nut shell rather than the meat. The meat of the nuts to which the mushrooms are attached looks normal and tastes normal. Sections of the meat washed in alcohol show under the microscope normal parenchyma cells full of crystaloid and globoid protein grains but with no sign of mycelium. On the other hand sections of a partly decayed half shell of a butternut to which a mushroom was attached showed mycelium present in the shell.

Because of the substratum on which this mushroom grows I am calling it Marasmius nucicola. A description follows:—

Marasmius nucicola n. sp.—Pileus 5-15 mm. broad, at first campanulate, becoming nearly plane or umbonate. Striate half way to the center, glabrous, reddish yellow to lemon yellow, fading to nearly white. Flesh thin, membranous. Gills adnate, moderately broad, not crowded, white or pale yellowish. Stem 3-4 cm. long, slender, smooth, reddish yellow to pale lemon yellowish, often darker above. Long, hairy, rooting base often 5-7 cm. long, extending and attached to a buried nut. Spores oval with a very short apiculus, 4-5 mu. x 8-9 mu., smooth, white. Odor none. Taste not pronounced. Edibility not tested. Cystidia numerous on edge of gills.

Under walnut and butternut trees in woods. Always attached to buried nuts of Juglans or occasionally of Carya. Often 3 or 4 sporophores are attached to the same nut. August to October.

LEGEND.

Fig. 1. Marasmius nucicola n. sp.

PRESENCE OF LIVING ORGANISMS IN LAKE ICE

Samuel Eddy, James Millikin University

The object of these experiments and observations was to determine what forms of life were existing in the ice of Lake Decatur. Lake Decatur is an artificial Lake seven miles long and one-half mile wide, created by damming the Sangamon river. The depth of the water varied from a few inches to forty feet. The periods at which the materials were collected were during zero weather when the Lake was entirely frozen over. The thickness of the ice ranged from eight to twelve inches.

On January 7, two samples of ice and two samples of water from below the ice were collected. The ice was taken from the surface near the shore and from the center. Each sample was immediately placed in sterilized bottles containing sterilized hay infusion and plugged with cotton. The samples of water at a temperature of ½ degree Centigrade were taken from the holes from which the ice was cut. The samples were placed in similar bottles and under the same conditions. A sample of mud from near the shore was also treated in the same manner. In the cultures from the ice and hay infusions, observations were made January 23, January 28, and February 6. On all these dates various bacteria were common. The only other form of life observed was Chlamydomonas which was present in small numbers on January 23, but multipled rapidly enough to be common on the other observation dates. In the cultures from the hay infusion, and lake water or mud examined under the same conditions on the same days, Chlamydomonas, Urosomas, Chilomonas, Coleps, Pleuronema, Stilonichia and many other unidentified protozoa were observed.

On January 25, two samples of ice, four of water and two of mud were collected and treated the same as those collected January 7. Nutrient agar was substituted for the hay infusion. Observations were made January 31 and February 7. The results were practically the same. Chlamydomonas and bacteria were the only forms of life in the ice cultures. Chlamydomonas, Leucophrys, Para-

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mecium, Ameba, and other protozoa were common in the water and mud cultures.

On February 22, four samples of ice and two of water were collected and treated the same as before. Three cultures of sterilized lake water and nutrient agar were made at the same time and subjected to the same conditions in order to determine if infection from the air could account for any of the resulting forms. Observations on all these cultures were made February 27 and March 4. In the ice cultures, Chlamydomonas and bacteria appeared. In the water cultures, Chlamydomonas, Pleuromonas, Ameba, and other protozoa were common. In the sterilized lake water culture used as an additional check, no forms of life were present, indicating that the probability of the origin of any of these forms from the atmosphere was slight.

On February 7, four cultures of Chlamydomonas, containing also Paramecium, were frozen from twelve to twenty-four hours and then thawed. The cultures were kept isolated and were observed February 14. The on y forms observed after thawing were Chlamydomonas and bacteria. These organisms were present in all four cultures. The Paramecium which were common before freezing never appeared after freezing and thawing.

In the eight samples of ice collected from Lake Decatur at three different dates, bacteria and Chlamydomonas seemed the only forms present. From the water just under the ice, many different protozoa were obtained. In all the cultures, except those of sterilized lake water, bacteria were observed, but were not regarded as of much significance as they easily withstand freezing and thawing. It seems that Chlamydomonas is the only form of protozoa in Lake Decatur able to survive freezing and thawing.

SOME SOUTHWESTERN LIMITS OF PLANTS IN INDIANA, ILLINOIS AND IOWA, WITH SUGGESTIONS ON THE SIGNIFICANCE OF THE PHENOMENA OBSERVED

H. C. Cowles, University of Chicago

(Paper not submitted for publication)

SOME OUTSTANDING FEATURES OF THE PLANT DISEASE SITUATION IN ILLINOIS DURING 1923

L. R. TEHON, STATE NATURAL HISTORY SURVEY, URBANA

The progress of plant disease infection, especially of crop plants, throughout the state, was kept under observation during the season of 1923 by the Natural History Survey's botanists. Their observations are reproduced in condensed form in this paper as a continuation of the papers presented at the two previous meetings of the Academy.

During the 1923 season plant diseases appeared in Illinois in their usual abundance and those attacking crop plants were responsible for large crop losses. The unusual weather conditions of the season favored the development of certain diseases, not usually very serious in our state, to the extent that they took on the appearance of severe epidemics.

WEATHER SUMMARY

While the mean temperature for the year 1923 was 1° above normal for the state, seasonal variations in temperature and precipitation in various parts of the state interfered with the usual routine of crop production. The snowfall was deficient in all parts of the state during January and February, leaving over-wintering crops exposed to the low temperatures recorded in February. Four months beginning with February had mean temperatures below normal and resulted in a backward spring which delayed the growth of winter wheat and the planting of corn. Precipitation was below normal north and west of the Illinois river, and generally above elsewhere, increasing from 27 inches in the northwest to 58 inches in the Ohio Valley.

Phenomena particularly favorable to plant disease development included the fact that 56 per cent of the year's precipitation occurred during the crop growing season. The number of cloudy days was greater only in 1915 and the number of days with rain was greater only in 1898 and 1915.

DISEASES OF FRUITS

Among Apple diseases, the development of Bitter Rot in epidemic form for the first time in nearly 20 years was the outstanding feature of the season. The epidemic ranged throughout the southern third of the state and the area of infestation was limited northward, with the exception of Macoupin county, by a line running east and west along the northern boundary of Clay county. The Black Rot disease, first found June 4 in Jackson county, was less prevalent than usual. Blister Canker was found in its usual abundance in Ben Davis orchards, and Blotch, our most serious apple disease, was found to be extending its range northward in commercial orchards. Apple rust occurred in its usual range in southern Illinois and along the Mississippi river to the Wisconsin border. Heavy infections of Fire Blight were reported on Jonathan, Transparent, Benoni, Wine Sap, and King David. Powdery Mildew, which requires a relatively dry season for its development, was seen once only. Scab appeared in greater amounts in western Illinois than in the south and central parts of the state.

Among the diseases of the Pear, Blight was as usual the most important. Brown Rot was seen only in Pike county and Leaf Blight only in Marion, Johnson and Pulaski counties. Scab was serious on both fruit and leaves in Champaign county. An unusual feature was the abundant development of Sooty Mold on pear leaves in southeastern Illinois following the attack of sucking insects.

On the Quince, Fire Blight appeared in its usual severity throughout the southern two-thirds of the state. Leaf Blight was equally severe but was limited to the southern half of the state.

Peach diseases were more severe than usual. The bacterial Shot Hole was abundant as far north as Bureau county and Brown Rot as far north as Champaign county. Leaf curl was the cause of severe defoliation through central Illinois in early spring, while Scab, rampant from spray failures, injured a considerable part of the crop in the south.

Plums suffered most severely from Brown Rot, which was most severe in the northern half of the state. Black Knot was prevalent in the southern half. Leaf Blight was more severe southward and was second only to brown rot in severity. A Leaf Curl of red plums, caused by *Exoascus mirabilis* Atk., was found in six counties. This disease appears to be increasing in abundance.

On Cherries, Brown Rot was especially abundant southward while Powdery Mildew was generally prevalent in central Illinois. Shot Hole was responsible for serious defoliation locally southward.

Grapes suffered to a greater degree than usual from Black Rot, and Bitter Rot was an important disease in Madison county. Downy Mildew was much worse than usual in the Mississippi and Illinois valleys, but Powdery Mildew was not reported.

Leaf Blight and Leaf Spot were both more prevalent than usual on Strawberries, and a root rot of unknown cause was prevalent throughout central Illinois, causing serious losses among the plants. Orange Rust appeared on Blackberries more commonly than usual and Cane Blight was serious in some commercial plantings on both Blackberries and Raspberries. Currants and Gooseberries suffered to some extent from Leaf Spot and the general attack of Gooseberry Anthracnose was serious locally in central Illinois.

DISEASES OF CEREAL CROPS

Leaf Rust of Wheat, usually the most important disease, was held in check by the low temperatures of early spring. The slow development of the crop, however, gave rise to the most general Stem-Rust infection in years. Loose Smut was less abundant than usual, while Stinking Smut became the most important source of loss, causing a crop reduction estimated at 6.4 per cent and a cash dockage in marketing the crop of more than $100,000.

The range of Flag Smut infestation was extended from the neighborhood of East St. Louis to include parts of nine counties, of which Hancock and Logan counties are the farthest north. Scab was unusually prevalent throughout the state. Anthracnose appeared for the first time as a serious wheat disease. Its distribution appears limited to central Illinois where it was seen most commonly on hard winter varieties.

The Crown Rust of Oats was much less abundant than usual, although there were severe local outbreaks northward traceable in some cases to the presence of the Buckthorn in cultivation. Smut was more prevalent and occurred everywhere, with the exception of a few counties where preventive treatment is consistently used. Stem Rust was rare in the south but occurred throughout the state.

Barley suffered only slight Leaf Rust infections, but the loss from Loose Smut was rather large. The Stripe disease was very important in northern Illinois. On Rye, the Ergot infection was slight but Leaf Rust infection was prevalent and fairly severe. Scab was found only in Christian county. Stem Smut was prevalent in central Illinois where it caused some very severe losses in individual fields.

Rosen's Disease of Corn was found in Alexander county. Stewart's Disease was not of great importance but was much more general than usual. The Black Bundle disease appeared to have a general distribution and was an important source of loss. The range of the Brown Spot disease was extended northward to Carroll county and was much more abundant southward than usual.

VEGETABLE AND FIELD CROPS

The Angular Leaf Spot of Cucumber was found in the state for the first time and the Anthracnose disease appeared in considerable severity in Union county on this crop as well as on Canteloupes and Muskmelons. Watermelons suffered much less than usual from Wilt but the wet season was especially favorable to the development of Anthracnose which caused total losses in some districts.

Cabbage Yellows was less severe than usual, but more than the usual injury resulted from the great prevalence of Black Rot. A slight Club-root infection was seen in Cook county and Black Mold was very serious locally in southern Illinois. Cauliflower also suffered severely from Black Rot.

On Tomatoes, Blossom-end Rot appeared locally and Early Blight was of general occurrence. Wilt was more serious than usual and Leaf Spot was as usual injurious to plants everywhere. Mosaic was seen only in Douglas and Effingham counties.

Potato Black Leg was seen in three scattered counties, Logan, Lawrence, and Monroe; and Curly Dwarf was found in several fields in Carroll county. Early Blight was especially prevalent in central Illinois while Scab appeared most serious southward.

DISEASE LOSSES

While the reduction in yield from the attack of plant diseases can not be accurately determined, it has been the custom for several years to estimate the losses in order to express in a concrete manner the importance of these diseases. The estimates shown in the following table indicate the importance ascribed to the diseases of some of our important crops.

ESTIMATED REDUCTION IN YIELDS* OF ILLINOIS CROPS IN 1923, DUE TO THE PRESENCE OF PLANT DISEASES

	Crop produced (bushels)	Per cent of reduction	Reduction in bushels	Value per bu.	Total value lost
Cereals					
Wheat	62,506,000	16.5	12,351,000	$0.94	$11,609,000
Oats	135,100,000	8.5	12,500,000	0.39	4,875,000
Barley	6,612,000	5.5	384,000	0.58	222,000
Rye	3,450,000	3.5	125,000	0.75	93,000
Corn	337,312,000	20.5	87,102,000	0.65	56,616,000
Fruits					
Apple	7,370,000	15.0	1,300,000	1.15	1,495,000
Pear	307,000	7.0	23,000	0.94	21,000
Peach	675,000	8.0	58,000	2.64	153,000
Vegetables					
Potato	9,568,000	2.0	195,000	0.88	171,000
Sweet Potato	880,000	0.5	4,000	1.10	4,000
Totals					
Cereals	544,980,000	17.10	112,462,000		$73,415,000
Fruits	8,352,000	14.18	1,381,000		1,669,000
Vegetables	10,448,000	1.86	199,000		175,000
Total	563,780,000	16.82	114,042,000		$75,259,000

* Estimates of this kind have been made since 1917 in Illinois and elsewhere and have come to represent the crop reductions which trained and experienced workers believe to occur. Experiments, however, have indicated that in several instances the actual reductions greatly exceed the estimates.

The reduction in yield or the loss in money value can not be arrived at for many crops because of the lack of production and price statistics, but the reductions indicated in the table of 112,462,000 bushels of cereals valued at $73,415,000, of 1,381,000 bushels of fruits valued at $1,669,000, and of 199,000 bushels of vegetables valued at $175,000, the whole reduction totalling 114,042,000 bushels valued at $75,259,000, should be sufficient to impress upon every one the importance to agriculture in Illinois of undertaking a comprehensive and effective plant-disease-control program.

For the control of these diseases there are now available methods suitable to every crop. The disinfection of seed for seed-borne diseases among cereals and vegetables, the application of effective sprays for disease of fruits and vegetables, the eradication of alternate hosts for certain diseases of cereals and fruits, and the use of resistant varieties for diseases not amenable to other treatment are already used to a limited extent and have been found to be so generally effective that a more extensive use is greatly to be desired.

SOME NORTH AND SOUTH STREAM VALLEYS IN ILLINOIS AND THEIR VEGETATION

George D. Fuller, The University of Chicago, and C. J. Telford, Assistant Illinois State Forester

A considerable portion of Illinois is characterized by a relative level upland in which streams have cut channels and developed valleys of varying depth and width. This upland has its surface covered with rich dark colored soils described by Hopkins and his associates (1) as upland prairie soils under the designations "brown silt loam" and "black silt loam". These soils, consisting of loam formed principally from wind-blown material, have a depth of 3 to 5 feet and are covered with a grassland that has been well described by Sampson (2). In contrast, the stream valleys display soils characterized as timber soils by the Department of Soil Survey of the State Agricultural Experiment Station and by them called "yellow-gray silt loam", or "upland timber soil".

The distribution of these soils and the character of their vegetation in LaSalle County has been discussed previously by Fuller and Strausbaugh (3). In this county the prairie soils cover about 80 per cent of the surface, while the timber soils are limited to 12 per cent and are distributed irregularly along the streams. It has also been pointed out (4) that it seems to be certain that all these timber soils were covered originally with forests and that no forests have ever developed upon the prairie soils. In a further attempt to explain the distribution of vegetation, which here seems to be limited by soil conditions, Fuller (5) has emphasized the peculiarities of the distribution of such timber soil along north and south streams, and has shown that the strip on the east side of the stream is almost always the wider and that it often reaches twice the extent of that on the west bank. Such uneven distribution of timber soils and forest is well illustrated along Big Indian Creek, a tributary of the Fox River.

The explanation usually current for the narrower strip on the west side of the stream is that prairie fires in their advance, driven by the prevailing westerly winds, make greater inroads upon the western edge of the forest than upon the eastern. Such destruction of trees and tree seedlings has been supposed to account for contraction of woodland areas along their western margins. In order to test the truth of this hypothesis and to discover whether the limits of the woodlands coincided with those of the slopes of the stream valley, through the courtesy of the State Forester, the junior author of this article ran a number of sectional lines or transects from west to east across the valleys of Little Indian Creek and Big Indian Creek in groups of two or three at intervals of from one-half mile to one mile. The position and extent of one group of three of these lines are shown in Fig. 1.

Along these lines the slope was determined accurately by levels and the results have been reduced to uniform scale, and a series of cross sections of the stream valleys have resulted that exhibit graphically the relative width and slope of the stream (Figs. 2, 3, 4). Each group of sections may be considered independently.

The sections A, B, and C across the valley of Little Indian Creek (Fig. 2) show that the valley is about 40 feet deep and that an average of the three sections gives a strip of timber soil (formerly covered with forest) 1000 yards wide on the west slope and a corresponding strip 2300 yards wide on the east slope. Further, the limits of the timber soil coincide exactly with the edge of the stream valley.

Another series of cross sections, D and E, from the upper part of Big Indian Creek (Fig. 3) show a valley 30 to 35 feet deep with slopes 600 yards wide on the west and 1600 yards wide on the east. Here, too, the angle of the western slope is decidedly greater than that of the eastern and the coincidence of the edge of the stream valley and the extent of the timber soil decidedly marked.

A third series, F. G, and H, come lower down the stream where Big Indian Creek has been augmented by the influx of the waters of the tributary, Little Indian Creek, and the waters have cut into the underlying rock (Fig. 4). Here the valley is about 80 feet deep, and the average width is 1100 yards west of the stream and 2200 yards east, while again the coincidence of the soil and the timber is very close.

From these examinations of the contours of the stream valleys it is evident that the timber soil varies in its distribution with the varying slopes of the valleys. Indeed, a close examination of such timber soils makes it entirely clear that they are but the subsoils of the prairie silt loams where the latter have been removed by stream erosion. The comparative youth of the stream valleys has permitted little modification of the soil upon their slopes. It is therefore clear that if, as has been shown, the edge of the slope of the valleys marks the limit of the timber soil, and hence that of the original distribution of forest associations, prairie fires cannot be accepted as an adequate explanation of the narrowness of the wooded strip on the western slope of the stream. The cause must rather be sought in some factor that affects the slope of the stream valley and thus indirectly the distribution of timber soils and their forest cover.

Two such explanations seem possible, either one of which is more satisfactory than the fire theory. Geologists have found that on account of the rotation of the earth the waters of the north and south streams have been deflected somewhat to the west and have thus eroded the western bank more rapidly and given rise to valleys of unequal slope. It seems rather doubtful, however, if the volume of water in these small streams is sufficient to account for the very decided difference here seen in the slopes of the two sides of the valley. Examining somewhat similar small north and south streams on Long Island, Jennings (6) is inclined to reject such an explanation

The other, and in the opinion of the writers, the more logical explanation is that the wind-borne soil material transported by the prevailing westerlies has been continually sifting in upon the western slopes and tending to fill up the western half of the stream valleys. This has at one and the same time checked erosion and caused the grassland to tend to invade the woodland. This explanation has been accepted by Jennings as the most reasonable for similar erosion phenomena on Long Island, and it seems to apply with even greater force in a region where the upland soil consists, according to authorities quoted, of wind-blown loessial material. We may, therefore, conclude that the prevailing westerly winds are the factor limiting the westerly extent of the forest strips bordering north and south streams in Illinois, but they are effective through the transportation of soil material rather than through their influence on the advance of prairie fires.

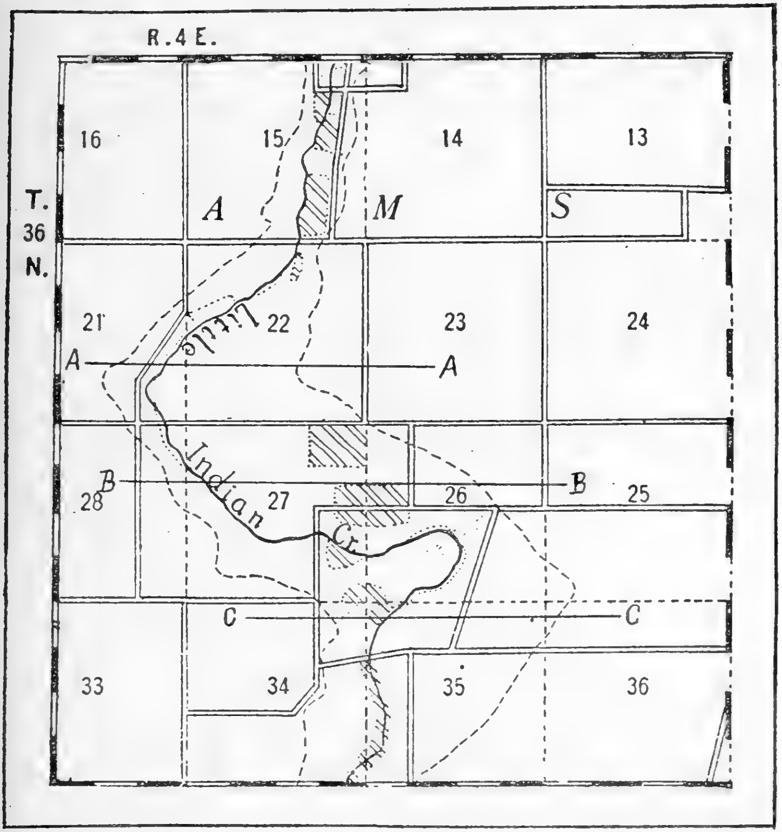

Fig. 1. Map of a portion of Little Indian Creek in Adams Township, LaSalle County, Ill., showing the original extent of the forests on the "upland timber soil," indicated by broken lines. On either side of the stream, the remnants of the forest, indicated by oblique hatchings and the transects A, B, and C, run from west to east across the stream valley.

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Fig. 2. Sections of the stream valley made by transects A, B, and C. The vertical scale is about 25 times the horizontal, and the limits of the "upland timber soil" are shown by short vertical lines.

Fig. 3. Sections of the stream valley made by transects D and E. The vertical scale is about 25 times the horizontal, and the limits of the "upland timber soil" are shown by short vertical lines.

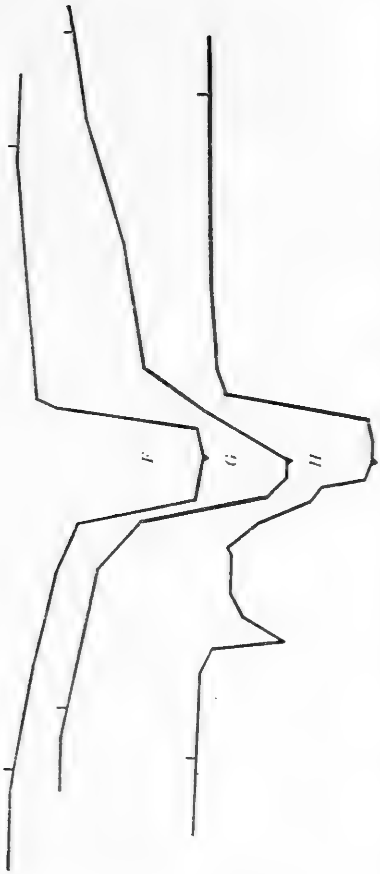

Fig. 4. Sections of the stream valley made by transects F, G, and H. The vertical scale is about 25 times the horizontal, and the limits of the "upland timber soil" are shown by short vertical lines.

PRELIMINARY CHECK LIST OF THE VASCULAR PLANTS OF THE ILLINOIS STATE PARK AT STARVED ROCK, LASALLE COUNTY

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The establishment by the State of Illinois of the first of its state parks at Starved Rock, LaSalle County, has served to focus and intensify the interest of citizens of the state, and of the Middle West generally, in this region. Its great natural scenic beauty attracts tourists and holiday-seekers generally, and its connection with the labors and adventures of the early French explorers and missionaries gives it interest to students of history. Its great wealth of geological and botanical opportunity are tending to make it a point of pilgrimage for college and university classes bent on more serious and concentrated examination. In the interests of the latter groups it has seemed worth while to offer the accompanying check list of the vascular plants of Starved Rock State Park.

Up to the present, no list at all approaching completeness has been prepared for this region, although incidental mention of elements in the vegetation has been made in a number of ecological publications. A local naturalist of an earlier date, Huett (1), makes mention of the "plants of the bluffs along the Illinois River" in his "Natural History of LaSalle County", and in the same work reviews the efforts of two pioneers—who published their contributions in country newspapers. Cowles lists the more striking and characteristic species in the interesting bulletin on the Park issued by the Geographic Society of Chicago (2), and also makes incidental citations in another paper (3). Fuller and Strausbaugh (4) worked in the neighborhood of the Park, though their operations did not come within its boundaries. Kurz (5) carried on some studies in the Park. The present writer, who worked there during the spring and summer of 1921, has in print three papers on the ecology of the region (6, 7, 8) and another in anticipation.

The preliminary and provisional character of this list must be recognized. This is particularly true in regard to the vernal flora. The list of aestival species is based on fairly thorough collections, one set of which has been deposited with the herbarium of the Field Museum of Natural History. Facilities for spring collecting, however, were unfortunately not so good, and the vernal species accordingly are based largely on field identifications and partial collections only. The writer also wishes frankly to disclaim any dogmatic certainty regarding a few of the more difficult groups; notable here are the sedges. Gray's Manual (seventh edition) was used throughout.

The writer's thanks are due to Professors Cowles and Fuller of the University of Chicago for encouragement, assistance, and generous provision of facilities; to Professor Conrad of Grinnell College for help in checking over identifications; and to the Illinois State Park Board for permission to collect in the Park.

Polypodiaceae

Polypodium vulgare
Adiantum pedatum
Pteris aquilina
Pellaea atropurpurea
Asplenium filix-femina
Polystichum acrostichoides
Aspidium thelypteris
Aspidium marginale
Aspidium spinulosum
Cystopteris bulbifera
Cystopteris fragilis
Woodsia ilvensis (*fide* Cowles)
Onoclea sensibilis
Onoclea struthiopteris

Osmundaceae

Osmunda regalis
Osmunda claytoniana
Osmunda cinnamomea

Ophioglossaceae

Botrychium virginianum

Equisetaceae

Equisetum arvense
Equisetum hyemale

Selaginellaceae

Selaginella rupestris

Taxaceae

Taxus canadensis

Pinaceae

Pinus strobus
Thuja occidentalis
Juniperus virginiana

Typhaceae

Typha latifolia

Alismaceae

Sagittaria latifolia
Alisma plantago-aquatica

Gramineae

Andropogon scoparius
Andropogon furcatus
Panicum capillare
Panicum scribnerianum
Echinochloa crus-galli
Setaria glauca
Leersia virginica
Muhlenbergia sylvatica
Muhlenbergia mexicana
Phleum pratense
Agrostis hiemalis
Cinna arundinacea
Eragrostis trichodes
Eragrostis pectinacea
Poa pratensis
Bromus purgens (?)
Elymus australis (?)
Elymus virginicus
Hystrix patula
Arundinaria tecta

Cyperaceae

Scirpus atrovirens
Carex stellulata
Carex laxiflora
Carex lupulina (?)
Carex grayi

Araceae

Arisaema triphyllum
Arisaema dracontium
Symplocarpus foetidus

Commelinaceae

Tradescantia virginiana

Juncaceae

Juncus tenuis

Liliaceae

Uvularia grandiflora
Allium cernuum
Allium canadense
Erythronium albidum
Asparagus officinalis
Smilacina racemosa
Smilacina stellata
Maianthemum canadense
Polygonatum biflorum
Polygonatum commutatum
Trillium erectum
Trillium grandiflorum
Smilax herbacea
Smilax hispida

Dioscoreaceae

Dioscorea villosa

Iridaceae

Sisyrinchium albidum

Orchidaceae

Spiranthes cernua

Salicaceae

Salix nigra
Salix longifolia
Salix missouriensis
Populus tremuloides
Populus grandidentata
Populus deltoides

Juglandaceae

Juglans cinerea
Juglans nigra
Carya ovata
Carya cordiformis

Betulaceae

Corylus americana
Ostrya virginiana
Carpinus caroliniana

Fagaceae

Quercus alba
Quercus macrocarpa
Quercus bicolor
Quercus rubra
Quercus velutina

Urticaceae

Ulmus fulva
Ulmus americana
Celtis occidentalis
Morus rubra
Laportea canadensis
Pilea pumila
Boehmeria cylindrica

Santalaceae

Comandra umbellata

Aristolochiaceae

Asarum canadense

Polygonaceae

Rumex crispus (?)
Rumex verticellatus
Rumex acetosella
Polygonum muhlenbergii
Polygonum pennsylvanicum
Polygonum acre
Polygonum persicaria
Polygonum hydropiperoides
Polygonum virginianum
Polygonum sagittatum
Polygonum dumetorium

Chenopodiaceae

Chenopodium hybridum
Chenopodium album

Nyctagineaceae

Oxybaphum nyctagineus

Caryophyllaceae

Cerastium arvense
Silene stellata

Portulacaceae

Claytonia virginica

Ranunculaceae

Ranunculus abortivus
Ranunculus recurvatus
Ranunculus septentrionalis
Thalictrum dioicum
Hepatica triloba
Hepatica acutiloba
Anemonella thalictroides
Anemone cylindrica
Anemone canadensis
Caltha palustris
Isopyrum biternatum
Aquilegia canadensis
Actaea alba

Anonaceae

Asimina triloba

Berberidaceae

Podophyllum peltatum

Lauraceae

Sasafras variifolium

Papaveraceae
- Sanguinaria canadensis

Fumariaceae
- Dicentra cucullaria
- Dicentra canadensis

Cruciferae
- Lepidium virginianum
- Sisymbrium officinale
- Erysimum asperum
- Radicula palustris
- Dentaria laciniata
- Arabis lyrata

Crassulaceae
- Penthorum sedoides

Saxifragaceae
- Saxifraga pennsylvanica
- Heuchera hispida
- Mitella diphylla
- Hydrangea arborescens
- Ribes cynosbati
- Ribes floridum

Hamamelidaceae
- Hamamelis virginiana

Platanaceae
- Platanus occidentalis

Rosaceae
- Physocarpus opulifolius
- Aruncus sylvester
- Gillenia stipulata
- Pyrus arbutifolia
- Pyrus ioensis
- Amelanchier canadensis
- Crataegus spp.
- Fragaria virginiana
- Potentilla monspeliensis
- Potentilla norvegica
- Geum canadense
- Rubus occidentalis
- Agrimonia mollis
- Agrimonia parviflora
- Rosa blanda
- Rosa humilis
- Prunus serotina
- Prunus virginiana

Leguminosae
- Gymnocladus dioica
- Gleditsia triacanthos
- Cercis canadensis
- Cassia chamaecrista
- Baptisia leucantha
- Trifolium pratense
- Trifolium repens
- Trifolium hybridum
- Melilotus alba
- Amorpha canescens
- Amorpha fruticosa
- Petalostemum candidum
- Tephrosia virginica
- Robinia pseudo-acacia
- Desmodium grandiflorum
- Desmodium nudiflorum
- Desmodium bracteosum longifolium
- Desmodium canadense
- Desmodium sessilefolium
- Lespedeza procumbens
- Lespedeza virginica
- Lespedeza capitata
- Vicia americana
- Strophostyles helvola
- Amphicarpa pitcheri

Oxalidaceae
- Oxalis violacea
- Oxalis corniculata

Geraniaceae
- Geranium maculatum

Rutaceae
- Zanthoxylum americanum
- Ptelea trifoliata

Polygalaceae
- Polygala sanguinea

Euphorbiaceae
- Euphorbia corrolata
- Euphorbia dentata
- Euphorbia heterophylla

Anacardiaceae
- Rhus typhina
- Rhus glabra
- Rhus toxicodendron

Aquifoliaceae
- Ilex verticellata
- Nemopanthus mucronata

Celastraceae
- Evonymus atropurpureus
- Celastrus scandens

Staphyleaceae
- Staphylea trifolia

Aceraceae
- Acer saccharum
- Acer saccharinum
- Acer negundo

Balsaminaceae
- Impatiens pallida
- Impatiens biflora

Rhamnaceae
- Ceanothus americanus

Vitaceae
- Psedera quinquefolia
- Vitis cordifolius (?)

Tiliaceae
Tilia americana

Malvaceae
Abutilon theophrasti
Hibicus militaris

Cistaceae
Helianthemum canadense

Violaceae
Viola pedata
Viola cucullata
Viola pubescens
Viola tricolor

Cactaceae
Opuntia rafinesquii

Lythraceae
Decodon verticellatus
Lythrum alatum

Onagraceae
Ludvigia alternifolia
Epilobium angustifolium
Epilobium coloratum
Oenothera biennis
Oenothera rhombipetala
Gaura biennis
Circaea lutetiana

Araliaceae
Aralia racemosa
Aralia nudicaulis
Panax quinquefolium

Umbelliferae
Erigenia bulbosa
Osmorhiza claytoni
Cicuta maculata
Cryptotaenia canadense
Taenidia integerrima
Pastinaca sativa
Heracleum lanatum

Cornaceae
Cornus stolonifera
Cornus paniculata

Ericaceae
Gaylussacia baccata
Vaccinium pennsylvanicum
Vaccinium canadense

Primulaceae
Steironema ciliatum
Dodacantheon meadia

Oleaceae
Fraxinus americana
Fraxinus nigra

Gentianaceae
Gentiana andrewsii

Apocynaceae
Apocynum androsaemifolium
Apocynum cannabinum

Asclepiadaceae
Ascepias incarnata
Asclepias phytolaccoides
Asclepias verticellata

Convolvulaceae
Convolvulus arvensis
Ipomea purpurea
Cscuta sp.

Polemoniaceae
Polemonium reptans
Phlox divaricata

Hydropyllaceae
Hydrophyllum appendiculatum
Nemophila marcrocalyx

Boraginaceae
Lappula virginiana
Cynoglossum officinale
Lithospermum gmelini
Mertensia virginica

Verbenaceae
Verbena urticaefolia
Verbena hastata
Verbena stricta
Lippia lanceolata

Labiateae
Teucrium canadense
Scutellaria lateriflora
Scutellaria versicolor
Agastache nepetoides
Nepeta cataria
Physostegia virginica
Prunella vulgaris
Leonurus cardiaca
Stachys palustris
Monarda fistulosa
Monarda punctata
Pycnanthemum flexuosum
Pycanthemum pilosum
Lycopus americanus
Mentha arvensis canadensis

Solanaceae
Solanum nigrum
Datura stramonium

Scrophulariaceae
Verbascum thapsus
Scrophularia leporella
Scrophularia marilandica
Chelone glabra
Mimulus ringens
Mimulus alatus
Veronica virginica
Gerardia grandiflora
Gerardia tenuifolia
Pedicularis lanceolata
Pedicularis canadensis

Acanthaceae
Ruellia ciliosa

Phrymaceae
Phryma leptostachya

Plantaginaceae
Plantago major

Rubiaceae
Galium aparine
Galium asprellum
Galium triflorum
Mitchella repens
Houstonia purpurea

Caprifoliaceae
Diervilla lonicera
Triosteum perfoliatum
Viburnum dentatum
Sambucus racemosa
Sambucus canadensis

Cucurbitaceae
Echinocystis lobata
Sicyos angulatus

Campanulaceae
Specularia perfoliata
Campanula americana
Campanula rotundifolia

Lobeliaceae
Lobelia syphilitica
Lobelia inflata

Compositae
Vernonia illinoensis
Eupatorium purpureum
Eupatorium serotinum
Eupatorium altissimum
Eupatorium perfoliatum
Eupatorium urticaefolium
Liatris scariosa
Solidago latifolia
Solidago hispida
Solidago uliginosa
Solidago ulmifolia
Solidago nemoralis
Solidago canadensis
Solidago rigida
Solidago graminifolia
Aster divaricatus
Aster furcatus
Aster novae-angliae
Aster azureus
Aster shortii
Aster drummondii
Aster laevis
Aster ericoides
Aster ericoides villosus
Aster ericoides platyphyllus
Aster multiflorus
Aster lateriflorus
Aster paniculatus
Aster linariifolius
Erigeron annuus
Erigeron canadensis
Antennaria plantiginifolia
Gnaphalium polycephalum
Polymnia canadensis
Silphium laciniatum
Silphium terebinthinaceum
Silphium integrifolium
Silphium perfoliatum
Ambrosia trifida
Ambrosia artemisiaefolia
Rudbeckia triloba
Rudbeckia subtomentosa
Rudbeckia hirta
Rudbeckia laciniata
Helianthus illinoensis
Helianthus grosseserratus
Helianthus divaricatus
Helianthus tuberosus
Actinomeris alternifolia
Coreopsis tripteris
Bidens frondosa
Bidens involucrata
Helenium autumnale
Achillea millefolium
Anthemis cotula
Chrysanthemum leucanthemum
Artemisia caudata
Erechtites hieracifolia
Cacalia atriplicifolia
Cacalia tuberosa
Senecio aureus
Arctium minus
Cirsium arvense
Taraxacum officinale
Lactuca canadensis
Lactuca ludoviciana
Lactuca hirsuta
Lactuca pulchella
Prenanthes alba
Hieracium longipilum
Hieracium canadense

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FOREST PRESERVATION—THE PATRIOT'S DUTY

E. M. North, DesPlaines

America is yet young. It is the springtime of her youth in spite of her spectacular development and the great inroads she has made upon her natural resources. We have made progress that easily outdoes any other nation in history, pioneering as we have done into new lands. We are still far enough this side of actual depletion of most of our natural resources to be able to arrest the usual course of waste to which every nation has fallen a prey. The United States is about to reap another great advantage from her educated citizenship in the promising conservation programs that are meeting with popular approval.

It is true that some of our natural resources are gone forever. In the absence of any conservation plan, the wild-pigeon is gone; the beaver is nearly extinct; the buffalo is maintained with difficulty in a few herds; natural gas, apparently inexhaustible at one time, is now but a memory in some sections of the country. Men here remember the six-or-eight-inch gas-wells in Indiana that were lighted for show day and night, sending a column of roaring flame a hundred feet high and turning darkness to daylight to the astonishment of beholders. They may also remember sitting in an Indianapolis hotel on a cold winter day with a gas-stove giving out a flame the size of a candle's. It is possible then to be recklessly and heedlessly destructive of wealth that belongs as much to the citizens of 2250 as of 1850.

For, after all, to whom does the land of a nation belong? The owners of a farm in one generation camp on it for a few brief years, take leave of life, and involuntarily surrender ownership to the succeeding generation. No man owns his piece of land, no matter how solemnly the Recorder of Deeds may officially declare it. It is to be the possession and the home of uncounted generations after him, who will come like himself, to camp on the spot, draw their sustenance from it for a few fretful years, and then move on in the great caravan of humans that press ceaselessly over the Great Divide. It would seem quite evident that the Great Designer of this interesting orb never intended that any single generation should take a mowing-machine to the natural resources of any region on the face of the earth.

This has been done in some lands with some of their natural resources. China today is reaping a harvest of penury and famine and flood through the indiscriminate exploitation of her forests for many generations. The inspiration of her sages and religion makers has not been wise in this matter; their deity failed to reveal this vital failure to them. Their people perish, often a million a year, from floods that need not occur. One would expect this in a country where the people do not read or write, and where national life has not been developed in any real sense whatever. They are like the over enthusiastic youth at the circus who spends all his loose change for red-lemonade and peanuts and finds himself without carfare at midnight, twenty miles from home. Before it is too late for our own young nation it is the part of a patriot to thrust the problem of conservation into the daily thought of his countrymen. The extent toward which forest depletion has been rapidly driving will make the average citizen rub his eyes and stare in amazement. As for our forest-resources, we are like a young man with all his front teeth out at twenty-five.

America once had inexhaustible forests over wide reaches of her territory—easily inexhaustible with any sort of early national inventory and planning. No section of this country outside of the great treeless plains needed ever to be a pauper begging for lumber. They had enough and to spare. But pioneering was done at fever-heat. Almost as by legerdemain the forests of whole states were cut away to such a degree that people can not today live upon millions of acres that once supported a thriving population. One can travel today in eastern states, in some regions for miles, and see only an occasional farm. The one time wealth-producing acres have been abandoned; farms that once had enough timber upon them to support a good-sized family today have only an occasional tree. In fact, all sections of the

United States except the far Northwest are wearing more and more the emaciated look of a hunger victim.

The Northeastern States, once rich in forests, are now hard put to it to run their huge paper pulp-mills, shipping in two-thirds of their supplies from Canada, and they are feeling much as did the Irishman who cut off the limb between himself and the tree. Already Canada has put an embargo on crown-forest shipments, and the paper-print factories are panicky lest export from private forests be also forbidden. Is it not humiliating to be an industrial suppliant at the feet of a British province for such a prime necessity as print-paper? Now some few attempts are being made in the East to remedy this matter by intelligent tree-farming, but it is too late to overtake the lost opportunity. What can we do if the Canadian supply fails us? Canada is not the one to worry about that. England with her serious housing scarcity, and her determined attempt at reforestation, is almost sure to call upon her loyal province over here to help her out, and an embargo of Canadian lumber-products is not at all improbable.

The great Northwest Territory from the Ohio to the Lakes was plentifully supplied with timber, almost an unbroken forest of noble hardwoods, when its doors were opened to the settlers who poured in like a horde of invaders to appropriate her natural resources. Restless, ambitious, energetic, resistless, they first laid the axe to the forests. Billions of feet of the finest lumber were fed to the Moloch of unregulated exploitation. Have you never heard men yet living tell how they cleared these forests for the domesticated plants of agriculture? The neighbors would gather upon invitation for a log-burning. The trees had been felled and partially trimmed; they dragged them into great piles as high as a house, and attaching cables, their horses in tandem drew them up inclined planes until they looked like grouped cottages and farm-buildings. Then the fire was applied, and respecting no aristocracy of species, quality or size, it consumed with lurid greediness black-walnuts, sugar, oak, poplar, elm and ash, often as much as six feet in diameter, monarchs upon which Nature had spent two or three hundred years of architectural efforts.

Even where some of the timber was left standing, often when taking out the salable timber, the wood-cutters were entirely careless of the trees about them, and many younger trees were and are still being destroyed when the giant falling ruins a score of others about him. Unscientific and ruinous pasturing has trampled down the soft forest-earth until it is hard and often baked, very inhospitable to struggling seedlings that do their best tc preserve the species. Forest fires too have been very destructive, and even today the forests actually burned would equal a strip ten miles wide from New York City to Denver, annually consigned to destruction. Careless campers, hunters and automobilists are responsible for the largest percentage of losses from this cause. The U. S. Forestry Department expects to accomplish a very large annual saving, 1,000,000,000 cubic feet, and $17,000,000 worth, by effectively curbing this loss. In our own state of Illinois more than half the fire-loss is due to the railroads, wood-cutters and careless campers. It is not unusual to see the tell-tale scars left by a dozen successive campers who built their camp-fires among the roots of some lordly roadside elm that had gladdened the eye of a generation of admirers of beauty.

What is the result among us in the Central West? 90 per cent of the original forest is gone, and at very heavy cost for transportation, you and I and our needy neighbors are importing 47 per cent of our lumber from distant regions, some of it from the South, herself already in straits for some species, but mostly from the remote Northwest Pacific States. From kings to paupers! There is more reality in the term than is pleasant to recall. Members here who are familiar with the housing conditions in our great cities and their suburbs are well aware that thousands of our citizens are living in dwellings of about the size and quality of store-boxes, unsanitary, unfit for habitation, such as no farmer would think of housing his animals in, for he would be sure that pneumonia would destroy them. This is a national wrong. Good patriotism can not rest without bringing about a change. America is too young a nation to be preparing a pauper class in any such numbers as these.

Even the South is beginning to realize that she has cut back her fingernails too close to the quick. Once the Southeast used to supply practically all the world's naval stores of tar, pitch, rosin, turpentine, etc., and she still claims to supply 85 per cent of it. But slowly and surely France is overtaking us with products from her artificial pine-forests under government supervision. We no longer have a monopoly on these products, and it seems probable that we must gradually say goodbye to a large percentage of it. Again the cause is found in the reckless handling of the patient pines that have suffered themselves to be vandalized by unscientific exploiters. From this same cause in other sections of the South other species are being so rapidly depleted that Florida citrus-growers are sending S. O. S. calls in every direction for crating for their fruits.

In the telling of the whole tale, volumes could be written by our Forest Department, but our time limits here are wisely narrow, and we can do little more than mention some of the main features. But before such a body as this it is worth any citizen's time if even but one more recruit is made in ten minutes for the policy of intelligent conservation of this valuable resource.

In the remaining minute or so it will be worth our while to hear the program of the U. S. Forestry Department, now drawn up in the form of a law under discussion in Congress under the name of the McNary Bill. This provides:

1. The initiation of a definite Forestry Policy, in which both the Nation and the States will bear an equal share of the responsibility both of oversight and financial support.

2. By bringing the nation to realize that it must no longer treat our forests as an inexhaustible resource, but that lumber must become a crop to be cultivated as wheat and corn are cultivated. This means additional educational facilities for teaching the new science of forest culture.

3. Legislation changing the present unfair tax-system that taxes growing forests that cannot yield any return, at the same rate as those acres beside them that are annually producing wealth.

These are all included in the McNary Bill, and any influence members may have for getting this bill through Congress can be turned to a service of intelligent patriotism in its behalf.

PAPERS ON CHEMISTRY AND PHYSICS

THE VARIATION OF PITCH OF THE NEW SINGING TUBE WITH LENGTH

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That the pitch of the new singing tube depends upon several factors, including the difference of temperature between the closed end and the remainder of the tube, the absolute temperature, and the linear dimensions of the tube has been known for several years. The relation between absolute temperature and pitch has been investigated,[1] and so also has the relation between pitch and density[2]; however, an exact and quantitative mathematical statement of the relations involved in the production of sound by heat by means of the new singing tube has not been offered. The object of the present investigation was to indicate in an experimental manner the variation of pitch with the external length of the tube.

With this aim in view, a tube was constructed of pyrex glass, of the form shown in Fig. 1. The dimensions of both the inner and outer tubes are given in Table I.

TABLE I

Tube No. 1.

Inner tube:	length	= 65.0 mm
	inside diameter	= 7.0 mm
	wall thickness	= 0.75 mm
Outer tube:	inside diameter	= 10.6 mm
	wall thickness	= 1.0 mm

The tube was then water-jacketed over its entire length to within 2 cm of the closed end, which was heated by means of a ring burner. The pitch of the tone emitted by the tube was measured by comparison with a tone variator. The tube was then removed from the jacket, and a portion of it (2 to 5 cm) cut off at the open end. The water jacket was shortened and replaced and the pitch again measured as before. This procedure was repeated until the outer tube was but a little longer than

[1] Phys. Rev., N. S., Vol. XV, p. 336.
[2] Phys. Rev., N. S., Vol. XXIII, p. 115.

the inner tube. The data taken for tube No. 1 are given in Table II.

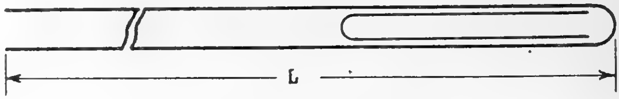

Fig. 1

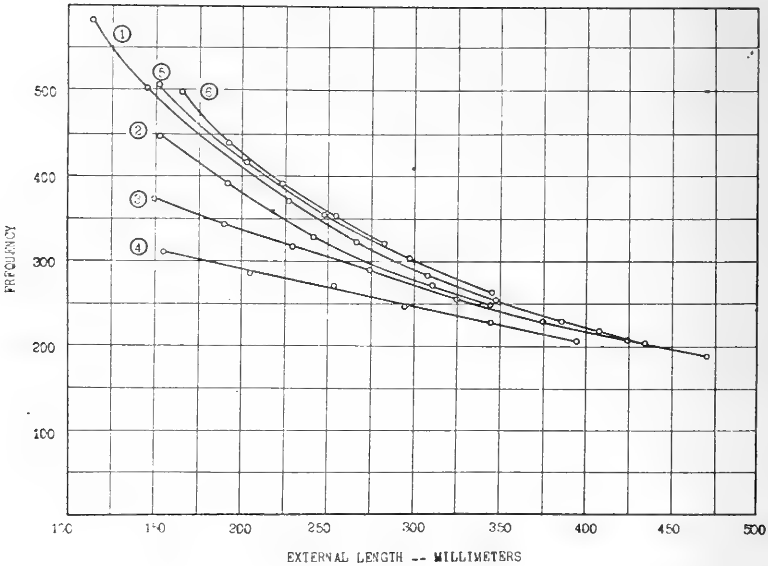

Fig. 2

TABLE II

Tube No. 1

External Length L	Frequency
434 mm	203
408	217
384	229
348	253
308	284
267	323
228	370
147	500
115	582

The variation of the pitch with the length of tube No. 1 is shown graphically by Curve 1, Fig. 2.

Other tubes were constructed in which the diameters of the inner and outer tubes, and the lengths of the inner tubes were different. These tubes were jacketed and the pitch for various external lengths measured in the manner described. The results of these observations are also shown in Fig. 2. It is not possible to draw definite quantitative conclusions from the results obtained. The curves shown, however, indicate that the pitch not only depends upon the *absolute temperature,* but also that it varies according to a *definite law* involving the external length, and the other dimensions of the tube. The observed data all fall on smooth curves, which fact favors the possibility of such a law.

POSITIVE REACTIONS OF HALOGENS ATTACHED TO CARBON

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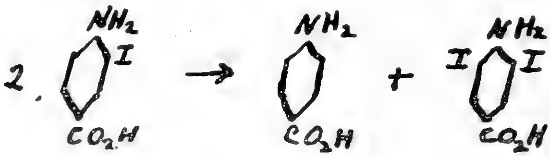
When the halogen atoms of an organic halogen compound can be removed by hydrolysis, they are usually replaced by hydroxyl, and appear in the solution as halide ions. This is often expressed by calling these halogens negative. In a number of cases, however, the hydrolysis of halogen compounds takes a different course, resulting in the replacement of halogen by hydrogen, and the appearance of the halogen liberated as HOX or an equivalent form. This behavior is well described by calling such halogens "positive". In neither case is there any intention of implying that, in the original compound, the halogen was necessarily either negative or positive to a degree sufficient to produce measurable ionization[1].

In most, if not in all, of the cases in which the halogen is attached to an amino or imino nitrogen, or to oxygen, the halogen is positive; this has long been recognized, and even made the basis of quantitative determinations of such compounds. Positive halogen attached to carbon has been recognized in certain aliphatic compounds[2].

In the aromatic series, a considerable number of the iodo and bromo-compounds show evidence of containing positive halogen, and it is in general possible to predict which will show this behavior[3]. A striking example is 3-iodo-4-aminobenzoic acid, which, as observed by Wheeler and Liddle[4], undergoes the following reaction when heated "for a few minutes" with hydrochloric acid.



[1] Cf., for the use of this idea of polar valence in organic compounds, Stieglitz, J. Am. Chem. Soc. *44*, 1293 (1922), and earlier papers; and Lewis, Valence and the Structure of atoms and Molecules (1923), particularly pp. 83 and 132.

[2] Nef, Ann. *308*, 329 (1899); Howell with Noyes, J. Am. Chem. Soc. *4*, 991 (1920); Macbeth and others, J. Chem. Soc. *119*, 1356 (1921); *121*, 892, 904, 1109, 1116, (1922).

[3] Nicolet, J. Am. Chem. Soc. *43*, 2081 (1921).

[4] Am. Chem. J. *42*, 453 (1909).

One notes that (a) an iodine has been removed, and replaced by hydrogen; and (b) the iodine thus removed retains the power of resubstituting in the bezene ring, a power which negative iodine does not have. A considerable amount of evidence collected since 1921 has confirmed the idea suggested at that time, that a somewhat similar behavior was to be expected on the part of any substance containing iodine in a position ortho- or para- to an amino- or to an hydroxyl-group, these two groups being among the most strongly negative known.

The rates at which iodine is removed under the conditions used (boiling with 10% hydrochloric acid, unless otherwise specified) vary greatly with the constitution of the substance examined. In many cases, too, resubstitution takes place less readily, and the iodine which then accumulates often oxidizes a portion of the substance. It is therefore often convenient, particularly when carrying out approximate quantitative measurements, to prevent both resubstitution and oxidation by the addition of a mild reducing agent. For this purpose stannous chloride has been used, and it may be emphasized that this has never as yet been found to act on any halogen which could not also be removed by acid alone.

From the relative stabilities of their inorganic compounds with oxygen and with hydrogen, it is obvious that iodine should show positive reactions more readily than bromine, and this in turn more readily than chlorine. This is found to be the case. When bromine occupies positions such as those specified for positive iodine, it is also removable under the same conditions, though some eight or ten times more slowly. The evidence for a similar reaction of chlorine, in the aromatic series, is indirect, though probably sufficiently definite, and for a single case only, namely, 2, 4, 6-triaminochlorobenzene.

More recent work has concerned itself with substances containing two amina- or hydroxyl-groups, and halogen ortho- or para- to at least one of them. Such halogens (bromine or iodine) are removed much more rapidly when the two negative groups are meta with respect to each other, and more slowly when these are otherwise located. For instance, iodi-p-phenylenediamine lost iodine less rapidly than o-iodoaniline, while 2, 4-diaminoiodobenzene reacted more rapidly than either, as did also the corresponding iodoresorcinol.

It might be well to emphasize the fact that halogens not in favored positions show no sign of reacting under any of the conditions used. This is shown, for instance, by the fact that 2, 4, 5, 6-tetrabromo-m-dinitrobenzene, warmed with a stannous chloride and acid, loses three of its four bromines quantitatively, giving 1, 3-diamino-5-bromobenzene. One might choose an even more decisive case; 2-iodi-3,5-dibromo-4-aminotoluene, after refluxing for 8-10 hours with the same reagents, loses all of its bromine, without the formation of a detectible amount of iodide ion. The product, 2-iodo-4-aminotoluene, should not lose iodine if the considerations already advanced are correct.

A SIMPLE FORM OF C. T. R. WILSON'S ALPHA-RAY TRACK APPARATUS

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About two years ago considerable interest was excited among scientists by the appearance of the Shimizu modification of C. T. R. Wilson's cloud apparatus for making visible the tracks or traces of alpha particles thrown off from radioactive material. The essentials of an alpha-ray track apparatus are: (1) a closed chamber in which alternate compressions and expansions of the air may be made to take place, (2) means for setting up an electrostatic field across the chamber, (3) a suitable device for cutting off this field at the proper time with reference to the changes in volume inside the cylinder, and (4) a source of alpha-rays inside the chamber. In the Shimizu apparatus these essentials are elaborately and efficiently provided for by (1) a cylinder of metal and glass in which an airtight piston, whose length of stroke is adjustable, is moved up and down by an eccentric crank on a shaft rotated by hand or by a small motor, (2) a conducting film of moist gelatine carrying some $CuSO_4$ placed on the under side of the glass cover of the chamber and a similar film of gelatine carrying India ink placed on the top surface of the piston, between which surfaces an electrical potential may be applied, (3) a suitably shaped, adjustable commutator attached to and rotated by the crankshaft, so connected that it serves to apply and withdraw the electrostatic field between the gelatine films at the proper times with reference to the compression and expansions inside the cylinder, and (4) a trace of radioactive material carried on the tip of a metal pin which projects into the chamber through a ground-in, airtight bushing.

It occurred to the writers that the alpha-ray tracks might be effectively revealed by an exceedingly simple apparatus built along the lines of a modified cloud apparatus described by one of the authors a number of years ago[1], and which is at present being made by the

[1] Science III, Dec. 24, 1909, p. 930.

Central Scientific Company of Chicago, Illinois. The simplified form of the ray track apparatus was made entirely of glass,—of Pyrex glass. Fig. 1 shows a vertical section through the axis of the compression chamber and bulb, while Fig. 2 is a view from the top downward, as the observer would view the apparatus. Several ray tracks are indicated as issuing from the tip of the plug

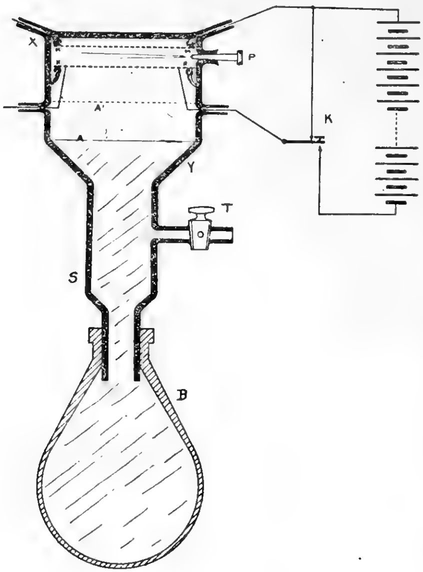

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Fig. 1

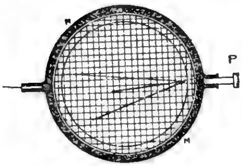

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Fig. 2

P. In Fig 1 also are shown the electrical connections. The main body of the apparatus was made of a 150 cc Pyrex beaker, one being selected with a clear, smooth bottom so that anything taking place within the chamber could be seen easily and without distortion, the bottom of the beaker forming the top of the chamber as shown in Fig. 1. The two electrostatic field plates MM and NN were made of coarse-mesh copper gauze and were held in place and kept flat by being wired to large rings made of small Pyrex glass rod. The upper ring with its plate MM was held in place against the top of the chamber simply by the tension of the two lead-in wires as shown. The lower ring with its plate NN was held in place by having three small legs of solid pyrex glass fused to the ring and the lower ends of these in turn fused to the walls of the chamber. Two only of these legs are indicated in the figure. Wires for electrical connection to the plates were carried into the chamber through capillary openings in the walls of the chamber as shown. In the experimental forms of the apparatus, these wires were held in place by filling the capillary tubes with "Bank of England" sealing wax. The plug P, on the tip of which the radioactive material was carried, was ground into a glass seat placed midway between the two plates. Finally, the mouth of the beaker was drawn down and sealed to a tube of smaller diameter, which was in turn drawn down to accommodate the stout walled rubber bulb used in actuating the apparatus. A small side branch tube, T, was provided for the introduction of water into the apparatus. The necessary electrical connections are shown in Fig. 1.

The procedure in operating the apparatus is, briefly, as follows: Fill the bulb and tube with water up to the level A. Insert the plug P. Connect the plate MM to, say, the positive pole of the source of DC potential and to the top contact of an ordinary two-contact tapping key, K, the tongue of the key being connected to the plate NN. Next connect the negative pole of the source of potential to the bottom contact of the key K. These connections are shown in Fig. 1. Then upon depressing the key the full potential of the source is applied across the plates, while upon releasing the key, the potential is removed and the plates are short-circuited together. For ease in observation the space between the plates MM and NN should be strongly illuminated. This may be done by means of a projection lantern, using a horizontal slit to confine the light to the region between the plates.

To observe the ray-tracks, compress the bulb B with the hand until the water level reaches point A, Fig. 1. Considerable pressure will have to be exerted on the bulb to do this. At the same time depress the key K, throwing the potential across the plates MM, NN. Then release the bulb and the key at the same time, and if everything is working properly, ray tracks should be seen in the space between the plates. The function of the electrostatic field is to sweep away the ions formed by the impact of alpha-particles, except those that are formed just as the expansion takes place and which form the nuclei for the wisps or tails of cloud which are the alpha-ray tracks. By repeated trials, the proper amount of compression and the timing of the withdrawal of the electrostatic field with reference to the start of the expansion will be found which give the best results. With the field plates spaced about 1 cm, a potential of 110 volts across the plates has been found to give satisfactory results. Five to eight blocks of 22.5 volt Radio B batteries may be used for this purpose, or the voltage from a 110 volt DC supply circuit may be used.

The ray tracks produced by this apparatus are, for the most part, clear-cut and distinct. The unavoidable turbulency of the air in the chamber, due to the presence of the gauze plates and supporting rings, causes the tracks to move slightly from their initial positions. However, this drift of the tracks after they have formed is not serious when the extreme simplicity of the apparatus producing them is kept in mind. Another point in the operation of the apparatus is that after a dozen or so expansions have been made, the under side of the top surface of the chamber becomes clouded due to condensation of water droplets upon it. However, this surface may be cleared readily by tilting the apparatus from time to time so as to wet the entire top end of the chamber.

A NOTE ON THE EFFECT OF TEMPERATURE ON THE TRANSITION OF CALCITE TO ARAGONITE

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In a study of the solubility of the different forms of calcium carbonate in carbon dioxide solutions and its bearing on corrosion problems, some things were noted which led to a little study on the condition of change of one form to another. The studies on solubility were carried out by shaking carbon dioxide solutions with solid calcium carbonate in a constant temperature bath until equilibrium was reached. Over a week was always allowed for this reaction.

Bicarbonate alkalinity, which represented the calcium carbonate dissolved, and free carbon dioxide were determined on the resultant solution. The results at any one temperature when plotted on ordinary coordinate paper gave a smooth graft of an exponential form. It was found that if they were plotted on logarithm paper they gave straight lines within the limit of error. Results for 0°, 20° and 65°C are shown in Fig. 1. It will be seen that the solubilities of both forms increase with temperature from 0° to 20° and that aragonite is appreciably more soluble than calcite at all times. At 25° and 35° results were obtained not much different from those at 20°; if any thing they were a little lower in both cases than were the 20° results. These results are not shown in Fig. 1. At 65° the two forms were about the same solubility and were lower than even the 0° calcite. At first these results were considered to indicate a transition temperature between the two forms of calcium carbonate, but later experiments on mixtures and a study of Johnson's[1] article shows this to be impossible. They may well indicate that the solubilities of the two forms become quite close at this temperature. This is supported by certain conductivity data and solu-

[1] J. Johnson, H. E. Merwith & Ed. Williamson, Am. J. Science, 4th ser. 41, 473 (1916).
Studies conditions of formation of different forms of calcium carbonate under different conditions.

bility products obtained by H. W. Foote[2]. Of course it is also possible that at this high temperature the unstable aragonite has partly changed to calcite and that the equilibrium is established with the more insoluble form. A specific gravity of the undissolved residue was run, but the results were not conclusive as the sample had not been ground fine enough and a true specific gravity was not obtained.

Fifty percent mixtures of aragonite and calcite were ground together, covered with water containing carbon dioxide and exposed to various temperatures. These mixtures were allowed to react one week when they were ground and the specific gravity determined. Temperatures of 20°, 37°, 65° and 100° were used. The change in specific gravity in every case indicated that the aragonite was being changed quite rapidly to calcite and that the reaction was more rapid at 65° than at 25° and 37°. The specific gravity determinations of the material exposed to 100° were not very concordant and no very definite conclusions could be drawn. This rapid change is contrary to most of Johnson's[1] findings.

Certain of the samples which were allowed to react at 65°C cemented firmly together to form a mass which was quite strong and which showed rather large crystals of calcite mixed in a matrix of small crystals. Samples exposed to other temperatures, while they became much more granular than the original material, did not cement together. The samples which were finely ground did not form as strong a material as that which was more coarsely ground. The condition of packing seemed also to have some effect upon the strength of the material. An attempt was made to form this cemented material by the use of ground marble and the aragonite from ground oyster shell. This material recrystallized into a more granular form but did not cement together.

This formation of a cemented material, using as a binder only a more unstable crystalline modification,

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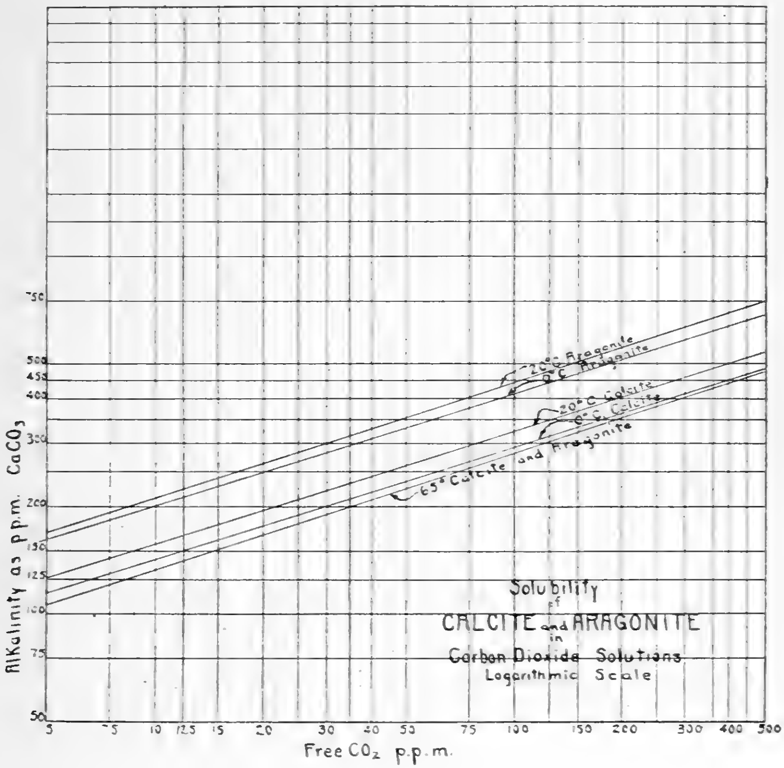
[2].H. W. Foote, Zeitshr. Physikal, Chemie, *33*, 740 (1900) Uberdie Physikalish Chem. Beziechungen Zwischen Aragonit and calcit.
Showed by oxalate reaction and conductivity experiments that the solubility of calcite and aragonite approached each other with increasing temperature worked from 8° to 59° also show increase and then decrease. Aragonite at 50° still considerably higher than calcite.

may at times have been operative in nature, and might, if suitable material were available and if proper conditions of temperature, concentration of solution and state of subdivision were worked out, be of importance practically.



THE MOLECULAR SPECTRUM OF AMMONIA

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PRELIMINARY REPORT

A number of years ago it was found that hydrogen chloride showed a double branched absorption band at a wavelength of approximately 45,000 A. U. This wavelength is found in the near infra-red spectrum. The bands were accounted for by Bjerrum (Nernst Festschrift, 1911) assuming that the diatomic molecule rotated about a line at right angles to the line joining the atomic centers and that the atomic centers vibrated along the line joining them. Such a system of molecules will absorb energy from a beam of radiation passing through them corresponding to the frequency of rotation and also the frequency of the combined frequencies of rotation and vibration. The double branched band will have frequencies corresponding to $f_v \pm f_r$, where f_v is the frequency of vibration of the molecule and f_r is the frequency of rotation.

Later experiments revealed the fact that the double branched band was not simple but made up of a number of fine bands. Bjerrum modified his theory involving the quantum theory. His theory was not altogether satisfactory, and later Lenz (Verh. d. D. Phys. Ges. 31, 632, 1919) following the idea of the stationary state of Bohr in his atomic theory arrived at a more satisfactory expression for the wavelength of these bands. The Lenz theory assumes that the molecules exist in a series of stationary states in regard to rotation and vibration, and that energy is emitted or absorbed during a transition between stationary states. Lenz's expression for the frequency of the emitted or absorbed radiation is

$$f = nf_o + \frac{h}{8\pi^2 I} \pm \frac{mh}{4\pi^2 I}$$

where f and f_o are the frequencies of the absorbed radiation and the atomic vibration frequency respectively, h is the Planck constant, I the moment of inertia of the molecule and m and n are small integers characterizing the stationary states of rotation and vibration respectively.

The interpretation of the above expression is interesting. When the molecule is in the state characterized by the quantum numbers n = m = O, it has no energy of vibration and of rotation. When a change occurs during absorption of energy such that n = m = 1, the frequency of the absorbed radiation is given by

$$f = f_o + \frac{h}{8\pi^2 I}$$

So far this so called zero branch of the curve has never been observed, as far as the writer is aware. If the molecule is in the stationary state characterized by n = O, and m = 1, then a transition to n = 1, and m = 2 gives rise to an absorbed radiation of frequency

$$f = f_o + \frac{h}{8\pi^2 I} \pm \frac{h}{4\pi^2 I}$$

This expression indicates two bands, one on each side of the above zero branch. If now we allow the change from n = O to n = 1, and m = 2 to m = 3, and so on, we have a series of equidistant bands which approximate the experimental values fairly well. Experimentally these bands are not equidistant. The above theory was developed assuming an independence of m and n, or that the moment of inertia of the molecule is independent of the angular velocity. By making the necessary modifications with this point in mind an extremely satisfactory theory is developed which accounts for the facts very well.

The above theory was developed for the diatomic molecule. No theory exists for the polyatomic molecule. However, double branched absorption bands with the fine structure have been observed for polyatomic molecules. Their characteristics are, in the main, similar to those of the diatomic molecule.

In an investigation to bring to light other examples of these double branched absorption bands it was found that ammonia gas showed a serrated double band with a zero branch at 30,000 A. U. The investigation was carried on with an infra-red grating spectrometer, using a radiometer as the receiving instrument. The grating was one of 2500 lines per inch and had a ruled surface 2 x 2 inches. A cell 10 cm. long with mica windows was so arranged before the slit of the spectrometer that it could be moved in or out of the beam of light brought to focus on the slit. Such an arrangement made it possible to determine the per cent absorption. The bands as observed for ammonia are not equally spaced, the wavelength interval between them increasing from about 140 A. U. on the short wave side of the band to 200 A. U. on the long wave side. In addition to the system of narrow bands a deep band was found at 299,000 A. U. which corresponds to the transition of $n = m = 0$ to $n = m = 1$ as indicated above. This appears to be the first substance found to show the zero branch of the double absorption band. Eight of the narrow bands were found on each side the zero branch. Inasmuch as the grating used in the investigation was a 2500 line per inch grating it did not have sufficient resolving power to make accurate quantitative determinations possible. It is planned to examine these bands under larger resolving power.

The frequency difference between the narrow bands is given from the expression of Lenz as

$$df = \frac{h}{4\pi^2 I}$$

From this expression it is possible to get an estimate of the moment of inertia of the ammonia molecule. Substituting wavelengths in the expression and solving for I we have

$$I = \frac{h\lambda^2}{4\pi^2 c d\lambda}$$

where c is the velocity of light, λ the wavelength of a band and $d\lambda$ the difference of wavelengths between two bands. Making the substitutions, we find 2.8×10^{-40} gm. cm^2 as the moment of inertia of the ammonia molecule.

Northwestern University
May 4, 1924.

A STUDY OF THE EFFECT OF METALS IN CONTACT WITH SOLUTIONS OF SILVER HALIDES IN VARIOUS SOLVENTS

J. H. Ransom and D. W. Hanson, James Millikin University

PRELIMINARY PAPER

During the performance of an experiment by a class of students large quantities of a very dilute solution of silver salts were produced, from which, both for economic reasons and for its effect on the student, it was desired to recover the silver. It occurred to one of the authors that the easiest and most direct way to recover the silver was to convert it into chloride, dissolve this in some solvent like ammonia, and precipitate the silver by treatment with some metal like iron or zinc. Whether metals would precipitate silver from such solutions was not known and a search through the available literature did not indicate that the experiment had ever been tried.

When silver chloride is dissolved in ammonia it is believed that a complex positive ion results which contains both silver and ammonia, $Ag(NH_3)_2$. Since more than the equivalent amount of ammonia is necessary to produce solution it is probable that this positive ion is in equilibrium with the silver ion, the concentration of the latter ion decreasing with the increase in concentration of free ammonia. In any such solution, however, there might be enough silver ions so that in contact with metals whose solution tension was greater than that of silver ions the latter might be discharged and the silver deposited. A preliminary trial with such a solution gave a gray powder appearing somewhat metallic.

The solutions of silver salts, left over from the students' experiment, were collected and the silver precipitated by an excess of hydrochloric acid. After washing the silver chloride it was dissolved in rather concentrated ammonia, making a nearly saturated solution. To this was added granulated zinc. Almost immediately the gray deposit formed, together with some gas, probably hydrogen, and towards the end of the experiment there were formed beautiful silver-white metallic crystals. Much of the gray powder was rather soft and malleable and when rubbed gave a metallic luster. Always there was a larger or smaller amount insoluble in dilute nitric acid, and this appeared to be silver chloride which had been affected by light. After some hours only the smallest traces of silver chloride remained in the solution.

These results were so encouraging that it was felt to be worth while to study the effect of various metals on solutions of the halides of silver, not only in ammonia solutions but in other solvents, especially in the "hypo" of the photographer. It is known that large quantities of the spent "hypo" liquors are discarded without the recovery of the silver contained in them, thus involving a great economic loss of silver as well as of "hypo". While a method is in use for the recovery of the silver it is felt by some photographers that it is more trouble than it is worth and the use of the recovered "hypo", if such it is, is not undertaken because of its possible injurious effect on the pictures.

When the silver halides, silver bromide especially, is dissolved in "hypo", sodium silver thiosulphate is formed. The solution may contain silver ions and the fact, as we show in this paper, that metals cause a deposition of the silver in a very pure condition is evidence that such is the case.

At this point the investigation was taken up by the junior author. The results, while only of a preliminary nature, are interesting, and we hope to extend the scope of the work at an early date.

After most of the results, here reported, were secured, there appeared in Chemical Abstracts, page 1094, (April, 1924) an abstract of an article in Chemische Zeitung by A. Steigmann, describing "A New Method of Precipitating Silver and Gold." In his method the solution of silver halide in "hypo" is treated with sodium hyposulphite $Na_2S_2O_4$, in the presence of soda which reacts with the sulphur dioxide produced during the chemical action. The abstract states that the fixing bath can be regenerated five or six times, but he recommends only three times. Since the hyposulphite is usually made by reduction of the sulphite with zinc, and since soda must be used to neutralize the sulphur dioxide which is converted into sulphite and this in acid solution, in which the "hypo" is always used, produces sulphur dioxide which might act in an injurious way upon the picture, it seems a more direct and better method to use the zinc directly with the "hypo" in recovering the silver. This would be especially true if, as seems evident from our results, the hypo is as good and safe a fixing agent after treatment with the zinc as when freshly made.

In order to study in a more nearly quantitative way the action of several metals on solutions of silver chloride in ammonia, a nearly saturated solution of the chloride was made and one-half of it was diluted with an equal volume of distilled water. In separate portions of both the concentrated and dilute solutions were placed weighed amounts of the metals, zinc, aluminum, copper and iron and then these were kept in a dark room until all the silver had been precipitated. Before the metals were introduced their surfaces were well cleaned. With all the metals except iron precipitation of silver began at once and all the silver had left the solution within twenty-four hours (the first test was made at the end of this time). In the case of iron in the dilute solution the action had started only slightly at the end of the first hour and was complete only after forty-eight hours. In the concentrated solution the iron remained perfectly bright for the first day, and not a trace of silver had deposited. On being brought into the light, however, action began within fifteen minutes and seemed to continue after it had been replaced in a dark room. When the action had become complete the metals were removed, cleaned and weighed, and the precipitate treated with quite dilute nitric acid. In the case of zinc quite a large amount of material was not dissolved in the acid and appeared like darkened silver chloride. With the other metals only a trace of material was found to be insoluble. In the case of zinc it was found that 54% more went into solution than was equivalent to the silver formed. This might be anticipated from the fact that water acts slowly on zinc to form the hydroxide. In the case of the other metals the excess loss was not determined.

Since the recovery of silver from "hypo" fixing baths is of commercial importance, most of the time was spent in its study. For this purpose a spent "hypo" solution was obtained from a local photographer. Before using this solution, however, preliminary experiments were performed with a fairly concentrated solution of silver chloride in sodium thiosulphate solution. The method used followed very closely that with ammonia solutions, using the same metals. With all of the metals it was found that the precipitation of silver began very slowly, only after two or more hours, and that it proceeded regularly to completion. With iron the end was reached only after forty-eight hours, but with the others twenty-four were all that was needed. Only slight traces of the precipitate were insoluble in dilute nitric acid. In the case of copper the silver deposited as a smooth layer upon the surface of the copper sheets; with the other metals the silver deposited very smoothly on the glass walls of the containing vessels, forming a mirror more or less perfect.

After this preliminary experiment a liter of the spent liquor, mentioned above, was treated with small rectangular chunks of pure zinc lying at the bottom of the flask. The silver slowly deposited as a mirror on the walls. About four grams of silver were deposited for three grams of zinc disappearing into the solution. This is far less silver than is theoretically possible (3.3 :1), but by using a larger surface of zinc suspended in the solution and by stirring the solution it is believed the amount might be increased nearly to the theoretical.

After the silver had become completely precipitated from the spent liquor a part of it was treated with sodium carbonate to separate the carbonate of zinc. After filtration of the carbonate it was found that the slightly acidified solution (with acetic acid) dissolved 62 grams of silver chloride per liter. The part of the silver-free solution from which the zinc had not been removed was found to dissolve 70 grams of silver chloride per liter.

This would indicate that the zinc salt in the solution had no injurious effect on the solubility of the silver halides, but rather improved it slightly.

In order to test the qualities of the treated "hypo" as a fixing agent the solution from which the zinc had been removed as well as that containing this metal was submitted to an expert student photographer for use in his fixing bath. He reported that both solutions worked in a perfectly normal manner, and that he could observe no decrease in efficiency as compared with the ordinary solution and no difference in the quality of the product.

It is planned to continue the investigation along several related lines and to the end of making the process a commercial success.

RECENT DEVELOPMENTS IN PHOTO-CHEMISTRY

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The advent of the quantum theory has given us a means of applying some of the principles of thermodynamics to photochemical reactions. According to this theory, the energy of frequency ν incident upon a given system is necessarily some multiple of an energy unit, $h\nu$. The Bohr theory of atomic structure has successfully applied this idea to the spectrum lines of hydrogen and to X-ray data. According to this theory there are several possible "energy states" or "stationary states" for an atom. When the atom is in its normal state it does not radiate energy, but if energy is added to the atomic system either by electron impact or by radiation, the total energy of the system is now greater than for the normal atom by a definite amount. This energy may be represented by E. If now the atom returns to its original energy state, light of frequency given by the simple equation $E = h\nu$ is radiated, where h is Planck's constant.

Several attempts have been made to apply the ideas of the quantum theory to photochemical processes. Einstein[1] has derived a photochemical equivalence law, which, briefly stated, equates the radiant energy necessary to cause a mol of substance to react to the heat of reaction

$$\Delta H = Nh\nu$$

In the case of a system A′ capable of changing by the action of radiation of frequency ν into a system A′, radiation of frequency ν' being re-emitted in the process according to the scheme

$$A + h\nu \longrightarrow A' + h\nu'$$

then the heat of reaction would be given by the expression

$$\Delta H = Nh(\nu - \nu')$$

It should be noted that radiation of frequency ν' would cause the reverse reaction to take place if it were allowed to act on the system A′.

[1] Einstein, Annalen der Physik, 37, 832 (1912).

One other important attempt has been made to apply the quantum hypothesis to photochemical processes. Perrin[2] has proposed a theory which has been discussed in detail and modified to a certain extent by Tolman[3]. The classical Arrhenius equation

$$\frac{d \ln k}{dT} = \frac{E}{RT^2}$$

connects the constant in the equation for a monomolecular reaction

$$\frac{dx}{dt} = k(A-x)$$

with a quantity E which has the dimensions of energy. Perrin states that this term represents an energy of "activation", and writes $E = Nh\nu$. Thus a molecule might absorb an amount of energy $h\nu$ and subsequently either decompose or return to its original state. This formula has been applied to the decomposition of nitrogen pentoxide with great care by Daniels and Johnston[4] and roughly to the decomposition of solid oxalic acid[5]. In neither of these cases was the formula found to agree with the experimental facts.

It is obvious, of course, that an idea such as that proposed by Perrin could at best hold true in an ideal case. For the ordinary photographic action of light on the silver halides all wave lengths of light seem to be active from the red end of the spectrum to hard X-rays, a fact which could not be explained by Perrin's hypothesis. Berthelot[6] has suggested that the effect of radiation would increase with increase in frequency according to an exponential law, in much the same manner that the rates of thermal reactions increase with the temperature. In the case of the decomposition of a crystalline body by the action of radiation, it would seem that Perrin's formula should fail for the following reasons[7]: a molecule in a crystal lattice is held to the other mole-

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[2] Perrin, Annales de Physique, *11*, 5 (1919).
[3] Tolman, Journ. Amer. Chem. Soc., *42*, 2506 (1920); *45*, 2285 (1923).
[4] Daniels and Johnston, Journ. Amer. Chem. Soc., *43*, 72 (1921).
[5] Noyes and Kouperman, ibid., *45*, 1398 (1923).
[6] Berthelot, Bull. de la Soc. chimique, *35*, 241 (1924). This article sums up many of Berthelot's views.
[7] Noyes, Comptes Rendus, *176*, 1468 (1923).

cules in the lattice by definite forces. A certain amount of energy must be added, therefore, in addition to the energy necessary to decompose a given molecule, in order to separate it from its fellows. Moreover, if present ideas of molecular structure are accepted, the action of light may be to set up vibrations of the atoms with reference to each other, or to cause a separation to a given distance of an electron. According to Perrin's theory the molecule would either decompose or return to its initial state. It would seem that the probability of decomposition would depend on the extent of the separation. Bearing this in mind, a formula analagous to that for the photoelectric effect would be obtained in which the rate of reaction is a linear function of the frequency

$$\frac{dx}{dt} = k\,I\,h(\nu - \nu_0)$$

In this formula the rate is assumed to be proportional to the intensity of the radiation, I, in the same manner as in most of the other theories.

The most general fallacy in reasoning connected with photochemical processes seems to be in making the assumption that one general theory can be found which will account for all reactions affected by radiation. It is well known that a catalyst will not cause a reaction to take place unless the reaction has a *tendency* to take place without the catalyst. In other words if a reaction leads to a decrease in *free energy,* as in the combination of hydrogen and nitrogen to form ammonia, a proper catalyst should greatly increase the rate of reaction, even though the rate of reaction is immeasurably slow under ordinary conditions. On the other hand if a reaction involves an increase in free energy, as in the combination of nitrogen and oxygen to form nitrogen dioxide, the mere use of a catalyst will not cause the reaction to take place. In the case of photochemical reactions, it seems that a similar distinction should be made.

Bodenstein[8] has classified photochemical reactions as

[8] Bodenstein, Zeit. phys. Chem., 85, 333 (1913). For a good summary see Lind, The Chemical Effects of Alpha Particles and Electrons, The Chemical Catalog Company, 1921.

either "primary" or "secondary". For "primary" light reactions the number of molecules reacting per quantum absorbed is either one or some small number. In this series of reactions the free energy change is either positive or very slightly negative (See Table I) for those reactions for which the free energy change is known. It seems probable that this could be stated as a general law.

TABLE I.

Primary Light Reactions (Bodenstein)

$2\ HI = H_2 + I_2$	; ΔF°_{298}	$= -630$
$3\ O_2 = 2\ O_3$	;	$= +64800$
$2\ NH_3 = N_2 + 3\ H_2$	;	$= +7820$
$2\ H_2O = 2\ H_2 + O_2$	;	$= +109014$
$S\lambda = S\mu$	;	-1 (?)

In the case of "secondary" light reactions, one quantum causes a large number of molecules to react. These reactions are almost always those which involve a large decrease in free energy, and the light seems more to play the role of a catalyst.

TABLE II.

Secondary Light Reactions (Bodenstein)

$H_2 + Cl_2 = 2\ HCl$	; ΔF°_{298}	$= -45384$
$2\ O_3 = 3\ O_2$	;	$= -64800$
$2\ H_2O_2 = 2\ H_2O + O_2$	;	$= -56660$
$CO + Cl_2 = COCl_2$	;	$= -16260$

It would seem safe to predict, then, that only those reactions which involve a slight negative or a positive free energy change will follow a photochemical equivalence law. For the other reactions light seems to be capable of starting a chain process which continues until it comes to an accidental end. As Nernst[9] has pointed out an "acceptor" which neither multiplies nor diminishes the products of the primary reaction, but transforms them directly into the equivalent quantity of finally measured product should give rise to a reaction which obeys the photochemical equivalence law. This point has been studied by Pusch[10], who studied the action of bromine on

[9] Nernst, Zeit. Elektrochem., 24, 335 (1918).
[10] Pusch, ibid., 24, 336 (1918).

hydrogen, heptane, hexane, toluene and hexahydro-benzene under the influence of light. The first took place much less than was predicted by theory, several quanta being required to cause one molecule to react; the next three took place more than was predicted by theory and hexahydrobenzene reacted according to theory. Since the free energy changes in organic reactions are little known, it is impossible to correlate these results with the rule enounced above.

The action of light on the hydrogen-chlorine reaction has formed the subject of many studies. As a result, it is impossible to state at present what the function of the light really is. Stark[11] suggests that the action of light is to *loosen* the valence electrons. It is impossible to make any generalization of this sort, and it is probable that the action in the hydrogen-chlorine reaction is not connected with the valence electrons as such but with the molecule as a whole. In some recent experiments[12] it has been shown fairly conclusively that a mercury surface which has been acted on by wave lengths below the photoelectric threshhold reacts more readily with nitrogen dioxide and with oxygen than an unactivated mercury surface. Since fields which would tend to hinder the elimination of electrons from the surface caused the speed of the reaction to become normal, it seemed that the emission of the electrons was the deciding factor. A large number of molecules of HgO were formed for each electron emitted, and since the free energy change is negative, this reaction should be classified as a "secondary" light reaction.

In conclusion, it seems that the field of photochemistry is in a rather unsatisfactory state from a theoretical standpoint. Much work is being done on synthesis of organic compounds, especially those compounds formed in plants by the action of sunlight and of certain carbohydrates from formaldehyde, and these reactions may lead to very important conclusions from the standpoint of the biologist.

[11] Stark, Atomdynamik, Leipzig, 1911, Vol. II, p. 207.
[12] Moore and Noyes, to appear in the June number of the Journ. Amer. Chem. Soc.

A LABORATORY EXPERIMENT FOR TESTING THE EFFICIENCY OF A SCREW JACK

A. P. Carmen and R. F. Paton, University of Illinois

Our object in devising this experiment has been to get a feasible quantitative college experiment which would fix the principle of work and the concept of efficiency of a machine. We chose as the machine a small screw jack, the particular jack being an inexpensive one used to lift light weight automobiles. The apparatus is shown in Figs. 1 and 2. The hand lever was removed from the gear

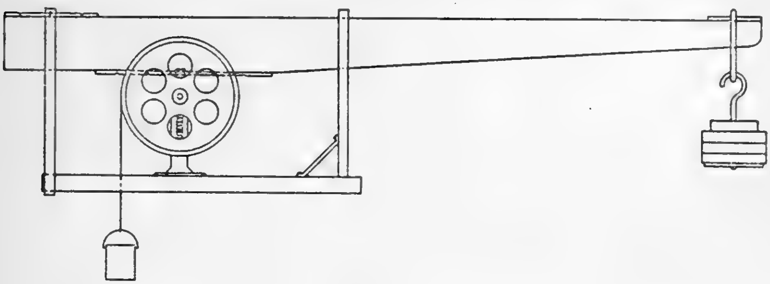

Fig. 1

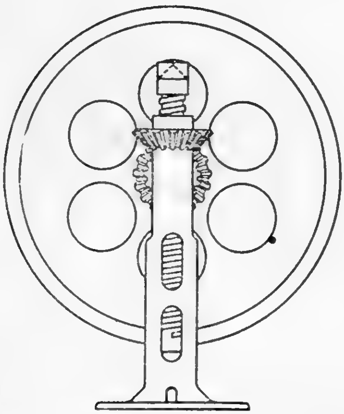

Fig. 2

wheel of the jack and a disk was substituted. The "power" force is applied as a weight hung by a wire cord which is wound in a groove on the periphery of the disk. This applies a moment of force to the small gear wheel which acts in turn on the gear turning the screw on the jack. The "weight" force which is overcome consists of a number of large iron weights hung on the end of a lever. The fulcrum of this lever is at the opposite end of the bar and the "power" force on the lever is the force exerted by the jack. The lever as constructed by us consists of an oak beam 1.5 inches thick, about 4 inches wide and about 70 inches long. The upper end of the jack screw was fitted with a wedge-shaped piece and this rests on an iron plate screwed on the lower part of the oak beam. The point of application of this "power" force can thus be shifted along the lever bar. This point of application will not in general be under the center of gravity of the lever bar so that the work done in raising the center of gravity must be taken into account in the final calculations of the efficiency of the machine.

The following is a sample set of readings made with this apparatus.

weight of lever	6490	grams
pitch of screw	.847	cm
distance of fulcrum to jack	46.0	cm
distance of fulcrum to center of gravity of lever	66.0	cm
distance of fulcrum to weight	166.0	cm
distance "weight" is shifted for two revolutions of disk	6.35	cm
distance "power" force moves for two revolutions of disk	177.8	cm
weights at end of lever	12410.0	cm
"power" weights in bucket required to just lift above "weight"	2040.0	gm

From the above data, the student calculates directly the following:

ideal mechanical advantage of jack	105.
actual mechanical advantage of jack	26.8
ideal mechanical advantage of lever	.266
actual mechanical advantage of lever	.230
ideal mechanical advantage of combined machine	28.0
actual mechanical advantage of combined machine	6.08
efficiency of jack	25%
efficiency of lever	86%
efficiency of combined machine	22%

Laboratory of Physics
University of Illinois
April, 1924

THE RELATION OF FLUE GAS ANALYSIS TO THE EFFICIENCY OF THE OIL BURNER

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INTRODUCTION

The extensive use of fuel oil in all types of furnaces gives economic importance to standards of furnace control. The small installation is seldom controlled from the measurements of a testing engineer as the variations in the efficiency of the installation seldom amount to enough to warrant the employment of an engineer. The large installations, however, are being controlled by the modern methods which have been developed for coal fired furnaces. These methods are tests of the intensity and quantity of combustion and, when applied to the combustion of fuel oil, indicate the efficiency of the furnace, provided, of course, they are interpreted in the right way.

Because of the rapid development of the oil burner industry, the discussion of the efficiency of the oil combustion has been left largely to the salesmen or promotors, while the factory engineers have been busy developing the production efficiency of the plants. Efficiency standards have been set by argumentation rather than being based upon information gained in the industrial laboratory. As a result many exaggerated claims have been made regarding the efficiency of the furnace, including claims of more than 17 per cent carbon dioxide in the flue gas. Of the many claims of advantage of the oil burned over the coal fired furnace the flue gas analysis should show the relation in efficiency of starting, change in load, and complete combustion.

COMBUSTION EFFICIENCY

The type of fuel used varies considerably, but with the lighter fuel oils, the average hydrocarbon indicated by the properties of the oil is probably represented by the formula $C_{10}H_{34}$. The quantity of this oil, or the percentage, cracked during vaporization, probably varies considerably, but the ease with which it is distilled would indicate that it is stable at the moderate temperatures. The vaporization in the burner is at a point where a large quantity of air is being admitted to the fire pot. The cool air keeps the temperature of this part of the fire pot very much lower than that of the flame. On the assumption that only a very small per cent of the hydrocarbon is cracked, the maximum percentage of carbon dioxide in the cooled flue gas can be calculated by calculating the combining volumes from the equation,

$$2C_{16}H_{34} + 49O_2 = 32CO_2 + 34H_2O$$

If we assume that the ratio of oxygen to air is 1 to 5, the reaction will be expressed by volume as follows:

2 volumes Distillate + 245 volumes Air =

32 volumes CO_2 + 196 volumes N_2 and inert gases

This gives us a ratio of 32 volumes of CO_2 in a total of 228 volumes of flue gas, which gives a percentage of 14.03% carbon dioxide as the maximum percent possible in the cooled flue gases. The maximum carbon dioxide from oil combustion is calculated by F. D. Harger[1] as 15.395% from the analyses of the oil given as C = 84.0; H = 14.0; O = 1.2; S = 0.4; N = 1.7. The calculation of the maximum percent of carbon dioxide possible from the combustion of the above oil is 12.52%.

The cracking and dissociation at the high temperature of the flame give the combustion a process of oxidation of carbon and hydrogen as dissociated in the flame rather than a molecular reaction. This change in the condition of these elements would not, however, change the resultant compounds found in the flue gases.

EXPERIMENTAL

Two types of burners were studied—the vaporization and the spray types. The temperatures were measured by means of a thermo-couple and potentiometer. A modified form of the Orsat gas analysis apparatus was used in analyzing the flue gases.

In the spray type found in the market at present, the oil being sprayed by air pressure, the quantity of air seems to be governed by the necessity of spraying the oil rather than by the amount necessary for combustion

[1] F. D. Harger, Fuel Oil, Vol. 11, No. 6, p. 9.

and by attempts to lower the air supply. The study of the effect of the air supply upon the efficiency resulted in the stopping of the spray and the burner, of course, was extinguished. The maximum carbon dioxide from this type of burner was found to vary between 4 and 5 per cent, 4.6 being the average. These conditions can probably be made more favorable by several adjustments, but it was found impossible by the author to keep the oil supply constant and change the amount of air supplied to the burner. In this type of burner, the oil supply, of course, depends upon the velocity of the air current.

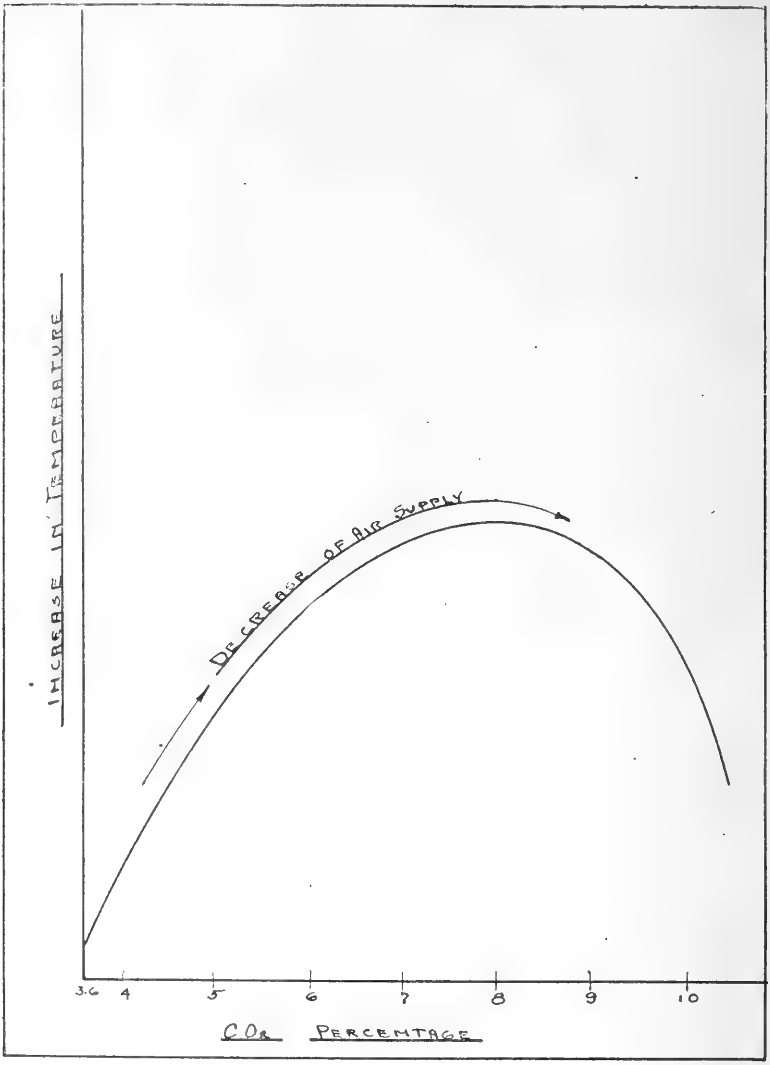
In the studying of the vaporization type of burner, the air could be controlled and the relationship of the temperature to the quantity of air necessary for the maximum efficiency was easily found. Figure 1 shows the relationship between the temperature and the percentage of carbon dioxide in the flue gas. The oil supply was held constant during these readings and the air supply was diminished. The maximum air supply that the burner could possibly use was used as a starting point and the readings were taken as the air supply was diminished. As is indicated on the curve, both the percentages of carbon dioxide and the temperature were found to increase to approximately 8.3% carbon dioxide. After that a quick break in the curve, indicating a lower temperature, shows that above this point, at least, the efficiency was quickly lowered on the carbon dioxide curve between 6.6 and 8.3%. There was only a comparatively small change in temperature, and this would indicate that an average in this range would be perhaps the most efficient in this condition. The conclusion from a study of the flue gases of the ordinary marketed types of oil burners can be summed up as follows:

1. A control of the air supply is very advantageous.

2. The air supply should be such that the carbon dioxide in the gas should come between 6.6 and 8.3%.

3. The construction of the burner should be such that a change in regulation would not affect the mechanical action of the burner.

4. An excess of forced air should be avoided because of the serious cooling effect it has upon the flue gas.



CHEMISTRY OF SEWAGE TREATMENT

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A recent conversation between an eminent scientist and a successful business man, which the speaker chanced to overhear, will serve to introduce the subject of this paper and to emphasize the need for greater general enlightenment in educated circles. Asked the scientist, "Is it possible to purify sewage?" "Oh yes," the business man replied, "We are building a sewage treatment plant for our town. I think it is to be some sort of an incinerator!"

Almost every chemical graduate has a general notion of how leather, rubber or Portland cement is manufactured, and even high school students of chemistry are likely to know how gas is produced and how water may be softened. These and other chemical processes are discussed both in the elementary and advanced texts on industrial chemistry. But the treatment of human and industrial wastes, while essentially a chemical process, is almost wholly neglected. Naturally, therefore, the scientifically trained student knows nothing about sewage treatment unless he has taken a special elective course.

In introducing the subject of sewage treatment I want therefore to say a few words about the amount and composition of sewage. Sewage may be defined as the combined water carried wastes of a city or community. In addition to the human and household wastes it may contain the by-products from almost any variety of industry; it may contain the washing from streets, and unless separate drains are provided it will include the surface run-off during rain.

In amount, the sewage includes the ordinary water consumption plus what is contributed from rain and other sources. The dry weather flow usually approximates rather closely the water consumption. This amount varies greatly between different localities. In Europe the sewage flow in dry weather will run from 20 to 40 gallons per capita per day. In this country it will be from

80 to 100 gallons for smaller residential communities and on up to 200 gallons per capita per day in some larger cities. This flow is not uniform throughout the day but rises and falls with the tide of human activities.

The amount of organic matter which is present in sewage is relatively small. Some notion of the concentration can be gained by imagining the total daily bodily wastes of one person plus his share of the industrial wastes diluted with from 100 to 200 gallons of water. Yet small as this amount of organic matter is, it must in general be reduced by 70% to 95% before the sewage may be discharged without offense.

The number of urban districts in the United States which have sewage treatment plants, or rather the number of those which do not have such plants will, I think, surprise you. Mr. Langdon Pearse, of the Sanitary District of Chicago, has compiled some interesting data in this connection which appeared as a committee report to the Society for Municipal Improvements. He states that of 68 cities in the United States of 100,000 population or over, including a total population of 27½ million, only 17 cities or a total population of 8¾ million have sewage treatment works. In other words, less than one-third of our larger cities treat their sewage. In the next group, in cities of 25,000 to 100,000, with a total population of 10 1/3 million, only about 12 per cent have treatment work.

As in the case in most young industries, the importance of technically trained operating personnel is not generally realized. The larger cities with treatment works employ a regular staff of chemists or at least a chemical consultant employed intermittently. Of the 26 cities of from 25,000 to 100,000 population with sewage plants, only six employ trained operators, while in cities under 25,000 anybody from the Mayor to the dog catcher may be detailed to look after the sewage works. This condition cannot long continue. Sewage treatment is a complex process and cannot be carried out successfully except under the supervision of trained chemists.

In discussing the manufacture of relatively pure water from the combined water carried wastes of a modern city

I want to invite your attention, first, to the raw material and the final product which must be produced; second, to typical factory layouts in which the process may be carried out; and third, to some of the chemical reactions which take place.

1. *Raw materials.* A general idea of the raw materials may be gained from the statement that the amount of sewage is very close to the cities' total water consumption. This ranges from 75 to 150 gallons in American cities per capita per day. In Chicago, due to the enormous waste of water, the consumption is over 300 gallons per capita per day. When the wastes from one person, even including his share of factory and trade wastes, are diluted with such a large volume of water it is apparent that the amount of organic matter per gallon of sewage is comparatively small. And yet it is exceedingly objectionable.

Sewage is most concentrated and the flow is greatest during the day. It drops off both in concentration and flow, reaching a minimum about midnight to 1:00 or 2:00 o'clock A. M. In addition to the hourly variation in concentration and flow, sewage also varies with the days of the week and the seasons of the year. In fact, so great is the variation in sewage that it is impossible to make a sufficiently reliable laboratory analysis of it. Where any considerable sewage treatment work is contemplated it is necessary to erect an experimental plant to try out various methods on a sufficient scale to allow for the effect of the numerous variables.

(2) *Typical factory layouts.* Although each plant must be designed to handle the particular local problem, there are certain steps that are usually made use of in purifying sewage. Time will permit us to mention only the two most important methods.

The new plants being built at Decatur and Urbana-Champaign may be taken as typical Imhoff tank and sprinkling filter installations. The sewage flows first through bar screens which remove larger debris of more than 2 to 3 inches in size. Next it passes through grit chambers in which large gravel, cinders, and grit particles settle out. Next it may be passed through some sort of fine screen. Screens do not happen to be used in the two new installations referred to. The sewage, still flowing at a fairly high velocity and carrying considerable matter in suspension, flows now into tanks where the velocity is reduced and sedimentation takes place. The tanks are of the so-called Emscher or Imhoff design, invented by Dr. Karl Imhoff and first used in the Emscher district of Germany.

The tank is a sort of two story affair in which the sedimentation takes place in the upper chamber. The sludge slips through the slot into the lower compartment where it is subjected to septic digestion. One of the features of this tank is the separation of a biolytic or digestion chamber. The vents at the sides allow the escape of gaseous products of digestion without stirring up the sedimentation chamber. This separate digestion of the sludge prevents the fouling of the liquor in the sedimentation chamber so that the effluent has a mild musty odor rather than the septic odor of the older septic tanks.

The effluent, now very materially improved and having no large floating particles but still with a distinct milkiness, may in some cases be discharged into the stream if the stream has sufficient volume. In most cases, however, it is passed through sprinkler nozzles on to a so-called filter in which the action is not one of filtering or straining at all, since the medium is broken rock of 2 to 3 inches in size. A slimy film soon develops on the surface of the stone, which acts in some way or other to take up all of the milky colloidal organic matter and oxidize much of the nitrogen to nitrate. The effluent of a trickling filter is perfectly clear, and it not only does not contain any putrescible organic matter but the nitrate constitutes what might be called an excess stability. The effluent is really of better quality than the water in many of our muddy prairie streams.

From time to time these filters "unload" a sort of black humus which usually is caught in secondary tanks of the Imhoff type. This process has for its net effect the digestion, liquifaction and oxidation of the organic matter, the end products being $(NH_4)_2CO_3$, NH_4NO_3 and a black humus containing 95% or more of water, and known as the sludge. This sludge is siphoned off from the digestion chamber of the tanks from time to time, drained on gravel or sand beds and hauled away. It is comparatively poor in nitrogen, most of that element having been converted into soluble salts. In some cases it is sold for as high as $2.00 per load.

The activated sludge process which is rapidly coming into favor substitutes an aeration tank and settling tank for Imhoff tanks and filters and is very much more compact.

The sewage, together with about 25% by volume of returned sludge, enters one end of the tank and the two are thoroughly mixed and aerated by means of air blown in through porous plates at the center and bottom of the tank. In from three to six hours the sewage is completely clarified, considerable nitrates are produced and the mixture passes on to settling tanks. The settled liquor is clear and stable and is discharged into the stream. The sludge, which contains 97-99% moisture, is partly returned to maintain the process while the remainder is dried and sold for fertilizer.

The sludge differs radically from Imhoff sludge. Activated sludge has practically the same chemical composition as microbial protein, containing from 7 to 10% of nitrogen. It is a very valuable fertilizer, but unfortunately no cheap method of drying it has been worked out. Much progress is being made by the Sanitary District of Chicago and elsewhere at the present time and the problem appears far from insoluble.

I have purposely avoided discussing the question of sludge drying from lack of time.

CHEMISTRY OF SEWAGE PURIFICATION

Two rather opposing theories have been proposed for the explanation of the reactions in sewage treatment, more especially the clarification and nitrification which takes place in the activated sludge tank or on the trickling filter.

The one is the Hampton Doctrine of Travis which Ardern summarizes as follows: "According to this theory the purification process is primarily and essentially a de-solution effect brought about purely by physical causes, and any bacterial or biological action is definitely ancillary." Dr. Remsen is quoted as saying that the value of a theory is to be judged by the experimental work which it stimulates. Judged on this basis the Hampton doctrine does not make much of a showing.

The other theory is that of Dunbar, with perhaps some modifications, and holds that the results are brought about largely by biological catalysts which produce biochemical reactions.

If one examines particles of activated sludge under the microscope he is impressed immediately with the fact that there is practically no adsorbed, precipitated or coagulated amorphous matter in these sludge particles, but that they are composed entirely of active growing microscopic organisms of varieties ranging from true bacteria up through the giant bacteria, with occasionally molds and yeasts, and including as well, a variety of free swimming and attached protozoa. These communities of microorganisms must obtain food, and this food must be supplied from the colloidal and dissolved matter and salts in the sewage. From what we know of the metabolism of microorganisms it is probable that the unicellular forms are absorbing through their membrane such soluble forms of organic matter as are able to pass through this membrane, and that they are also secreting enzymes which are capable of peptizing or liquefying colloidal particles too large to be directly absorbed. Protozoa, on the other hand, can easily be seen to approach and ingest visible particles of organic matter. This biological theory of the action of activated sludge might be summarized and emphasized by proposing what seems to be a rather striking analogy, namely, that the purification of sewage effected by microscopic communities appearing as flocs is entirely similar to that of disposal of garbage by feeding it to hogs. It does not seem probable that adsorption of colloids or mechanical precipitation plays any greater part in the metabolism of microorganisms than they do in the digestion of the larger animals. One serious objection to the colloidal theory of coagulation is that the colloidal particles in sewage and the activated sludge particles are, so far as we are able to determine, both negatively charged. Since adsorption of colloids is most effective between oppositely charged particles it should not be applied to the conditions of the activated sludge particles without reservation. Furthermore, adsorption is an almost instantaneous action, while considerable time is required for the activated sludge reaction.

The biological theory suggests a somewhat different notion of the importance of oxidation in sewage purification than that ordinarily expressed. When garbage is disposed of by feeding to hogs, only as much oxidation takes place as is required to furnish energy for the life processes of the hogs. Final oxidation does not take place until the pork chops are eaten and burned up in the body to furnish human energy. If the analogy of this process to sewage disposal is admitted, oxidation appears as an incidental reaction. Biochemical precipitation of colloids would appear to be the important phase of the reaction.

The Sludge-Digestion Spiral—In nature organic matter is worked over by succeeding generations and races of micro-organisms until a large percentage of it has been broken down to ammonia, nitrates and carbon dioxide, leaving a relatively small amount of black humus as a residue. The course of this reaction might be represented by a spiral. Suppose at a point A we start out with the dissolved and colloidal organic matter in sewage. Microbial spores then develop, producing bacteria, molds and sometimes even higher forms whose nourishment is drawn from the organic matter, until when we arrive at point B all of the organic matter has been taken up to form the living substances of the growths which develop. If these growths continue their life processes they produce a certain amount of carbon dioxide and ammonia, and then eventually die and decompose, bringing us to the point A′, where we again have dead and more or less liquefied organic matter. The distance from A to A′ would represent what some authorities refer to as the "wet-burning" or "moist combustion" which has taken place during the first lap around the spiral. If we continue to go round and round this spiral we eventually arrive in nature at a condition where a fairly considerable portion of the organic matter has been mineralized and a black stable humus substance remains.

Sewage treatment by means of biolytic tanks, sprinkling, or contact filters and subsequent secondary tanks gives us practically the result indicated by the spiral. The heavy solids are attacked and worked over by certain groups of bacteria in the sludge digestion chamber of the biolytic tank until practically nothing but a black humus remains. The liquefied product, together with the collodial and dissolved organic matter in the sewage, is taken in by the organisms of the biological jelly on the sewage filter. In this jelly the same spiral of activities goes on. A cross-section cut with a knife through the growth on the sewage filter stone shows on the outside the new whitish growth composed of various types of bacteria and protozoa. Just below this new growth there is a layer of less active dying or dead bacterial filaments upon which varieties of protozoa are feeding. These protozoa in turn die, and various forms follow, undoubtedly, including some of the same anaerobic forms which are active in the sludge digestion chamber of the tanks, which produce immediately adjacent to the stone a black stable humus. From time to time this humus sloughs off and is finally worked over in the digestion chamber of the secondary tanks. As a result of allowing this process to go on to the limit we obtain a relatively small amount of comparatively inoffensive sludge of low N_2 content, the N_2 having been largely converted into ammonium salts. The process, however, requires rather a large area for its practical application.

In the Activated Sludge Process, we start out with the idea that the sludge is a valuable fertilizing material, and therefore for the most economical operation of the process we should try to get as much sludge as possible. Since it is a biological process the course of the reaction will be along the course of the same spiral described above. But since we are going to considerable expense in order to provide a condition favorable for the growth of the microscopic life, namely, by blowing air into the sewage, we will waste considerable effort if we allow the process to proceed very many laps around the spiral. The most efficient process would seem to be one which removes the sludge as near the point B as possible; that is, as soon as a luxuriant growth has been developed and before any of this growth begins to die and decompose. This fact is the fundamental distinction between tank-and-filter treatment and activated-sludge treatment, the object of the former being to go round the spiral approaching the center as nearly as possible, that is with the maximum of wet-burning, while the latter should go only to the point B.

There is also a mechanical difference between the activated-sludge process and the tank-and-filter system. Hering has shown that the amount of purification is proportional to the surface exposed. Since it is necessary to use rather large stone in filters to avoid ponding or clogging, it is obvious that the ratio of surface to volume, that is the efficiency per cubic foot, is comparatively low, while in the activated-sludge process the floc surface is relatively enormous, being in the neighborhood of 500 sq. ft. of surface area per cubic foot of aeration tank volume.

It will not be possible to discuss all of the chemical changes which take place, but I want to consider briefly the nitrogenous compounds and the changes which they undergo. In this field we find that the chemistry of soils and fertilizers and the chemistry of sewage have gone hand in hand. Chemists in one line apply freely the advances made in the other. Although the chemistry of nitrogen and the changes which it undergoes in nature is one of the oldest subjects of chemical investigation we find that there is much misinformation in the literature and much still to be learned.

When bacterial enzymes attack the organic matter of sewage, progressive hydrolysis takes place with the formation of ammonia. This is known as ammonification and is brought about by a variety of organisms.

If aerobic conditions prevail, the nitrifying organisms oxidize nitrogen to nitrites and nitrates and the mineralization of nitrogen is complete.

These reactions are pretty well understood and in fact a matter of common knowledge among chemists. The fact that these reactions can take place in the reverse direction has, however, but recently been demonstrated.

If we start with nitrates we find that under anaerobic conditions they are reduced. This process is generally referred to as denitrification and most authorities state that denitrification results in loss of nitrogen. Experiments in our laboratory and elsewhere indicate that this is not true. Nitrates when reduced are synthesized into protein, the living protein of micro-organisms and bacteria. Likewise free ammonia in some cases decreases during the process of sewage treatment, but here again nitrogen is not lost but protein is formed. Thus we see that in sewage treatment we may have protein compounds undergoing hydrolysis, liquefaction and oxidation, or the reverse action may take place and protein may be precipitated.

The carbon and sulfur cycles are equally interesting but would be beyond the limits of the time alloted this paper.

THE INTER-RELATION OF THE SCIENCES

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The study of the sciences as unified and related subjects has an interesting analogy in the field of physical chemistry. Research in radio-activity and in atomic disintegration has led to a conception of the elements which points out a fundamental unity between them. Recent theories on atomic structure seem to indicate that atoms of helium are the most important components of the positive neucleus of every atom, and that differences in elements are not due to differences in matter but merely to differences in numbers and arrangements of these atoms of helium and the electrons which revolve about them. Now it is important to note that although the conception of elements was originally based on the assumption that there were different kinds of matter, this classification of simple substances is still justified not only by their obvious differences but also by their practical value to the chemist.

In the same way the sciences may be shown to be as closely related without detracting from the importance of the classification into departments. This classification is necessary because the general situations presented by nature are too complex to be studied as units. Nature presents an apparently simple phenomenon such as a rainfall, but history tells us that those who attempt to solve its mysteries without classifying its various aspects completely fail to arrive at valid conclusions. Mythical gods such as Thor, the God of Thunder, were invented to explain a situation too complex for their method of research.

Instead of drawing conclusions directly from nature's phenomena, the modern scientist idealizes certain aspects and studies them separately in the various departments. It was in accordance with this scheme that Mr. John Aitken discovered the importance of dust in precipitating a rainfall by passing steam into two large receivers, one filled with ordinary air and other with filtered air. The first was filled instantly with condensed vapor in the usual cloudy form while the other remained quite transparent. In the same way Schönben explained the fresh penetrating odor noticeable after an electric storm, by passing an electric spark through oxygen and identifying the same odor.

Although our classification is entirely justifiable we must remember that nature has no such scheme in mind when she provides her phenomena, and consequently most of them do not fit conveniently into our water tight compartments. We have a good example of this in osmosis. Its character and explanation is physical, but its importance comes in chemistry, as a proof of ionization, and in biology where it explains the rise of liquids in the roots of plants and trees.

It is because our classification is more artificial than natural that we are constantly finding relations between the sciences. Each science depends upon the others, and examples of this interdependence are numerous.

The fundamental conceptions of chemistry are physical in character as well as in the method of arriving at them. The atomic theory is undeniably physical, but, at the same time it is true that its proof is based on contributions from both sciences. Historically, the chemical law of combining weights was a strong factor influencing its adoption, but recently the objective reality of the atom has been established by calculation of its mass and dimensions from data obtained from radium emanation. The close approximation between results obtained in this way and those from more indirect methods is the physicist's proof of the atomic theory.

Other chemical conceptions are greatly enriched by considering them in the light of sub-atomic physics. Oxidation in chemistry originally was a narrow and restricted term which included only the addition of oxygen to metals. If oxidation is kept entirely within the field of chemistry, there is little possibility of broadening its meaning. It is true that it may be defined as the increase of positive valence, but where these valences come from is a problem of the physical chemist. We now define oxidation as the loss of electrons with the result that not only has the scope of the term been enlarged but the very nature of its mechanism has been determined. Now oxidation is based on the ability to lose electrons so that whether it will take place in a given case can be predetermined by referring to the electromotive series which lists metals in the order of their ability to lose electrons.

Helium is an element which forms no compounds. The chemist would say that this is because it is inactive, but the physical chemist has gone much farther when he explains it as due to the inability of helium to lose electrons and thus gain a positive valence, while the phenomenon is entirely accounted for by the sub-atomic physicist who says that the helium atom is composed of a positive neucleus and negative electrons which swing in an orbit which is in perfect equilibrium, so that there is no tendency for an electron to leave it.

Probably the most obvious contribution of physics to chemistry is in apparatus embodying physical principles. Whenever chemical changes or properties are not directly observable by the senses, the physical instrument is a necessary medium. When the hands cannot detect heat we use a thermometer; when the eyes cannot perceive the arrangement of the atoms within a crystal, we use X-ray diffractions to interpret this arrangement.

The spectroscope is a true product of the inter-relation of physics and chemistry, first because it was the outcome of joint research by a physicist, Kirchoff, and a chemist, Bunsen, working together in the same laboratory, and second because it has found application in both fields. To illustrate, Bunsen applied it to the analysis of water of certain springs and thereby discovered two new elements, caesium and rubidium. In the hands of Kirchoff it explained the dark lines in the sun's spectrum as being due to absorption, and as a result it became the means of determining the composition of other planets.

Another physical instrument of value to the chemist is the polarimeter. This apparatus is used for measuring the degree which an optically active substance will rotate the plane of polarized light. Its importance to chemistry came when it was found that some substances with the same formula, which had hitherto been considered identical, differed in their effect on polarized light.

For example, lactic acid from beef extract rotated the plane to the right, being dextro-rotatory; lactic acid from the fermentation of milk sugar, with a certain ferment, was levo-rotatory, while the synthesized product was inactive. The chemist usually explains such isomers by a difference in arrangement of the atoms, but in the case of lactic acid only one structure could be conceived, unless, as Van't Hoff suggested, spatial relations were considered. So the immediate importance of the polarimeter was the incentive to study organic structure.

The inactive lactic acid referred to was found to be a mixture of the dextro and levo forms, so that the problem arose of separating them. In most cases the chemical and physical properties of two optically active isomers are the same except in their effect on polarized light, and so the usual method of separation based on differences of properties was difficult to apply. But here biology made an important contribution in the form of certain bacteria, which, when introduced into the mixture, would destroy one and leave the other. These living cells secrete complex proteins called enzymes which catalyze organic decomposition in order to use the energy liberated. Now in accordance with laws of evolution each organism will be provided with the enzyme which can attack the substances it finds in its environment, and consequently one which will be indifferent to most other substances. The mould penicillum glaucum is thus capable of destroying levo-lactic acid but is indifferent to the dextro-form, so that when it is introduced into the mixture, it will leave only the latter acid.

Aside from this practical value the study of enzyme catalysis is of the greatest importance in biological chemistry. The value of a compound as a food is largely dependent upon its ability to undergo decomposition, and since these decompositions are brought about in many cases only through the agency of certain enzymes, the question of food value becomes largely one of whether the necessary enzyme is present. The enzyme's selection of compounds has been shown to be according to the stereochemical structure of the molecule, and so one of nature's most fundamental processes, that of digestion and metabolism, may be quite as much chemical as biological.

Other complex problems of biology can often be simplified by resolving them into their physical and chemical components. Professor Lillie has shown that nerve currents, the biological basis of psychology, are essentially electrical and chemical in nature. Also, Sir Wm. Bateson, an eminent authority on evolution, believes that all its theories must be in accordance with facts of physics and chemistry. It is from this point of view that mutation, the act of differing from parent to offspring, has been resolved into problems of these two departments. Crystallization, diffusion, electric or magnetic lines of force, and harmonic vibration are factors which make for similarity between organisms from the same source; so that to find conditions which would modify these factors is to form a basis for the explanation of mutation. The contribution of physics has been such conditions as temperature and pressure, while the chemist has been studying the effect of colloids on crystallization, all of which show that mutation is not as obscure a process as it appears on the surface.

The biological discovery of insulin as a cure for diabetes had little practical value until the chemist had worked out a method of preparing it in quantity. The biological method was to extract it from the pancreas of a dog, by first destroying the pancreatic juices in order that they would not digest the insulin. Since this process required six months it was impractical, and the problem was turned over to chemists. After a year of research they were able to prepare it from the sweetbreads of cattle so that now the industry is able to supply the 18,000 people in the U. S. who take insulin daily. The function of insulin is to destroy the excess sugar in the blood, and the amount administered must be exactly in proportion to this excess, for an overdose of insulin is harmful to the patient. The difficulty is that in a given dose the amount of pure insulin is not known, so that its strength has to be determined by injecting it into a rabbit and measuring the amount of sugar destroyed. The present problem of the chemist is to prepare a compound of such purity that its strength will be known directly, thus eliminating the trial and error method.

We have thus shown how each science is dependent upon the others. It may have become evident that whenever one science has contributed to another, the contribution comes back much more useful to its original department. The chemist borrowed the electron theory from the physicist, developed it as an explanation of oxidation, then returned it to the physicist much more valuable because now he could use it in explaining the Voltaic cell and the storage battery. In the same way the spectrum came back to the physicist in the form of the spectroscope which he could use in explaining the dark line spectrum of the sun and in determining the composition of other stars. The biologist's knowledge of enzymes was greatly increased by loaning them out to the chemist for use in stereochemistry. Biological methods could never have found that the ferment's choice of foods depends upon so insignificant a thing as the interchange of a few hydrogen and hydroxyl groups.

It is such illustrations as these which show that if the inter-relation of the sciences is put to practical use, as is being done in the border-line sciences, it will lead to a greater exhaustiveness and accuracy in scientific research.

PAPERS ON GEOGRAPHY AND GEOLOGY

THE AIM IN TEACHING FOREIGN GEOGRAPHY

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Traveling is likely in the future to become increasingly frequent, as governments will cease to hinder and will begin to recognize that it is to the public interest for more people to meet and mingle with those of other nations. Seeing this, the authorities will begin to aid travelers to remove natural obstacles, instead of putting artificial ones in our way.

The greatest need for all travelers is knowledge of every kind. He who knows the most before he starts will learn the most on the way. Over the door of the Union Station in Washington is this inscription: "He who would obtain the wealth of the Indies must carry it with him to the Indies."

2. The study of foreign peoples should develop the appreciation of the real brotherhood of mankind, our mutual interests, and our true interdependence.

3. The course should make plain and rather dwell upon points in which other peoples excel our own. There should be much comparison of natural resources, climate, and manufactures. Our geographies make the United States too much the center of the world and minimize the relative importance of other countries. It does us good, therefore, to get hold of a British atlas, or to refer to a Japanese chart, or a German guide book, or a French or Dutch colonial publication with a different world view. It is something to stir us out of narrowness to realize that every new day starts in Japan, while Europe and, later still, America are finishing up the preceding day.

4. Differences of religion, custom, and faith should be presented without bias or prejudice, as likewise differences in climate, dress, resources, and manufactures. Somehow or other, most of our pupils get the idea that foreigners are ignorant and stupid, inferior to ourselves in ability and inheritance. Perhaps ninety percent of what we teach about other races involves the assumption that they are inferior to our own, and is more cal-

culated to instill prejudice than to lay the foundation for mutual understanding.

5. All of our ideas of the shapes of countries come from maps and models, and likewise nearly all our ideas of their size. While, however, we learn the shapes correctly, we fail woefully in getting a correct idea of the relative or the actual size of foreign countries or of distances between places. This is due directly to having such a variety of scales to our maps that our resultant memory image has shape only, but no scale by which we can calculate or think size adequately.

To most of us, our Western States are thought of as too small and New England as too large; we think Great Britain as relatively too large and Russia as too small. Europe is too large and Asia is too small in our mental map to enable us to make true comparisons. For illustration, Missouri and Washington are each larger than all of New England, but do they seem to have that size in our thought? The Yellowstone National Park is about the size of Porto Rico and is larger than Rhode Island and Delaware combined. Java has the same area as England, and Ceylon is half as large. Maine is larger than Ireland. New Zealand is considerably larger than the Island of Great Britain, with England, Scotland, and Wales. Formosa is larger than either Maryland or Holland. Borneo is larger than Texas. India stretches as far as from the mouth of the Chesapeake to Panama. Korea is larger than either Idaho, Minnesota, or Utah. From Peking to Canton, China, it is about as far as from Duluth to New Orleans.

How many of us think of these countries in their true size? It is a great deal as tho we used a pair of field glasses in looking at part of the earth's surface and then reversed the glasses and looked thru the other end at other countries. It is thru this sense impression from maps of varying scales that our minds are furnished with memory images that are inconsistent with reality. The scale of the maps in our atlases and on our wall charts is determined chiefly by the convenience of the printer and the cost in making the pages of uniform size and therefore of varying scale. The price we pay is utter confusion in our source impression of size.

Scales should be standardized into one uniform set of scales, easily transferable from one into another; e.g. 100 miles to an inch, 50 miles to an inch, 20 miles to an inch, 10 miles to an inch, and 1 mile to an inch. It should be possible to get a map of any country in any of the standard scales. This would make possible direct comparison of size by superposition of the maps. Such scales as 6½ miles to an inch and 22½ miles to an inch, simply should not be used, because the distances on such a map will not be translated into miles. Recent publications are moving in this direction, but confusing scales are still very abundant.

STREAM POLLUTION, A GROWING MENACE TO WATER SUPPLIES

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The pollution of the streams of Illinois by sewage and factory waste has reached a point where a statewide protest should be formulated and a campaign organized to reduce the present evil and to prevent further increase. The public must be informed and positive action must be taken. We seem to have ample law and no fault is found on this score; we have a State Board with power to act, and we have no desire to criticize the Board. Stream pollution is largely the result of indolence and ignorance, which do not take into account the effects, and which seek the easiest way of getting rid of waste and sewage. A late report of the Illinois Department of Health says: "Contaminated water is a mighty dangerous enemy." It is time that attention be given in every institution and every commercial body of the State to the menace that this indiscriminate practice constitutes.

First I will emphasize the fact that the time is approaching when as much as possible of the water that falls from the clouds must be conserved for animal and vegetable and industrial consumption.

In my own county last year a great railroad company was forced to haul water from an artificial reservoir forty miles away; an electric light and power company was reduced to an extremity to procure an adequate supply of the right kind of water; farmers were compelled to haul water for stock, streams were so dry that one could walk on their beds, and municipalities were at their wits' ends to obtain water fit to use and in ample quantity. The procuring of unspoiled supplies is each year becoming more difficult.

The source of our supplies is the rain. Is it possible to formulate a policy by which a larger quantity of this may be made available before it is contaminated with organic, animal or mineral impurities? Authorities give the average annual rainfall for the State at thirty-five inches. In years of maximum rainfall, a total of fifty inches or more may be precipitated, while in years of least rainfall the total may not be more than twenty-four inches or even less. It is in these years of least rainfall that the need of conservation of water becomes most apparent, and when the effects of pollution become most acute and dangerous.

Drift formations of various depths cover most of our State and the yellow clays, sands and gravels absorb water which is diffused through their layers. Below the yellow clay lies a blue or bowlder clay that as a rule is impervious to water. Part of the rain sinks through the soil and subsoil into this yellow clay, which thus over a large area is a water bearing stratum. Water is retained in it because of blue clay underneath. This underground reservoir is not by any means inexhaustible, although our State report properly calls it our largest and most valuable supply, and surface wells over much of the State extend into it. The level in this formation has been lowered, and it can no longer be relied upon, as in pioneer days, to meet the increasing demands. Professor J. A. Udden in one of the early Bulletins says: "The general level of the ground water is being lowered." As early as 1908, the Bulletin spoke of the insufficiency of the yellow clay supply.

Another important consideration is that the widespread tile drainage of the surface has accelerated the run off so that not so large a quantity of water as formerly reaches the yellow clay. In a general way one can figure this run off at nearly one-third of the precipitation. It is estimated that nearly one-third is evaporated and at some seasons the proportion is greater. This leaves about a third to sink into the water bearing clays, sands and gravels, and a portion of this seeps out along the edges of the blue clay into the streams or breaks out in springs. Or very great economic importance, therefore, is what becomes of the portion that seeps into the clays or runs into the streams. It is on this that man and all other animal and even vegetable life must depend for most convenient supplies.

In the State Bulletin of 1913 it is stated that "With very few exceptions there are no sources of water supply in Illinois that are free from possible contamination." Again it is declared that "all running streams are in danger of pollution." To this it can be added that many of our streams are now polluted.

The report of 1917 listed 433 municipalities with water supplies, of which 189 are from rock wells; 149 from drift wells; 67 from streams; 22 from Lake Michigan, and 10 from springs. To these must be added the tens of thousands of drift wells on private premises. One must also consider the hundreds of municipalities that do not yet have public supplies and whose needs must be kept in view.

Let us take first the pollution of the run off as exhibited in our streams. This is accomplished by the contamination of watersheds as well as by the discharge of waste and sewage into the channels. Cedar Fork, a small stream that flows through Galesburg, furnishes an illustration. Untreated sewage and much waste go into this and render the water foul and exceedingly offensive. These putrid discharges poison the water for eight to ten miles below the city. Estimating the watershed of the creek at seven square miles, when it crosses the west city limits, this creek would have in a year of average rainfall a run off of 1,500,000,000 gallons of water, with seepage of possibly a quarter of a billion more. Sewage renders all this absolutely unfit for use. If this water were conserved and impounded the gas company and other industries along its banks would have an ample supply. As it is, not a frog will venture into it for miles below the city and fish life was long since extinguished. Live stock will not drink the water and the stream, which might be an asset, is changed into a liability to the farmers.

This is not an isolated case by any means. Because it is easiest and cheapest, cities and factories all over the the State are using streams as open sewers and receptacles for waste. Neither lake, river or creek is spared. When we are discussing this, we naturally think of Chicago, but after an investigation I am convinced that most of the cities of the State, little and big, are equally guilty and that poisoning of the water that falls pure from the clouds is nearly a general practice.

Let us take the pollution of the Illinois river, a stream once renowned for its beauty and charms. Through the drainage canal it receives much of the sewage of Chicago, and is so befouled by this that even the bottom of Lake Peoria, far down the river, has its blanket of filth. The main tributaries of the Illinois are the Kankakee, DesPlaines, Fox, Vermillion, Mackinaw, Sangamon, and Spoon rivers and Crooked creek. The report of 1921-2 says: "The conditions of the sewage of the Illinois river are more pronounced than ever before."

The Fox river valley is quite thickly populated. The large cities of Elgin, Aurora and Ottawa use this as a sewage channel, not to mention smaller towns that find it a convenient depository. The discharges of twelve Elgin sewers pass into the river. Elgin is, however, building a sanitary sewer system. Aurora has nine sewers connected with the channel and there are sewer outlets from various private and manufacturing plants along the river, without treatment. Aurora is said now to be agitating a drainage district. An effort was made by the Rivers and Lakes Commission several years ago to abate the nuisance but the war interfered.

The DesPlaines river is polluted by the sewage of Joliet and by its factory waste. The corrupt condition of the Sangamon river is in the reports deemed a special object of concern. The sewage of Springfield and Decatur goes into it. The report of 1918-19 declares that Sangamon river is greatly polluted below Decatur. Decatur now has a million dollar sanitary sewer system, just completed, and that will take care of raw sewage and waste save in times of flood. Jacksonville and Bloomington empty their sewage into creeks but it finds its way into the Illinois river. The Kankakee river receives the sewage of Kankakee and there are other towns along it that may contribute toward fouling it.

Both Streator and Pontiac on the Vermillion river use it for sewage and waste purposes. In the State report of 1920-21 special mention is made of the foul condition of the river at Pontiac. Another comment is that "During a large part of the time, the Vermillion river below Streator consists only of sewage, industrial waste and mine water." We understand that Pontiac has built a disposal plant and that Streator is considering one.

Peoria is on the Illinois river, and its sewage and waste go into it. We have the authority of a fish and game official, familiar with the condition of the river there, that when the water is low the stream is in a foul condition and that the fish are liable to be affected injuriously.

It seems unnecessary to multiply instances, for this is enough to indicate the extent to which the Illinois river system is being used for sewage purposes. Practically all the large streams that flow into it receive more or less sewage. Although a state wide, detailed survey has not been made there is reason to believe smaller municipalities also are polluting the tributaries, so that from all parts of the river basin filth and industrial waste are being conveyed to the main streams and thence to the river itself. In its 1921 report the Commission says: "During the last year complaints have been received from numerous farm organizations, where streams have been so polluted by industrial waste or city sewage as to prevent their natural and lawful use for agricultural or other legitimate purposes."

Specific mention is made of conditions at Joliet, Ottawa, Seneca, Morris and Elgin. It is stated that the Desplaines and Illinois rivers are badly polluted and for years have been unfit for bathing or domestic uses, or for stock, and the fish industry has been completely destroyed as far down as Peoria. The stench at times in the summer is offensive and also a damage to navigation. Several States have laws regarding sewage treatment to avoid stream pollution. Such a law would be a progressive step in Illinois of a great public benefit."

The Mississippi river we have heard referred to as an open sewer. One will not allude to what other States are doing to it. It is enough to speak of the offenses against it in our own commonwealth. The Father of Waters must forsooth be forced to hold his nose when a whiff comes his way.

At Quincy, the sewage is emptied into the river above the city water intake, which, however, is far out in the channel. The sewage and factory waste of Moline, partially treated, go into the tail race and then into the Mississippi river channel at Rock Island. Rock Island pours the contents of its sewers into the Mississippi. The sewage and waste of the large city of East St. Louis are conveyed into the Mississippi river below the city. Alton finds the river a convenient receptacle for its waste and sewage. Cairo's sewage and waste pour into the Ohio and then into the Mississippi river. Other cities along both sides of the river from the north end of the State are abusing this magnificent waterway and contributing to its contamination. In low water the river is for weeks and even months likely to be a foul and filthy stream.

Tributaries that flow into the Mississippi river are polluted also. Take Rock River, one of the most picturesque rivers in the state, whose banks have been noted as picnic grounds. One of its tributaries is the Pecatonica river, and within the city limits of Freeport raw sewage flows into it in five places. This includes factory waste. Rockford, the main city on the river, known for the extent of its industries, turns its sewage into the river, and the report for Sterling, another good sized city, is of the same nature. All this sewage must tend to make the river less desirable and a menace. Belleville, not far from the Mississippi, uses a small creek for sewage in part, although it has a disposal plant. Shelbyville reported, "We are emptying everything into the Kaskaskia", and a similar answer came from Vandalia. On the other side of the State one finds Danville emptying its sewage into the Big Vermillion.

In nearly every case the reports make the statement that the rivers and streams are too foul to use as sources of supplies without treatment. In the state department report for 1919-20 we find this strong statement: "Stream pollution is depriving the public of the legitimate use of the water therein. For years streams not only in Illinois but in many states have been accepted as a natural means of sewage disposal. Increased development and growth of population have resulted in a load of sewage or industrial waste that the streams can no longer carry with due regard to public health or to the use of the streams for stock on the farm". It is but simple justice to say that several of these cities are taking steps that may lead to the installation of disposal plants. Decatur and Elgin are leading the way, and my own city is agitating this question. One of the chief difficulties is in getting the people to vote the necessary funds.

In the 1923 report of the proceedings of the annual meeting of the civil engineers of the State is found an address by Paul Hansen who enumerates 103 disposal plants, and makes the comment that many of the plants are neglected, ten of them abandoned and eleven overloaded, disclosing that efficiency in many instances is far from maintained.

Thus is the run off from practically one-third of the rainfall, expedited by tiling and sewers, seriously affected, and the citizens of our State are being deprived of many billions of gallons of water annually. Cities are finding it increasingly difficult to find a stream of sufficient size to serve as a supply, when impounded, owing to the unsanitary condition which may extend even to the watershed.

Judging from the reports at hand it is the common practice of cities to create a reservoir on a stream and empty the sewage into the stream at some point below the reservoir. The next town below finds itself short of water and becomes aware that the city above is using the river for a sewer. But it builds its dam, and erects an extensive purifying plant, expecting that chlorine and other chemicals will protect the lives of the people, and in turn conveys its sewage to a point below its dam, thus contaminating the water for the next town below. This goes on for the length of the stream. The health of each of these places depends upon the efficacy of the purification plant, and any imperfection in this that causes raw water to get into the distributing system is likely to result in serious epidemics. Some of our Illinois cities have had sad experiences along this line. Polluting a river for the city next below is a great deal like poisoning your neighbor's well. Cities that have deep wells or spring supplies are likely to show least responsibility. One might cite Rockford, Freeport, Peoria, Aurora and Joliet.

Illinois is not all equally favored. South of a line running east and west through Champaign, water, according to the 1914 Bulletin, is seldom obtained in large quantities either from deep rock or the drift, and such ground water usually is very hard. Some exceptions exist in Southern Illinois; but it is frequently the case that there is no choice but to adopt a surface supply in the south half of our State. This means the impounding of water, and this enhances the importance of maintaining the streams in an uncontaminated condition.

On the other hand many of the cities in the north half of the State are not obliged to resort to ground water due to the accessibility of deep rock supplies. These waters, as a rule, while fit for domestic uses, are not adapted to industrial purposes without treatment, due to the mineral content. Impounded surface water is generally much preferred and hence the large use of impounded water for boiler and other mechanical uses.

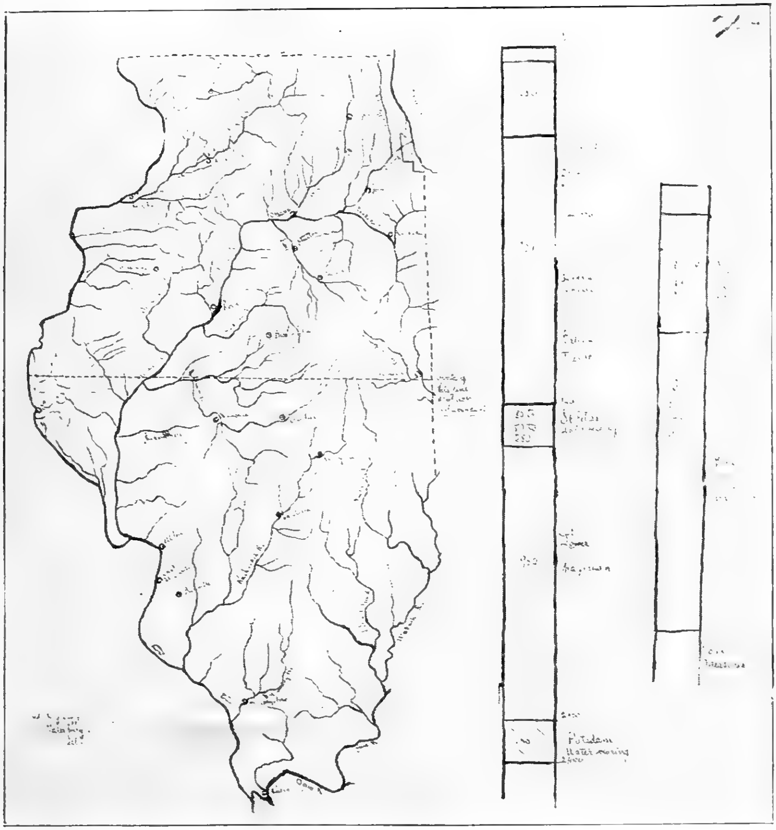
In the north part of the State two formations are recognized as fairly sure sources of supplies, and water may be found in others but not with the same degree of certainty. Sometimes it may be too heavily charged with minerals even for domestic uses. These two formations are the St. Peters and the Pottsdam. The former underlies much of six states and is regarded as one of the most remarkable water rocks in the world. Scores of municipalities procure their supplies from this formation, but the State reports indicate that constant pumping is gradually lowering the water level. The Pottsdam formation lies below the St. Peter's and is separated from it by the Lower Magnesium. Observation, however, indicates that the water level in this is also being slowly lowered.

Thus there is raised the question whether these rock supplies are inexhaustible and whether finally a dense population will not even in the north part of the State have to rely upon the surface and ground supplies; in other words on the rainfall. The question in view of the possible decline and the often quick exhaustion of the ground supplies in a dry season relates not merely to the preservation of the purity of the surface water but to its conservation.

Take Knox, my own, county. In it are 440 streams, little and big, enclosed between ranges of hills. Many of these streams could be dammed and the water preserved. We have built up a wonderful system of surface drainage that empties the surface layers of their water, more rapidly than formerly, and hastens exhaustion of the moisture so that crops suffer. Last year the drouth cost Knox county farmers a third of their corn crop. With reservoirs there could be at least partial irrigation. Even Congress has considered means of impounding water so as to prevent destructive floods. It is estimated that in Knox county, an annual rainfall of thirty six inches means the precipitation of four hundred and fifty billion gallons of water on its surface, and the immense run off of 150,000,000,000 gallons, if not more in flood years, goes on its way to the ocean, while during the dry season the beds of the streams may be dry. It goes without our making use of it.

Illinois has some good laws on the subject of stream pollution but in view of existing public sentiment it is difficult to apply them. For instance, the Statute provides that, "It shall be the duty of the Department of Public Works and Buildings to see that all the streams and lakes of the State of Illinois, wherein the State of Illinois or any of its citizens have any rights or interests, are not polluted or defiled.

"It shall be unlawful for any persons, firm or corporation to throw, discharge, dump, or deposit, or cause, suffer or procure to be thrown, discharged , dumped or deposited any acids or chemicals, industrial wastes or refuse, poisonous effluent, or dye stuff, clay or other washings, or any other substance deleterious to fish life, or any refuse matter of any kind or description containing solids, substance discoloring or otherwise polluting any navigable lake, river or stream in this state, or lake,



The state map in a general way shows the drainage system of Illinois and the cities that are the principal sources of stream pollution.

The deep well geological section shows the formations passed through in borings at Galesburg and vicinity that reach to the Potsdam. The other section is of the surface formations in Knox county, and with some variations will apply to much of the State.

river or stream connected with or the waters of which discharge into any navigable lake, river or stream of this State or upon the borders thereof, or any water-course whatsoever." The drainage district for Chicago and the Desplaines river are made exceptions.

It was also provided by the Fifty-second General Assembly that it is necessary to submit plans and obtain a permit from the Division of Waterways before any work can be done legally toward the construction of a sewer outlet for the discharge of sewage into a lake, stream or water course of the State.

In all this I have been trying to show:

First—That under the present methods, ground supplies are not adequate the year around.

Second—That the usability of our surface waters represented by our streams is lessened by their pollution by sewage and factory waste.

Third—That the available supply could be increased by the suppression of such pollution and the enforcement of a law that would compel cities or permit them to provide for the disposal of sewage and waste. For the good of all, municipalities must be taught to observe sanitary law.

Fourth—That sewage and waste pollution of the streams is a menace to health, a source of disease, and renders water unfit for use, and constitutes a public nuisance, besides killing aquatic animal life and making the water a possible source of disease to domestic animals, which may communicate it to man.

Fifth—That conservation, checking flood waste, would probably carry the supply through the heated season and save much expense and trouble.

Sixth—That the uncertainty attending the life of deep well supplies makes the saving of surface supplies all the more important.

It seems to me that it would be well for us to urge the legislature to provide the State Water Board with an appropriation sufficient to enable it to make a comprehensive survey of the extent of pollution of Illinois streams and to formulate the most practical remedies. In the meantime, I believe that the systematic education of the public should be undertaken and that they should become informed not only of the dangers of the indiscriminate use of our streams as open sewers and waste receptacles, but also of methods of conserving rainfall and making more of it available. It is a subject that could be pursued to advantage in our schools. Our streams should not continue to serve as cess pools, but should be converted back to their original state of wholesomeness.

COAL BALLS HERE AND ABROAD

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A coal ball is a calcareous or siliceous coal seam concretion which frequently contains recognizable plant fragments.* These plant fragments have furnished our entire knowledge of the inner structure of paleozoic plants. They have been observed since 1835 in England where Williamson used them in his monumental studies of fossil plants since 1875, a work which was continued by D. H. Scott in England, C. D. Bertrand in France, and many others.

The existence in America of coal balls was suspected by the author who succeeded in obtaining in 1922 the first specimens of genuine American coal balls. These came from Harrisburg, Illinois; later good specimens were found in Danville, Illinois, in Calhoun (Richland County), Illinois, and in Streator, Illinois. Other American deposits are in Iowa where coal balls showed up at DesMoines, Indianola, and Chariton. Good specimens were also collected by the author near Sturgis, Kentucky, and at Cayuga, Indiana. They were found outside of England, France, and America in Austria, Germany, Russia, Czecho-Slovakia, Poland, and Australia.

Of the American coal ball specimens from Harrisburg, Danville and Calhoun thin sections have been made in the botanical laboratory of the University of Chicago. The following genera of fossil plants were observed and their structure carefully examined:

Harrisburg—
- Sphenophyllum stem
- Lepidodendron stem
- Lepidodendron sporangium
- Stigmaria and rootlets
- Anachoropteris
- Angiospermophyton
- Root with spongy tissue
- Fern sporangia and spores
- Calamites leaf, probably in all three places.

Danville—
- Lepidodendron stem
- Lepidodendron sporangia
- Stigmaria and rootlets (few)
- Sturiella minor
- Fern sporangia
- Root with spongy cortex
- Peculiar leaf
- Calamites leaf

Calhoun—
- Sphenophyllum stem
- Calamites stem
- Bothrodendron stem
- Microsporophyll and sporangium
- Megosporophyll and sporangium
- Stigmarion rootlets
- Numerous multeseriate fern, sporangia with spores
- Lyginodendron stem

* Jose Maria Feliciano, *The Relation of Concretion to Coal Seams* (Journal of Geology, Vol. 32, pp. 230-239, 1924.

The results of these investigations are being published by Dr. G. H. Hoskins and Miss Fredda Reed in the Botanical Gazette. The most important of these discoveries was the appearance of a paleozoic angiosperm in one of the Harrisburg Coal Balls.* Among the unpublished material are several other angiosperm specimens which make the existence of angiosperms in the paleozoic beyond question.

Our entire knowledge of the inner structure of paleozoic plants has been based upon English and French coal balls. It is to be hoped that the American coal balls which have come under observation will contribute in the near future as rich material as was obtained formerly from England and France, and that our knowledge of plant structure will in this way be greatly enriched from American sources.

* J. Hobart Hoskins: *A Paleozoic Angiosperm from an American Coal Ball,* The Botanical Gazette, Vol. 75, pp. 390-399.

GLACIAL PHENOMENA IN THE VICINITY OF CARBONDALE

J. E. Lamar, Illinois State Geological Survey, Urbana

The area particularly discussed in this paper is that of the Carbondale quadrangle, in the northwest corner of which the town bearing the same name is located. This quadrangle may be roughly divided into three topographic units according to the bed rock formations which underlie these units respectively, as shown in the accompanying figure. The northern unit is that underlain by the Carbondale formation, composed of sandstone and shale, which when eroded, gives rise to a gently rolling surface. The central unit, which is by far the largest of the three, is underlain by the massive sandstones and shales of the Pottsville formation. This part of the quadrangle is very rugged and constitutes a portion of the Illinois Ozarks. Sandstone bluffs and cliffs are numerous. The southern unit of the quadrangle is that underlain by the limestones, shales, and sandstones of the Chester group. It has a varied topography. In places it is like the northern unit, and elsewhere like the central unit, particularly in the areas where some of the prominent cliff-forming sandstones are well developed.

The north three-fourths of the quadrangle drains to the north; the south one-fourth to the south. The northward drainage eventually merges in Craborchard Creek, which flows westward across the northern part of the quadrangle, but turns abruptly to the north in the northwest corner to join Big Muddy River.

The Illinoian glacier spread over the northern half of the region just described. It came dominantly from the north and perhaps a little from the east. The ice of the glacier was probably porous and much crevassed from the buffeting against the hills of the country over which it had passed, and its advance was seemingly very slow. The rapid melting and pronounced deposition which accompanied the formation of the terminal moraines of the Wisconsin ice were essentially missing. The melting of the Illinoian ice seems to have been comparatively slow. The ice moved over the rolling topography of the northern unit of the quadrangle without great difficulty, but when it encountered the rugged upgrade slopes of the Pottsville unit, the forces which were pushing it ahead seem to have been insufficient to send it completely up the grade. The southward progression of the glacier, therefore, is thought to have ceased more because of a lack of motion of the ice itself rather than to the predominance of melting over ice advance. There was probably a geologically brief period when the advance and the melting back of the ice were equal and the margin therefore maintained a fairly constant position. During that time deposits accumulated at the ice front in thicknesses somewhat in excess of those formed elsewhere in this region, but in this rough topography did not form a prominent moraine.

The first important event in the general glacial history of the region was the shutting off of the drainage of Craborchard Creek from Big Muddy River. It is not known where the ice first interrupted the drainage of the creek, whether near Big Muddy River or farther up stream, but eventually the result was the same. All the precipitation as well as the water from the melting of the glacial ice was therefore ponded in that part of the valley of Craborchard Creek not occupied by ice and its tributaries until it became high enough to cross the divide at the headwaters of the creek some 20 miles east of Carbondale near New Dennison. Just how high the water stood in the valley can now only be approximated, but it certainly stood as high as 435 feet above sea level, for that is the present height of the New Dennison col. The maximum depth of the lake was about 100 feet. With the continued advance of the ice, certain northward flowing tributaries of Craborchard Creek were cut off from the main stream and became local lakes. Some of these lakes at times found exit across divides into neighboring valleys which still discharged into Craborchard Creek. Two cols which were produced in this fashion, but probably during the early stages of Lake Craborchard, occur in Secs. 1 and 2, T.10 S., R.1 E., where the waters of Little Grassy and Caney creeks probably crossed the divide into Sugar Creek and thence joined the main drainage.

During the existence of these lakes, deposition of materials from the melting ice was constantly going on. In the Craborchard lake, which was probably by far the largest on this quadrangle, it seems possible that unstratified gray clay accumulated in portions of the lake basin where deposition was continuous. From time to time boulders and pebbles fell from bergs and ice blocks floating about on the lake and became imbedded in this lake bottom clay. Thus it is possible that some of the gray clay till-like material which contains sparse pebbles may have originated. This method of origin does not, however, preclude the probability that the greater part of the gray till was formed in the commonly accepted fashion, but is merely a suggestion as to how a very similar sort of deposit might have been formed under special conditions.

In the smaller lakes and the larger lake alike there were deposited in considerable thicknesses statified materials composed for the most part of sand and silt. There is some gravel found with these sands and silts, but it occurs in lens-like deposits, some of which seem to have been built up as small deltas where comparatively rapid moving water entered a quiet body of water. In some of the smaller valley lakes in the central part of the quadrangle, fifty or more feet of these sands and silts accumulated. They are commonly underlain by pebbly clay till, and in places have this material intercalated with them. The valley of Sycamore Creek, in the eastern part of T. 10 S., R. 1 W. particularly, has excellent exposures of these sands and silts.

In two of the lakes the water seems to have become high enough to have spilled across the divide and found an outlet to the south to Ohio River. These lakes occurred in the valleys of Drury Creek and Little Grassy Creek respectively. The former lake had its inception when the ice shut off the drainage of Drury Creek from Craborchard Creek. By the time the ice had advanced south to a point about a mile and half south of Bosky Dell, the lake was about eight miles long and the water in it at that point was about 200 feet deep. The surface elevation of the lake was about 600 feet. Some of the water spilled over a small col in Sec. 20, T.10 S., R.1 W., thence into Cedar Creek, and eventually into Mississippi River. The farther advance of the glacier, however, eventually shut off this exit and the water found its way across the divide to the south through a col just north of the town of Cobden. The elevation of this col is a little over 600 feet and drainage through it, and the previously mentioned col, may have been contemporaneous for a time. The Cobden col is not a particularly large col, its size suggesting that the quantity of the water passing through it at any time was not large. The col is cut in formations of the Chester group which are not particularly resistant to erosion. The character of the bedrock, therefore, would not have been a particular hindrance to the enlargement of the col had it contained a torrential stream. Glacial boulders have been found in the valley of Cache Creek south of the col, and though the presence of some of them doubtless may be assigned to transportation by human agencies, it is probable that most of the larger boulders were carried over the Cobden col in floating blocks of ice, and later left stranded farther down-stream.

It is a matter of interesting speculation whether with a head of 200 feet of water in Drury Lake some of the water of the lake may not have followed the natural trend of drainage to the north through the much crevassed glacial ice, eventually to find a mode of egress into the Mississippi or its tributaries; also, whether in places sedimentation may not have been going on within the body of the ice where it was saturated with water.

The lake in the valley of Little Grassy Creek was not as large as that in the valley of Drury Creek. Its maximum length was about three miles and it probably began when the ice blocked the valley in Sec. 19, T.10 S., R.1 E. The water in this lake stood at least as high as 570 feet above sea level. This is the present elevation of the Water Valley col over which the water from this lake found its way southward into Bradshaw Creek and eventually into Ohio River. The col is cut through a faulted area in which the Kinkaid limestone of the Chester group and a massive sandstone of the Pottsville formation are exposed. The fractured character of the bedrock forming the floor of this col is a factor favoring rapid erosion. The col, however, is only about an eighth of a mile wide and does not itself seem likely to have carried a great volume of water, nor does Bradshaw Creek, into which the waters entered after crossing the col, show evidence of having carried an abnormally large volume of water.

Most of the materials which were presumably deposited in Little Grassy Creek lake have been eroded away, but in places in the valley a deposit of gray clay containing much rotted limestone boulders is found which was probably formed during the existence of the lake.

Very little outwash seems to have been developed in front of the margin of the ice after it had reached its maximum southern extent. Igneous boulders are found in places for distances of two miles or more south of the margin of the glacial deposits, but they are merely loose in the beds of the creeks and were not seen in any definite arrangement that could be considered characteristic of outwash deposits. The absence of these deposits is probably due to the rapid and pronounced erosion which has taken place since glacial times, and also to the tendency of the present drainage to transport the debris in the valleys to the north. Outwash boulders transported in this direction soon become mixed with other glacial material and are indistinguishable from it.

The retreat of the Illinoian ice seems to have been in a measure a replica of its advance in so far as the deposits which the ice left are concerned. Local lakes were formed in valleys, and Drury and Little Grassy lakes extended to the north until the ice ceased to obstruct the drainage in that direction. In these lakes more silt and sand accumulated, and elsewhere where water sorting was not active, a deposit of more or less heterogeneous materials.

To summarize, then, the outstanding features of the glaciation of the Carbondale quadrangle are as follows:

1. The advance of the ice to its maximum southern limit was accompanied by the formation of lakes in the valleys of many streams draining toward the ice. In the case of two lakes water rose high enough to cross the

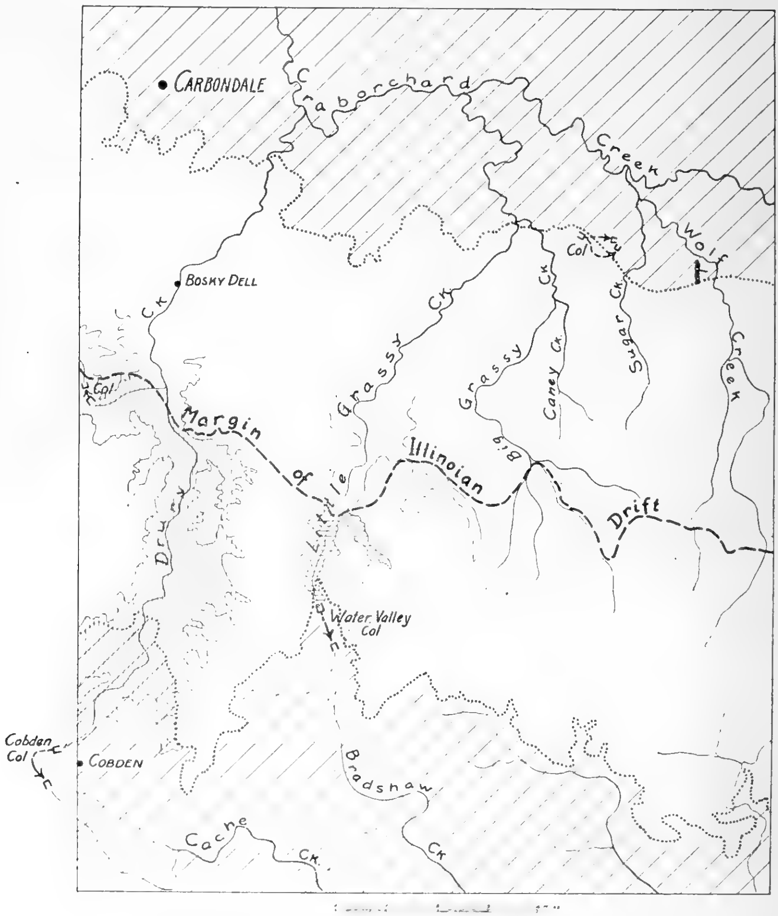
divide of the Illinois Ozarks and to find an outlet to the south.

2. In these lakes were deposited primarily sand and silt. The silts are in some cases stratified, in others not stratified.

3. In an environment of such rough topography the terminal morainic deposits are not pronounced.

4. Outwash deposits are essentially lacking because they were either not formed or have been subsequently obliterated by erosion.

CARBONDALE QUADRANGLE



Northern ruled area underlain by Carbondale formation
Central unruled " " " Pottsville "
Southern ruled " " " Chester group

Glacial lake in valley of Drury Ck.
" " " " Little Grassy Ck

OUTLINE OF THE GEOLOGY OF THE OREGON QUADRANGLE[1]

Arthur Bevan, University of Illinois

Acknowledgment.—In the summer of 1923, under the auspices of the Illinois Geological Survey, the writer made a geological study of the Oregon quadrangle, a brief resume of which is here presented. A more detailed report will appear in the near future in regular bulletin form, published by the Survey.

Location.—The Oregon quadrangle comprises an area of approximately 235 square miles in the northern part of Illinois, about midway between Rockford, Freeport, and Dixon. It is mainly in Ogle County, but includes a narrow strip of territory in southern Stephenson and Winnebago counties.

Drainage.—Rock River enters the quadrangle at Byron, near the middle of the eastern border, and flows through the southeastern quarter of the area, past Oregon at the south margin. The well developed drainage of most of the area is directly tributary to this voluminous master river and its few large affluents within the quadrangle, with the exception of a few headwaters of Pecatonica River along the northern border.

Topography.—Dissection by the numerous streams has progressed until most of the area is in topographic late youth. The greatest dissection, which locally has reached a mature stage, is in a narrow belt on both sides of Rock River and throughout a broader belt along Leaf River, a comparatively small stream that flows easterly across the middle of the area to join the Rock a short distance below Byron. The greatest local difference in elevation is about 250 feet near Oregon, which is not much less than the maximum relief of approximately 300 feet for the entire quadrangle. The least dissection is in the southwestern portion, where an area of several square miles is still an undissected till plain.

Striking contrasts are exhibited in the topography of this quadrangle, and between it and that of much of the

[1] Published by permission of the Chief of the Illinois State Geological Survey.

surrounding territory. This is an area of advanced stream dissection in the midst of an expansive, slightly dissected till plain. Flattish upland rock ridges, thinly mantled with glacial drift, whose preglacial surfaces truncate the underlying strata, are present. Rock River flows for some distance in a youthful valley, locally a deep gorge, whereas Leaf River, its tributary of much less volume, occupies a mature valley in the same type of formations. Some other streams flow in places in broad open valleys but elsewhere their courses are entrenched in narrow rock gorges. A conspicuous topographic element, without homologue in this area, is a broad east and west depression, the Oregon Basin, in the vicinity of Oregon.

It is obvious from this brief outline of the salient topographic features of the quadrangle that its physiographic history has not been simple, but that the present surface has been produced by the successive action and interaction of several geologic processes. In brief, the present topography is dominantly that of surfaces stream-carved from rock of variable resistance and diversified structure, which throughout much of the area has been only slightly modified by deposition of glacial drift, with some conspicuous features due to drainage changes that resulted from the later invasion of the bordering territory by ice-sheets. Certain details have been impressed upon the major features by post-glacial activities.

Stratigraphy.—The rocks which crop out in this quadrangle consist of indurated sedimentary formations of the Ordovician system, and unconsolidated deposits of Pleistocene and post-Pleistocene age. The former range from lower to upper Ordovician, and the latter from Illinoian to the present. In descending age order the exposed formations are:

Recent: alluvium, dune sand, talus.
Late Wisconsin: valley trains, alluvium.
Early Wisconsin: alluvium, loess (?).
Post-Illinoian: loess.
Illinoian: till, fluvio-glacial deposits.

Upper Ordovician: Maquoketa shale.
Middle Ordovician: Galena dolomite.
Platteville limestone.
Glenwood sandstone.
St. Peter sandstone.
Lower Ordovician: Shakopee dolomite.

The oldest rock known by actual observation to underlie this part of the state is the upper Cambrian, or Potsdam, sandstone. It does not appear at the surface but has been encountered in a few of the deeper city wells.

Above the Potsdam sandstone is the Prairie du Chien series, which is commonly divided in this general region into three formations—Oneota limestone at the base, New Richmond sandstone, and the Shakopee dolomite at the top. The lower two formations do not crop out in this quadrangle. The Shakopee is exposed in a single restricted area on the crest of a sharp plunging anticline. Its most striking characteristic at this place is the number of sudden changes in lithology in the vertical succession of the beds. This can be illustrated by listing the principal lithologic types in the exposed 13 feet of the section. They are 1) dense, dull, platy limestone, 2) finely to coarsely crystalline limestone, 3) fucoidal limestone with poorly preserved fossils, 4) magnesian limestone, 5) cherty dolomite, 6) limestone or dolomite with well rounded grains of quartz scattered through it or segragated in irregular patches, 7) calcareous sandstone composed largely of the same type of sand, and 8) thin, variegated shales.

The well-known St. Peter sandstone is extensively exposed along the crests of folds in the vicinity of Oregon, and a few small outcrops are present elsewhere. It has commonly the same lithologic characteristics that are typical of it throughout the general region, but differs in some details, as, for example, the local concentration of iron.

Almost everywhere in this quadrangle the St. Peter is overlain by the Glenwood sandstone. This is a bluish-green rock composed in the main of fine, angular quartz sand through which is scattered a variable percentage of typical St. Peter sand grains. The persistent color and distinctive texture make this formation an excellent horizon marker. A slight unconformity appears to exist at its base. A few miles east of Oregon the typical Glenwood is supplanted laterally by a series of beds, transitional between the typical St. Peter sandstone and the typical Platteville limestone, which consists of alternating thin limestones, ordinary sandstones, vermicular sandstone, clay, and shale. One section of these transitional beds is 40 feet thick.

The Platteville limestone crops out generally in the vicinity of Oregon, Byron, and Leaf River, where in the main low anticlines have been eroded. It is composed principally of limestone with a variable content of magnesium carbonate. The lower part of the formation can be identified readily by its buff color in natural exposures and its stratigraphic relations to the Glenwood and St. Peter sandstones. It is difficult in many places to distinguish the upper portion from the lower beds of the overlying Galena dolomite, especially if the outcrop is a small isolated one of beds not far from the contact of the two formations. There are, however, certain dependable contrasting characteristics by which most of the exposed beds can be confidently identified. A diagnostic feature is its content of fossils, which are more or less common throughout the formation, but are so abundant and of such variety at some horizons as to constitute a "fossil sea floor." Gastropods, pelecypods, and brachiopods are most common, with corals, cephalopods, ostracods, and trilobites somewhat less abundant to rare. Evidence has been discovered that the formation lies unconformably in places upon the St. Peter sandstone.

The Galena dolomite is the uppermost bed rock over the greater part of this quadrangle. Partial sections only are exposed in any of the outcrops, most of which are roadside or gully ledges a few feet thick, although continuous sections of considerable thickness occur in some ravines, gorges, and quarries. A diagnostic feature is the fossil *Receptaculites,* which ranges from a short distance above the base of the formation to well past its middle portion, with some horizons marked by its abundance. Other fossils are scarce, but locally the beds contain numerous shell fragments or poorly preserved shells or imprints of shells. Much chert is present in portions of the formation, as scattered nodules along the bedding planes or in thin well-defined nodular beds. Certain strata are characterized by pores and pits up to a few inches across, which give rise to a rough, peculiarly fretted surface. Rusty calcareous sand, in separate particles or loosely adherent, partially fills most of the pits on weathered surfaces or throughout the fresh rock. In places these beds have disintegrated into a friable mass that resembles loosely cemented sandstone.

The youngest indurated formation is the Maquoketa shale, which occurs in this area as a single outlier on the summit of Bunker Hill, in the extreme northwestern corner of the quadrangle. About 70 feet of shale with intercalated thin beds of more or less fossiliferous limestone constitute the exposed section.

Beyond doubt the Niagara dolomite, which caps a series of hills to the west, formerly covered this area, but the last vestige of its outcrops has been destroyed.

The mantle rock immediately overlying the bed rock is very largely glacial drift, which is almost entirely of Illinoian age. No till of an earlier or later epoch is known to occur in this quadrangle. Some outstanding characteristics of the Illinoian drift are, 1) the large amount of gravel and sand in many parts of it, 2) the depth of leaching and oxidation, 3) its thinness throughout much of the area, and 4) the rough conformity of its surface in many places to the contour of the underlying bed rock.

The drift is not uncommonly a sandy and gravelly till. Large masses of stream-deposited gravel and sand are locally present in it. Numerous other large bodies of sand and gravel occur upon the surface of the till as kames and eskers. Both the included gravels and the superficial deposits are especially abundant in the Oregon Basin and in Leaf River Valley. The eastern portion of the largest esker in the state, the Adeline esker, is in the western part of Leaf River Valley in this area.

Since its deposition the till has undergone extensive chemical changes. It is deeply oxidized, and limestone fragments as well as the calcareous portion of the rock flour have been leached from the upper several feet. That peculiar and distinctive product of long-continued weathering of till, gumbotil, is exposed in several places beneath the mantle of loess.

The maximum thickness of the drift in this quadrangle remains to be determined from a study of well records, but a striking feature of the area is the abundance of rock outcrops wherever slopes have been washed or gullied. In many places the bed rock is only thinly veneered with till, and on many ridge crests the present thickness of the till is not more than a few feet. Over much of the quadrangle the original thickness of the drift was not adequate to mask the topography of the rock surface, so that pre-Illinoian valleys and divides can be traced in the existing topography.

Borings show that the flattish uplands west of Rock River are underlain by loess to a depth of 15 or more feet. The thickness is much less on slopes, but this undoubtedly is due in large part to wash and creep during and subsequent to deposition of the loess. Traces of an old soil bed and fragments of vegetation are present between the loess and the underlying weathered Illinoian till.

The only recognizable deposit of Early Wisconsin age in this area consists of alluvium deposited in the eastern part of the Oregon Basin. It was made by streams that were blocked by outwash from the Early Wisconsin ice-sheet when it covered the region east of this quadrangle. Some of the loess may have been deposited during this epoch, but the amount is probably relatively insignificant when compared with the pre-Early Wisconsin loess.

The late Wisconsin deposits consist in the main of valley train material that partially filled Rock Valley and of alluvium that was deposited in tributaries which were blocked by the drainage down Rock River. Other streams have made their normal deposits up to the present time. Winds have whipped up some of the sand into low dunes in Wisconsin in recent times, and meager talus slopes have been formed along some of the cliffs.

Structure.—The structure of the formations in the Oregon quadrangle departs markedly in many places from the simple gently dipping to slightly flexed structure which is generally considered to be typical of northern Illinois. Axes of sharp narrow anticlines with accompanying broad shallow synclines cross the area in a westerly to northwesterly direction. A characteristic feature of these anticlines is the narrowness of the folded zone and the steepness of the dips in this narrow zone. Gently dipping limestones will suddenly exhibit dips of 20° or more. In one instance the dip changes sharply from a few degrees to more than 40°. In another instance the St. Peter sandstone unexpectedly appears with steep dips, in the midst of gentle north-dipping Platteville limestone. Between these folds the strata are commonly only very slightly tilted or horizontal. These few examples indicate the character of the deformation in the Oregon quadrangle.

POT-HOLES AND CERTAIN FEATURES OF GLACIAL ABRASION

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Illinois and neighboring states are covered to a considerable extent by glacial deposits. These are subject to local examination and study. Investigation of the content of the drift shows that it is very largely of local origin, but that it contains a noticeable amount of material which has been brought from far beyond the local outcropping rocks. Some of the material has been brought from the northern side of the Great Lakes. In the areas of southern Canada one may see the glacial gathering grounds, stripped of their mantle rocks, exposed today almost in the condition in which they were left by the last ice sheet.

This paper has to do with certain phenomena observed in the Killarney area, a district on the north shore of Georgian Bay, the extreme northeastern corner of Lake Huron. This area is remarkable for the striking physiographic contrasts it displays. Early in the history of geological work in North America, the area was described briefly by Alexander Murray[1] in 1848. No one could pass this spot without seeing the great snow white quartzite hills, known as LaCloche mountains, rising above the hummocky granite plain which stretches with little interruption to the Laurentian highlands of eastern Ontario and Quebec. Here is a strange physiographic disconformity, the sudden end of a great range of quartzite hills, cut off transverse to their general line of extent by a lowland of granite. In general, we find the towering peaks of folded mountains to be of igneous composition, but in this case, we find the plains are granite and the hills sedimentary rocks. Examination shows that the quartzite formations are faulted, and destroyed by granite intrusions.[2]

ICE WORK

The major effects of glaciation which are common to most of the country north of Lake Huron are well illus-

[1] Alexander Murray, Exploration geologique du Canada, 1848, p. 113.
[2] R. Bell, Geol. Surv. Canada Ann. Report, Vol. IX, 1898, pp. 8-9. A. E. Barlow, Geol. Soc. Am. Vol. IV, 1893, p. 315-321.

Fig. 1. Pothole and glacial grooving on shores of Lake Huron.

Fig. 2. Solution potholes in granite near MacDonald hotel, Killarney.

trated in this area. The highest peaks have been glaciated, indicating that the ice was at least 1200 feet in altitude above the present level of Lake Huron. The lowlands are polished and stripped to the bed rock in most places, so that the granite plain is hummocky with the roches moutonnees so characteristic of glaciated countries, with small swamps and ponds in the intervening depressions.

Along the lake shores the minor effects of ice erosion are well exposed. Deep grooving both above and below water level is strikingly developed on the northern shores of some of those islands which are composed of dense, fine grained granite gniess. (Figure 1.) This sort of abrasion on a larger scale has greatly modified the shape of the shore line, especially in such places as the south shore of Philip Edward Island, and the mainland and fringing islands east of Beaverstone Bay, where the structure of the rocks is parallel to the direction of the ice movement. In many places small and giant chatter marks are common.

Chatter marks are concave towards the direction from which the ice came, and they are on the stoss side of the roches moutonnées. There are also certain breaks which are the opposite of chatter marks; they are on the lee side of the rocks, and they are concave toward the direction in which the ice was going. They are not true features of plucking because they do not follow apparent joint planes, nor are they controlled by them. They appear to have been formed much in the same way as giant chatter marks, except that they are on the upper part of the lee side of the rocks, and that they are concave in the opposite direction to that characteristic of chatter marks. They break away on the lee side apparently because there is a breaking face on that side. The reason that chatter marks are scoop shaped is because there is no vertical breaking face, and the plane of fracture returns to the surface, which is the only available breaking face.

The granitic rocks are pitted with shallow depressions in many places after the fashion of pot-holes.[3] (Figure 2.) Pot-holes are usually thought of as those depressions which are worn by swirling boulders or pebbles below the falls of a rapid river or in other eddying streams, but the great abundance of concave surfaces on the Killarney granite and gneiss makes any reasonable observer at once give up any such explanation for the thousands of "pot-holes" in this district, unless indeed he believes that the whole area was at one time overflowed by a huge and very widespread torrent. Streams doubtless followed the glacial period, but such an explanation does not fit all the cases because many of the depressions have the smooth, polished surface characteristic of glacial polishing. Many of these depressions antedate the last glacial sheet which covered the land. Observations show that a variety of causes has brought about similar products in different manners.

The granite at Killarney has a nearly horizontal sheeting. It tends to break off in rather irregular and shallow slabs of rock as a result of frost work. Glaciers riding over these granite surfaces broke out some of these slabs and carried them away. The place left, in several cases found, is almost scoop shovel shaped. (Figure 3.) The glacier chipped out a piece of rock, which broke in a vertical direction down to the sheeting plane in a curving surface which was convex toward the direction from which the glacier came, provided the breaking surface was on the sheltered side of the rocky knob or roche moutonnée. In some other cases the granite broke out from the bed rock on the downstream (stoss) side of the outcrop, concave towards the direction from which the ice was coming, as a sort of giant chatter mark. In either case, the passing ice in time smoothed off the edges of the broken rock, and left a polished depression in the midst of an otherwise convex surface, looking something like a pot-hole. (Figure 4.)

In other cases the primary depression was made by the conjunction of three or more joint planes which loosened upwards a piece of rock of pyramid shape. After frost had heaved this piece loose, and passing ice had carried it away, the place from which it came provided the start of another polished depression which looks like a pot-hole. Near Killarney these joints were

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[3] Pot-holes have been described and classified in detail by E. D. Elston. The Scientific Monthly, Vol. V pp. 554-567 and Vol. VI pp. 37-51 (1918).

Fig. 3. Potholes due to removal of granite sheeting slabs.

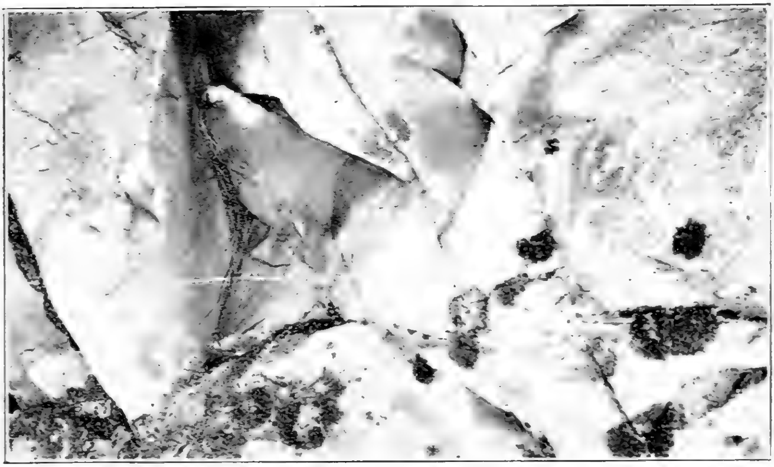

Fig. 4. Glaciated depression made by intersecting joints.

Fig. 5. Concave fractures of Killarney granite.

Fig. 6. Solution cavities in pegmatitic granite.

found to have the following positions; strike N. 180° E., dip 40° W; strike N. 15° E., dip 39° S; and strike N. 85° E., dip 87° S. A similar process is responsible for some of the so-called rock "tanks" in arid regions[4].

Again it happens that the Killarney granite has a natural conchoidal fracture in some places, and (Figure 5) under any stress, such as that, for instance, of a passing glacier heavily loaded with locally burdensome drift, it is likely to break along curved surfaces. A piece which breaks out of a plane face naturally leaves a concave surface, and after such a surface has been glaciated, that too is like a pot-hole.

There are porphyritic phases within the granite and the gneiss which are not of the same fine, even grain characteristic of the rest of the rock, and the parts which are weaker than others weather more readily and leave hollows in the surface, which are likely to have been smoothed off by glaciation. (Figure 6.)

In the side of a nearly vertical surface facing northward, on the north side of an island south of Philip Edward Island, there is a cavity, over a foot deep, which penetrates a glaciated surface, and which seems to be in part of age greater than the last ice sheet. This hole is gradually growing larger by a sort of spherical scaling within the hole. The hole is growing on opposite sides of a narrow crack in the rock. The crack appears to be the thoroughfare by which ground water works into the rock, oxidizes the minerals, and causing them to expand in volume, creates a pressure sufficient to crack the rock. The shape and position of the hole is such that pieces which break off fall out of the hole into the lake; thus fresh rock is repeatedly exposed to the agency of disruption. Of course this is not a pot-hole, for it is quite impossible for a pot-hole to form in the side of a vertical cliff, yet it is a hole, and after glaciation such a hole would be distinguished with difficulty, in some situations, from a real pot-hole made by swirling boulders. (Figure 7.)

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[4] Kirk Bryan, U. S. Geol. Surv. Water Supply, Paper No. 498, (1923), p. 43.

In the immediate neighborhood of Killarney, in the village itself, one may see all but the last type of glaciated rock hole. At the rocky point, at the west end of the channel, on the north side of the water, one may see the depressions formed by two types of giant chatter marks. In the walk outside the MacDonald Hotel one may see the depressions formed by the intersection of joints, and by the conchoidal fracture of Killarney granite, and there are excellent illustrations of the way in which the glacial abrasion truncated and partly destroyed some depressions which had been made at an earlier time. Only those which came in the later period of glaciation are preserved intact. In a garden near the store of Mr. T. Jackman there is a rock exposure which shows admirably the way in which some of the pegmatitic and miarolitic material in the granite weathers into pitted shapes something like pot-holes.

A significant argument that the pot-holes are indigenous to the granite and not the result of any outside agency is the fact that the quartzites of the same district contain almost no such depressions. Photographs show the peculiar shape of the glaciated surfaces of the granite rock moutonées. Almost all of these peculiarities are due to a normal glaciated surface, which is convex upwards in the direction of glacial movement, truncating a smooth surface which has been glaciated, although not fashioned by glaciation, and which is concave upwards. Some of these concave surfaces were in existence before glaciation, some came into being during glaciation, and others came after glaciation. (Figure 8.)

Thus it is stupid to suppose that all concave surfaces, or even holes, in glaciated rocks are due to the work of subglacial streams. It is quite clear at Killarney that several other agencies made such depressions, and there is no evidence that any of these "pot-holes" were really made by the spinning and swirling of boulders caught in an eddy of a subglacial stream or at the bottom of a moulin in a glacier. Striking as these holes are, they do not seem to have been bored by any natural gimlet, such as a spinning boulder in running water. Indeed, this area provides the evidences of "pot-holes" of hitherto undescribed methods of development.

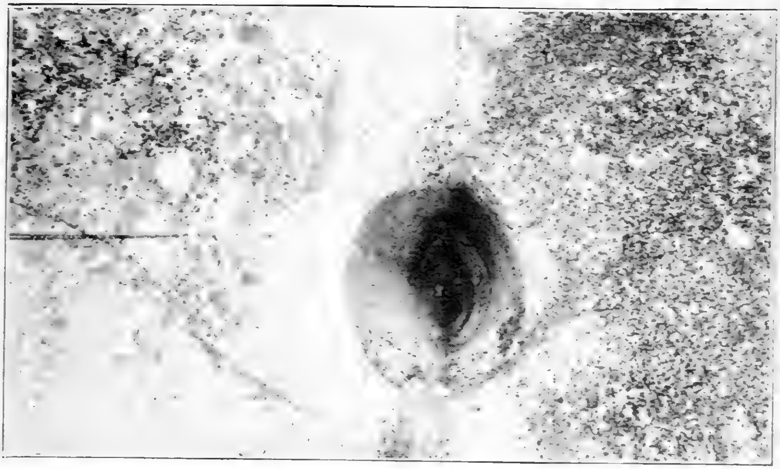

Fig. 7. Cavity in granite due to spheroidal weathering.

Fig. 8. Concave surfaces of glacial erosion, simulating potholes.

SOME QUESTIONS IN GENERAL AND PETROLEUM GEOLOGY WHICH ARE SUGGESTED BY OIL OCCURRENCES IN CRAWFORD COUNTY, PENNSYLVANIAN BEDS

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SUMMARY

Over a considerable part of Crawford County, oil production from Pennsylvanian sands is conditioned by other factors, perhaps as important as the LaSalle Anticline. Certain features indicate a nearby source for the oil and this may be important in future exploration work.

GENERAL

One of the controlling features, perhaps the most important, of the oil fields in southeastern Illinois is the LaSalle Anticline which extends from the vicinity of LaSalle southeast nearly to the Wabash River at St. Francisville. Productive territory has been developed through Clarke, Crawford, Lawrence, and Wabash Counties for a distance of seventy miles, and although this area of production varies in width up to sixteen miles, commercial accumulation of oil extends to a distance of eleven miles northeast from the axis on the less steeply dipping flank.

Thus far production has been developed from Pennsylvanian sands on down to the Trenton limestone, but the development in any one place is limited to a small portion of the vertical range. (Martinsville area excepted.) Thus in Lawrence County most of the oil produced comes from rocks of Mississippian age. In Crawford County production is chiefly from Pennsylvanian and Mississippian rocks, and in Clarke County, the Pennsylvanian, Mississippian and Ordovician rocks are each important locally.

All of this production is along the LaSalle anticline and is clearly related to it. During the past eight years detailed studies have brought to light certain features, which when better understood may assist greatly in further development. In 1915, Rich[1] made a careful study of the Birds Quadrangle in Crawford County, and noted the allignment of the Pennsylvanian sand production at right angles approximately to the axis of the anticline. He concluded that the Pennsylvanian beds were essentially flat-lying over this area, and that oil accumulation in the Robinson sand seemed to be conditioned on its thick and massive development. Differences in elevation of the sands due to arching and folding are less in amount than differences due to irregularities in the sand lenses themselves.

Later work by Mylius[2] in Clarke County disclosed certain features in the northern part of the field, to account for which he hypothecates cross folding. As some of the production includes pre-Pennsylvanian rocks, the problem is modified somewhat, but the fact is noted that something other than the LaSalle anticline is involved in the oil occurrences in this part of the field. Recent field work, as yet incomplete, in the north one-half of Crawford County is adding its quota to the information relative to our south-eastern oil fields and furnishes some conspicuous contrasts between Pennsylvanian and pre-Pennsylvanian production. Here the upper sands (Robinson) are elongated in a direction approximately N. 52° E, whereas upper Mississippian production (Chester), developed here in only a small way, follows the direction of the anticline. As noted by Rich in the Birds Quadrangle, differences in elevation of the top of the Robinson sand are influenced less by folding and warping than by lensing. Some of these areas are irregular in shape with no conspicuous or symmetrical elongation. Others are several miles in length, and these longer dimensions are in the northeast-southwest direction. Another noteworthy feature is the occurrence of all of these elongated areas on the northeast side of the axis of the anticline. In no instance have they been reported or observed on the west flank of the fold. The most prominent development of this nature occurs between Birds and Annapolis, a distance of about twenty miles.

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[1] Rich, J. L., Oil and Gas in the Birds Quadrangle, Ill. State Geol. Survey, Bull. 33, pp. 105-145.

[2] Mylius, L. A., Extract from Bulletin 44, Ill. State Geol. Survey.

Summing up the observations to date, we have the following:

1. Robinson sand production is commonly elongated in a northeast-southwest direction. This does not hold true for the Chester. Perhaps correlation is at fault.

2. These elongated areas are all east of the fold, but are found very close to it.

3. The sand top drops less rapidly from west to east than to the north or south. Available data, though too meagre to be very satisfactory, indicate overlapping sand lenses.

QUESTIONS

Since these occurrences are somewhat independent of the general structural conditions along the LaSalle anticline, they raise some interesting questions.

1. Are these transverse elongations due to cross folds, faults, sand lenses, or some other agency?

2. Why are they confined to the east side of the anticline? Perhaps the final solution will show that they are not so confined.

3. Are they limited in occurrence to the immediate vicinity of the anticline, and if so, why?

4. Do these occurrences suggest certain phases of Paleogeography? What are some possibilities?

5. What and where is the probable source of this oil? Is it local or may it be remote? Has any of the oil migrated very far?

6. What is the general artesian circulation of the Illinois basin? Is there a critical relation between the oil accumulation and the present artesian circulation through the basin? If so, what?

7. How are these questions related to future exploration?

SOME TENTATIVE SUGGESTIONS

At present studies are too incomplete to answer finally most or all of these questions, but some points seem reasonably clear.

Cross folding is not apparent here because the sands appear to be missing where the synclines should be found. Contours on the top and the bottom of the Robinson sands would be at variance. Is cross folding known to occur anywhere?

Displacement or faulting of the sands does not seem to be shown from a study of the well logs. This hypothesis, however, is not untenable so far as the writer knows. Sufficient confirmatory evidence is lacking.

A study of the well logs indicates the existence of elongated sand lenses and bodies. This material is somewhat variable, and shale or lime breaks are commonly reported within such sand bodies.

Studies of present development fail to show these transverse zones on the west side of the anticline, although recorded dry holes indicate a fairly thorough testing of the west flank. The Pennsylvanian beds are more nearly flat on the east flank than on the west. Perhaps this is sufficient reason either for occurrence of the sand lenses or for their gathering oil. Only the higher portions of such sand lenses might favor commercial accumulation of oil, and hence the importance of a position near the crest of the anticline. Do these sand lenses indicate near-shore phases of Pennsylvanian geography? No fossils from them are available for study, but the interspersed limestones are marine. This is demonstrated by a study of samples from outcrops and from diamond drill cores. Were the sand lenses formed as off-shore bars, beaches, dunes, river channel fillings, or composites on a delta? Rich favors the delta hypothesis for the Birds Quadrangle, and it seems in harmony with conditions to the north and northwest of that area. If this were the case, was the shore line parallel approximately to the LaSalle anticline as has been commonly supposed? Did a large river discharge its debris into the sea in or near Crawford County, and in what direction did it flow?

Some differences of opinion are held as to the probable source of the oil, but greater favor is now accorded the idea of a local source and of limited migration to the present sand reservoirs. Abundant organic material was present in the muds (both lime and siliceous) at the time of deposition, and only a small fraction of this would be needed to furnish the amount of oil now known to have been present. Most of the geologic section is made up of shales and limes, and as most if not all of these were marine, the local supply of organic material was perfectly adequate.

Present conceptions of artesian circulation, in a basin such as our Illinois Paleozoics form, favor the idea that marginal movements are much more rapid than are those in the deeper part of the basin. Such circulation doubtless has been changed many times since the Illinois Paleozoics were deposited as rock debris, but most of this circulation has probably moved southward. During Pennsylvanian time the LaSalle anticline formed a structural high, along both sides of which there may have been relatively rapid movement of meteoric water. If not too rapid this would favor oil accumulation in suitable reservoirs. With an oil content in some of the shales of 12 to 16 gallons per ton[3] the adequacy of material is no problem. If this hypothesis should prove correct, the oil now developed is local in origin and large areas to the west of the fold may justify test drilling where structural and textural conditions can be determined as favorable. Similarly, reserves in the Mississippian and lower rocks were developed under physiographic conditions unlike those of the Pennsylvanian, and for obvious reasons may be expected to conform more closely to the larger structural features.

[3] Ashley, G. H., Bulletin 641, U. S. Geol. Survey, pp. 314-319.

THE SOUTH AMERICAN INDIAN AS A GEOGRAPHIC STUDY

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South America offers many surprises to the traveller, but none of them is more arresting than those which relate to the Indian. He gives an atmosphere to the west coast countries which has no counterpart anywhere. At first sight of some of the world's famous ruins, such as Sacsahuaman, Ollantaytambo, Tiahuanaco, and others, there comes an almost irresistible conviction that the builders of these tremendous structures with their huge blocks of stone were of a better blood than that of the modern Quechua or Aymará with his sullen and hopelessly sad hang-dog expression. Nevertheless, the near ancestors of these spiritless people were a part of the proud and powerful Inca Empire.

The contrasts between a brilliant past and a sordid present is in constant juxtaposition. The resourcefulness of the ancestors, their activity, application, and conceptions of big things are everywhere as evident as the filth, the poverty, and the degradation of the descendants, making the contrasts all the more striking. It is hard to believe that living in the same general physical environment in contact with a superior, at least a more advanced race, should have produced such a marvelous change in such a remarkably short time.

It is not surprising, therefore, that for many years the belief existed among most investigators that the Incas, the Chibchas, the Mayas, the Aztecs, and our own Moundbuilders were of a different racial stock than that of the Indian of today. Little by little, however, an overwhelming mass of evidence has accumulated, which shows that all belong to the same stock, and that practically all their cultural evolution, as shown in major and minor antiquities, has taken place in the New World. This has been done in a comparatively short time, for we have no undisputed evidence of glacial man in America. Various evidences tend to show that the American Indian came to this continent shortly after the stone polishing stage had been inaugurated in the land from which he came.

To the student of geography these facts are interesting and vital, for this means that the progress evolved in the New World has been, very probably, as distinct from any Old World development as though it had originated on another planet. The Indian is a product, therefore, of the American environment, and the differences in advancement can be explained only by the differences in the natural conditions which made certain advances possible. A study in this field ought to be productive in working out fundamental geographic relationships, which here should be found in their simplest forms.

The field of investigation, however, is not an easy one, for much is still unknown. The student of geography needs to know, rather definitely, how much of the development of this culture was accomplished under the Asiatic and how much under the American environment. What cultural elements did this migrant bring with him on which to start? Have all the cultural elements of both continents come from the same or from different groups, or migrations? After their arrival on these shores, did their dispersal come at once before a local development had taken place, or was the dispersal due to slow spreading from the periphery of the group? Can certain similar elements of culture originate simultaneously in far distant places, or when such are found, may they have been transmitted by contiguous groups and may they be traced to an original center? These and a host of other questions must be answered before the Geography of the American Indian can be written.

The non-Anglo-Saxon sections of the New World offer by far the best conditions for such study. Even in the regions north of the Rio Grande much still can be found out concerning the life relationships of the American Indian, but it is to be regretted that so little attention is paid along lines of investigation where facts readily attainable now will disappear most probably in this generation. However, in South America the general lack of white development in many sections offers possibilities of study entirely unknown here, for even now some of the countries are more Indian than white.

When one speaks of the American Indian in South America, it becomes necessary to explain the term used.

In the Indian countries little or no distinction is made as to blood relationships. The distinctions arise from the great contrasts among the people in wealth and social position, and are very sharply drawn. To find statistics on the "Indios" or "Mestizos" does not mean Indians or mixed bloods but merely those of the lowest and next lowest rank, those without wealth and social position. Anyone with sufficient leisure, who can maintain his family without work, belongs to the white class. Possibilities of change from one class to another are rare, as opportunities for the accumulation of wealth by the poor are few. A class division, therefore, may be made, into one with opportunities and into one without hope. The latter group for want of a better name may be called Indian.

Mixing of bloods has gone on without any sentiment against it ever since the time of the "Conquistadores", so that there are, very probably, few native whites without some strain of Indian blood, and likewise few Indians, except in some of the undeveloped sections, that are free from admixtures. The number of pure blood Indians in the plateau countries is much greater than pure blood whites. The Bolivian census for 1900 gives the Indian population as 48.42 per cent of the total and the white as 14.64 per cent, the rest being mestizos. These figures representing classes may be fairly correct, but the absolutely pure white population is probably less than two per cent of the total. The figures show, however, the dominance of the Indian blood in the life of the Republic.

If there is such a thing as cultural evolution controlled or modified, at least largely, by the environment, then there should be such a thing as regional cultures brought about by regional activities,—in other words, a regional geography of the American Indian. South America has been divided into four major cultural areas on the assumption that the activities based on the getting of food are the most fundamental. These culture groups are as follows: (1) the Chibcha in Colombia, agriculturists of the upland type; (2) the Manioc in the Amazon basin, agriculturists whose main food was the roots of the mandioca; (3) the Guanaco, in the Pampas of Argentina, hunters whose activities were much like those of our plains Indian; and (4) the Inca, on the high plateaus of Peru and Bolivia, agriculturists whose progress far outstripped that of any others.

If such a classification is legitimate from a geographic point of view, then the geographer has a large field before him and some serious problems. Why was the evolution so slow here even in the most progressive sections when compared to Old World development? It seems incredible that the Indian lived here without much progress while civilizations in the Old World rose and fell. The natural environment of the western world, for the most part, seems to be stimulative enough now. Climate and topography were then much the same as now. The available resources, of course, are immensely greater now than then, and probably will continue to multiply as methods are discovered to use the resources locked up for the present. Were the migrants a dullard group, driven from their old environment by the more progressive and thus in their wanderings reached a new world? The evolutionary trend has not been in that direction, for many a full blooded Indian has shown great brilliancy along certain lines.

Whatever the geographer of the future will find, one of the most striking facts is that the descendants of that most advanced group, the Incas, are at present in the most pitiable condition of any group in either continent. Their poverty is great, with little or no possibility of changing their status under present conditions. This is not due to laziness or lack of energy, but largely due to a vicious system in which they find themselves. Their condition is well nigh hopeless and if they have a philosophy it is one that accepts the inevitable. Their "chicha" is their curse as it undermines their physical and moral welfare. It is also a blessing in that it enables them to forget a sordid world and to conjure up a new one with hope. Their "coca" dulls their minds and sensibilities and makes of them little else than a beast of burden. However, it also dulls the gnawing pains and the recollections, if there are any, of ancient splendor. The environment is powerless now to stimulate for there are other forces which dominate.

PALEOZOIC KARST TOPOGRAPHY

George E. Ekblaw, State Geological Survey

Karst topography is that unique physiographic expression which is characterized by surficial sinks, "lost" rivers, natural tunnels or bridges, subsurface solution channels, and subterranean caverns. The name "Karst" was applied because of the remarkable development of this type of topography in the Karst or Carso plateau of Austria.[1]

Since it results from solution, karst topography can occur only in areas that are closely underlain by thick beds of limestone, dolomite, gypsum, salt, or other soluble rock formations. Most of the known areas of karst topography are underlain by limestone or dolomite. Many karst areas occur in the United States and other countries.

In many localities, such as northwestern Illinois and southwestern Missouri, valuable mineral deposits have been described as filling ancient solution channels and cavities. This is indirect proof that karst topography existed in geologic periods other than the present. Unique and direct evidence of this fact was obtained last summer in the vicinity of Kankakee, Illinois, which area is underlain by Niagaran limestone or dolomite at a very shallow depth.

In the quarry of the Lehigh Stone Company, seven miles west and one mile south of Kankakee, are "clay pockets" which on examination proved to be deposits of shale in cavities that are clearly fossil sinks. All of the cavities have the shape of a funnel or a cone with the apex downward. In some of them the walls have a gentle average slope; in others they are precipitate. Again, regardless of the degree of their slope, the walls have a constant and consistent pitch from top to bottom, or they may be made up of alternating projecting and receding layers when the slope is precipitate or of alternating pitches and flats when the average slope is gentle. Except where the wall has collapsed before or during deposition of the shale, it has gen-

[1] Sanders, E. M., "The Cycle of Erosion, in a Karst Region (After Cvijic)", Geog. Review, v. 11, No. 4, p. 593-604, 1921.

erally a smooth surface, which is apparently the result of solution. In size the cavities vary from ten to a hundred feet in diameter and from twenty to forty feet deep, and their outlines may be circular, oval, or irregular. They are not arranged regularly relative to one another, but they do show a rude parallelism, controlled probably by joint-planes where solution would be favored. Occasionally two or more cavities may be so close that their upper portions coalesce to form one large pit with several separate downward projections. Along the joint-planes are many smaller vertical tubular solution channels, also filled with shale.

The shale which now fills the cavities is of two general types. The more abundant type is usually light greenish-gray, non-laminated, silty, and contains much crystalline iron-sulfide. It also contains rounded pebbles of limestone and chert. Frequently it is laminated, in which case some of the laminae are either fine, gray sandstone, or thin, black layers of carbonized plant fragments. Rarely the laminae are of variegated colors of purple, blue, green, and gray. This shale has a sub-conchoidal fracture; it weathers rapidly to a non-plastic, non-tenacious silty, gray mud. It fills all the cavities except that portion in each of a few of the larger ones which is occupied by the second type. The second and less common type of shale found in these cavities is black, laminated, carbonaceous, full of carbonized, well-preserved plant fragments and brown spore-cases or seeds, and with an abundance of botryoidal nodules of iron-sulfide that are of all sizes up to about three inches in length. When fresh, this shale has a conchoidal fracture that continues across several laminae. It weathers rapidly on exposure, first dividing into sub-conchoidal, lamellar flakes and then further disintegrating into a black, non-plastic mud. Two or three showers with intermissions of but a few days afford sufficient opportunity to reduce the fresh shale to mud.

Where both types of shale occur in the same "pocket" there is a sharp line of contact between them, and the green shale contains weathered masses of the black, indicating decisively that the green is younger than the black shale and that there have been at least two separate generations of sinks in this one area. In addition to these two types of shale, there are rare occurrences of a granular, fine or coarse grained, calcareous sandstone that is made up of grains of quartz and of the surrounding limestone. In several cavities there are deranged masses of limestone that are collapsed portions of the walls, and around these masses the shale is practically undisturbed from its horizontal position, showing that the collapse occurred contemporaneous with the deposition of the shale. Similarly, where there are irregularities of the walls or recessive channels, they are filled by shale that is stratigraphically continuous with that in the main pit.

Some idea of the extent of the area which exhibits this phenomenon may be gained from the following facts. The Lehigh Stone Company abandoned an old quarry two miles west of the present one because of the prevalence of "clay pockets". While testing prospective areas on which to locate the present plant, they found similar "clay pockets" abundant over a wide expanse of this region. In an old quarry on the west side of the Kankakee River at Kankakee it is reported that there were found "soapstone pockets," which are doubtless the same as the usual "clay pockets", containing good shale. Several of the farm wells in the intervening territory have been drilled through "mud" for many feet instead of the usual rock, and this fact, considered in the light of the chance location of well sites, indicates that the shale-filled cavities must be numerous, to say the least.

In the eastern part of Bradley, two miles north of Kankakee, are two small circular swamps overgrown with willows, which probably mark the location of large shale-filled sinks like the others. Dr. D. J. Fisher of the University of Chicago reports that in the quarries about Joliet are similar cavities filled with green clay or shale, but there the evidence was insufficient to warrant any positive statement as to their origin or age. Smaller cavities in the Niagaran limestone, filled with Devonian shale or clay, have been reported from a quarry near Elmhurst[1] and from McCook, near Summit[2].

[1] Weller, Stuart: A Peculiar Devonian Deposit in Northeastern Illinois; Journal of Geol., v. VII, No. 5, 483-488, July-August, 1899.

[2] Personal communication from G. W. Hawley, State Geological Survey.

There is no reason to believe that these cavities are anything but sinks; every geologist who has seen them agrees to that. The only other possible explanation is that they are pot-holes, but their shape disposes of that possibility without argument. Their age can be determined from the deposits that fill them; all geologists who have examined them believe that the green shale or clay and sandstone is Pennsylvanian in age, but the age of the black laminated shale is in doubt. An authority to whom the material was shown has suggested that it may be Devonian; another, that it may be Pennsylvanian; but neither of these has yet had opportunity to study the deposits or the plant fossils sufficiently to make a definite statement. The color of the shale and the occurrence of Devonian shale in cavities in the Niagaran limestone near Chicago tend to strengthen the possibility of Devonian age. If it proves to be Pennsylvanian, the marked difference in character of the two shales and their abrupt contact where they occur together are ample proof of two distinct epochs of deposition.

Two hypotheses may be offered to explain the conditions under which the sinks were filled by shale. One is that after the sinks were formed the outlet at the bottom of each became choked and the pits gradually filled up with material washed into the resulting ponds by surface run-off, in which may have been included much organic debris. The possibility that some of the debris is the residue of plants growing in the sink itself is untenable because the shale is in horizontal layers as is found only in subaqueous deposits, shows no old soil or peat or coal, and contains no plant remnants in place. The other hypothesis is that the area was completely submerged beneath the sea, and there filled with silt, sand, and organic debris. The regularity of the deposits seems to indicate the latter hypothesis the more probable, in which case the abundance of plant remnants indicates that the area was near the shore of that sea.

It is safe to state that at some time after the deposition of the Niagaran limestone or dolomite in the Silurian sea over this area and preceding either the Devonian or the Pennsylvanian period, there was relative emergence of sufficient relief to permit ground water to develop subsurface channels and caverns with surficial sinks. Then there was a complete relative submergence, during which the sinks were filled with black shale, but whether this relative submergence was of Devonian or Pennsylvanian age must yet be determined. A second relative emergence permitted the development of a second generation of sinks, some of which were formed in the rock forming the walls of those developed during the first emergence. A second relative submergence, undoubtedly Pennsylvanian in age, provided opportunity for these sinks in turn to be filled, this time with a green shale.

Since that time there have been relative emergence and subsequent erosion of such overlying formations as may have been deposited, bringing the area to its present altitude. So far as the writer is aware, modern or Pleistocene karst topography nowhere occurs on the Niagaran dolomite, although its altitude would seem to permit such occurrence; in Paleozoic times there were two distinct periods or epochs when a youthful karst topography was well developed in the same formation. Whether this is due to a decrease in the solubility of the Niagaran dolomite or to some other cause is at present a matter of conjecture.

AGRICULTURAL ADJUSTMENTS TO THE NATURAL ENVIRONMENT IN SOUTHEASTERN MINNESOTA DURING THE PERIOD OF BONANZA WHEAT FARMING

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The period of bonanza wheat farming in southeastern Minnesota covered approximately the two decades from 1860 to 1880. During all of this period the wheat crop constituted the principal economic activity in the area, and during much of it the counties in this part of Minnesota were the leading wheat producing counties of the state. Peculiar interest attaches to the development and decline of wheat culture on a single crop basis in southeastern Minnesota, because this area was one of the first, if not the first section of the present spring wheat area to be settled and it, therefore, pioneered in spring wheat farming. To appreciate the rapid rise of bonanza farming in the area, it must be remembered that southeastern Minnesota was opened for settlement in 1853, and that in the ensuing four years most of the land within a two days' haul of the Mississippi was occupied. The area, therefore, was settled and considerable of it was under cultivation before 1860. Thus settlers in the area were in a position to be benefited by the high prices for wheat and other farm products which prevailed during the Civil War. Of the crops grown, wheat shortly proved to be the most profitable because it commanded a high price, it produced abundantly on the fertile upland prairies, it was grown with a relatively small amount of labor, and it shipped satisfactorily via the existing means of transportation to eastern markets.

The hard labor and considerable expense connected with the settlement of a new area, and with bringing the prairie into cultivation, placed the pioneers in desperate need of a cash crop. Wheat met this need admirably. As a rule the pioneers had limited financial resources. Many of them had sold a farm or small business to obtain the money to cover their traveling expenses to the West, to pay or partially pay for their new land, and to buy the tools and other equipment needed to break and cultivate it. Once in Minnesota, the cost of opening a farm was estimated as follows:[1]

The price of their land	$200.00
The price of team and wagon	150.00
The price of two cows	40.00
For rebuilding house	100.00
Breaking twenty acres	60.00
One steel plow, for crossing	14.00
One harrow	6.00
Axes, shovels, spade, forks, scythes, etc	25.00
House furniture, and provisions for family, which must be bought till they can raise them	200.00
	$795.00

That amount now seems a small price to pay for a farm, but it was more than many men could get together at that time. In order to secure the money necessary to purchase land or to develop their property some men had to work for a time as hired men or spend the winter in the pineries working for the lumber companies.

During the first few years of settlement, the chief interest and business of the settler was to plow a part of his farm, though it was not possible or desirable for a man to plow all of it. In general, no more was plowed than a man could cultivate himself, which was about 40 acres.[2] As the sod on the prairie was compact and deep, it was not easy to break. Such strenuous work required a big 16-inch breaking plow and from four to six oxen or horses. As few of the settlers had more than one team, they commonly put their teams together and plowed each man's land in turn.[3] In the wooded areas, plowing was possible only after the trees had been cleared off, and even then the roots of the trees made plowing difficult. For a number of years it was necessary for a farmer to raise most of the food for his family. Corn, potatoes, rutabagas, and turnips did well in newly turned sod, in spite of the fact that in most instances farmers were too busy to give them much attention.[4]

During the rush of settlers in 1855-1856, when foodstuffs had to be imported into Minnesota, a farmer who had a surplus of these crops or of pork or other meat

[1] 1st Annual Report of Commissioner of Statistics for Minnesota (Hartford, 1860), pp. 30, 87.
[2] Ibid., p. 87.
[3] Mills, J. C., in History of Fillmore County (Chicago, 1912), p. 503.
[4] Ibid., p. 505.

undoubtedly found an active market for it. By the second or third year, wheat was planted and it did well. It was ground into flour at small waterpower grist mills which shortly after settlement developed at many points in the valleys. In case a local mill was not available, the wheat had to be hauled many miles to a mill, but this involved much time and labor, and often one-third or more of the flour was taken for grinding. A team of horses or oxen, a few chickens, a hog or two, and a cow represented the stock on an average farm. Some attempts were made to raise sheep, but for a number of years so many of them were killed by wolves that they did not prove profitable.[5]

In addition to the work connected with growing a crop, it must be remembered that the settlers had to obtain fuel for the long, cold winter; cut wild hay on the prairies or the valley meadows for the stock; build homes, barns, fences, and churches; open roads, and bring supplies from market, so that, altogether, the first years of settlement in southeastern Minnesota were characterized by strenuous toil and considerable hardship, and were fraught with anxiety as to whether or not prosperity eventually would reward their efforts. In view of these conditions, it is easy to understand that, when it was demonstrated that large crops of wheat could be produced from the virgin soils and that wheat sold for cash, wheat growing came to be almost the sole economic interest of the farmers.

Although by 1859 it was evident that wheat farming had become the principal money crop in the area, it was not until the decade from 1870 to 1880 that bonanza wheat farming reached its maximum development (Fig. 1). This was due to the fact that a number of problems affecting the industry had to be solved before maximum acreage and production were attained. Of these the discovery that spring wheat was better adapted to local conditions than winter wheat, the introduction of milling processes suited to hard wheat, the improvement of transportation on the river, the establishment of warehouses and eleva-

[5] History of Winona County (Chicago, 1883), p. 263.

tors to handle the grain, and the building of railroads were the more important.

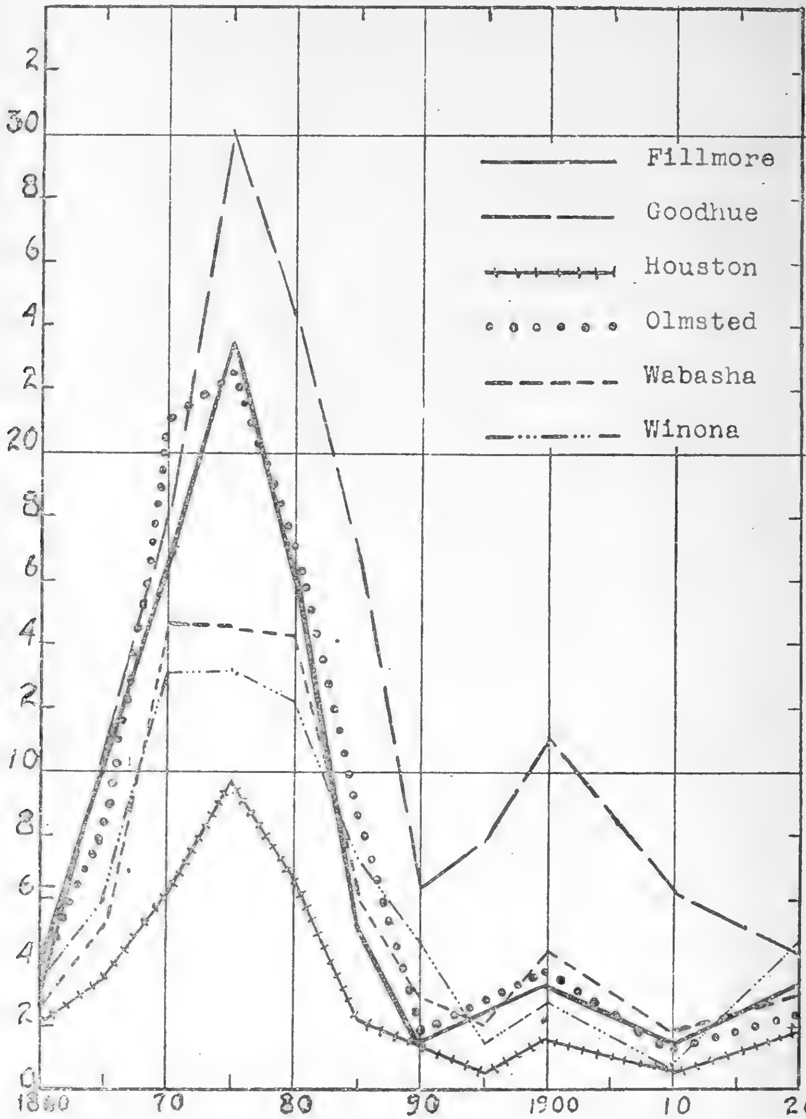

Fig. 1. Production of wheat in units of 10,000 bushels in the six counties of Southeastern Minnesota by five year periods from 1860 to 1920 inclusive. Data for the even years is from the United States Census, for the odd years from the annual reports of the Commissioner of Statistics for Minnesota. Statistics for 1905 and 1915 are not available. The graph shows that in these counties the period of bonanza wheat farming extended approximately from 1865 to 1885.

Fig. 2. Southeastern Minnesota. The major portion of the wheat produced in Southeastern Minnesota has been grown on the broad, nearly-level, loess-covered, upland into which the deep, steep-sided valleys of Root, Whitewater, Zumbro and Cannon rivers are cut.

Wheat culture in the area began in 1853 when a crop of winter wheat was raised on the alluvial terraces in Rollingstone Valley in Winona County,[6] and probably also in some of the terraces in Houston and Fillmore counties. Such alluvial terraces rise in many places above the flood plains of the streams, and comprise the principal areas farmed in the valleys. Wheat raising spread to the upland somewhat slowly because the valley

[6] Ibid., p. 262.

walls of the Mississippi are so steep that the upland farms were not readily accessible, until roads were built to them. Southeastern Minnesota is a region of nearly horizontally bedded limestone, sandstone, and shales, dissected to topographic early maturity by the Mississippi River and a number of its tributaries. It consists of nearly level upland tracts, the surfaces of which are about 1,150 feet above sea level, and of the valley floors of the Mississippi River and its tributaries, which lie from 350 to 400 feet below them. The upland corresponds in surface to most of southeastern Minnesota, and it constitutes the larger part of this area. The Root, Whitewater, Zumbro, and Canyon rivers flow across the area from west to east (Fig. 2). The deep valleys of these streams divide the upland into wide, flat-topped ridges which, like the rivers, extend from west to east across the area. The broad summits of these ridge-like remnants of the upland are fine farm lands, but their margins are not because they are too greatly dissected by the head ravines of the streams. The following table shows that

SHIPMENTS OF FARM PRODUCE FOR RIVER POINTS IN SOUTHEASTERN MINNESOTA IN 1859[7]

(Bushels)

Ports	Wheat	Oats	Corn	Barley	Potatoes
Red Wing	30,000*	.....	.....	.....	.....
Lake City	18,000	.....	.....	.....	3,400
Wabasha	4,800	10,000	.....	.....	2,000
Reed's Landing	3,000	5,000	.....	.....	1,000
Minneiska	12,000*	.....	.....	.....	.....
Mt. Vernon	3,000*	.....	.....	.....	.....
Winona	177,000	35,000	.....	9,000	6,000
La Crescent	15,000	1,000	2,000	.....	2,000
Hokah	3,000	.....	.....	.....	.....
Brownsville	32,000	4,000	.....	1,000	.....

in 1859 wheat had already attained first place among the crops.

The large shipments of wheat from Winona were due to the fact that Winona County was settled early, and that a larger tract of undissected upland suited to farming is tributary to Winona by wagon haul than to any other point along the river. A road was built at an early

[7] Robinson, E. V.: Early Economic Conditions and the Development of Agriculture in Minnesota (Minneapolis, 1915), p. 45, as corrected from 1st Annual Report of Commissioner of Statistics for Minnesota (Hartford, 1860), p. 155.

* All grains, but principally wheat.

date from Wabasha Prairie, a river terrace on which the city of Winona is located, to the upland along each of the several small valleys which focus on the terrace.

During the pioneer years some attempts were made to grow winter wheat on the upland prairies. Of those in Olmsted County local reports state that winter wheat was a success only once in three years[8], and this experience was found to hold on other prairies. In most years the wheat was killed during the winter because the prairies were so broad, open, and windswept that the snow was blown off, leaving the wheat exposed to the alternate freezing and thawing occasioned by diurnal and cyclonic temperature changes. In some years the fall of snow was too light or came too late in the season to protect the wheat[9]. In other years a warm spell melted the snow and covered the fields with water, which if it became ice killed the wheat.

In the valleys and timbered tracts, snow drifts much less than on the prairies, so that winter wheat was grown successfully. In 1859, the commissioner of statistics addressed specific inquiries to the different counties, asking for reports on the success of winter wheat. The replies showed that it was a failure in the counties which were mainly prairie, but was a success in those which included large areas of bluff lands or timber[10]. Until the improved methods of milling were introduced, the winter wheat crop in the valleys and wooded tracts in the southeastern part of the state was important. Good flour was made from it in the small water-power mills located near rapids or falls in the streams. Some of these mills gained a considerable local reputation for their flour. A few of them have been in business for more than fifty years, grinding the small amount of wheat annually produced in the communities tributary to them.

The pioneers shortly discovered that spring wheat is adapted admirably to the conditions on the upland prairies. The crop seldom is damaged by frost[11], as the growing season, varying from 140 to 150 days, is ade-

[8] First Annual Report of Commissioner of Statistics (Hartford, 1860).
[9] Ibid., p. 94.
[10] Ibid., p. 94.
[11] Purcell, V. G.: Climatic Conditions of Minnesota, Minnesota Geological Survey, Bull, No. 12, pp. 19-21.

quately long for this crop. Wheat is sown in the latter part of April or early in May, and grows rapidly through May, June, and the early part of July, which are the months of greatest rainfall. It ripens and is harvested in August, in which month hot, dry spells of weather are characteristic. The farmers have discovered that if sowing is delayed by a late spring or by other causes, the crop may come into "the milk" during a late summer dry spell and be injured. Judging by a comparison of crop yields with the weather records spring wheat has done well in most seasons since its culture began in this area. However, the decrease in yield per acre after 1875 was attributed incorrectly, by some writers, to vagaries of the weather[12].

By 1860, in the river counties of Minnesota, houses and barns were built and other improvements made, so that the farmers had time to cultivate more of their farms. In that year fifty per cent of the improved land in the counties facing on the Mississippi, and thirty per cent in the counties remote from the river but still within hauling distance, were planted to wheat[13]. As it became evident that wheat was the most profitable crop, more and more land was devoted to it. A man's income increased with the size of his crop, and consequently large acreages were planted.

The establishment of the one-crop system in this area was favored by the large yields of wheat produced from the fertile soils. The average yield per acre for the state as a whole was 22.05 bushels in 1860[14]. With the exception of Houston County, all of the counties in this area had an average yield per acre greater than that for the state. In some townships in these counties the average yield per acre was exceptional. In New Hartford township in Winona County it was 33.2 bushels, in Douglas township in Fillmore County, 27.7 bushels, and in Goodhue township in Goodhue County, 27 bushels[15]. In the next decade the average yield per acre varied from time to time, according to the season, but in 1875, twenty

[12] History of Winona County (Chicago, 1883), p. 99.
[13] Second Annual Report of Commissioner of Statistics, pp. 128, 129, 131.
[14] Second Annual Report of Commissioner of Statistics of Minnesota (St. Paul, 1861), p. 57.
[15] Ibid., p. 58.

years after settlement, the average yield per acre was 21.08 bushels in Goodhue, 18.02 in Fillmore, 19.64 in Olmsted, 18.06 in Wabasha, 17.55 in Winona, and 17.34 in Houston County[16]. After 1880, however, the average yield rapidly decreased. While statistics are not available to show which type of soil maintained high yields for the longest time, there is little doubt that the yield on the loess soils was satisfactory for some years after other soils were exhausted.

The scarcity of labor which prevailed in these early years somewhat retarded the increase of wheat acreages. Land was so cheap that nearly every man owned or hoped to own a farm rather than to work for some one else. Other parts of the West were developing at the same time, and the immigration of laborers into any one area seldom equalled the demand for them. As a result of this labor shortage and the profits in wheat farming, labor-saving farm machinery was adopted rapidly. Sulky plows, disk harrows, seeders, reapers, binders, threshing machines, fanning mills and other machines found a ready sale when they were put on the market. In southeastern Minnesota the use of farm machinery was favored by the nearly level surface and the fine textured, well-drained loess and weathered drift soils of the upland prairies. Moreover the shortage of labor during harvest, when it was most acute, was solved, in part at least, by the importation of gangs of men who had previously worked in the wheat fields in states to the south. The extension of the wheat growing area northward simply prolonged the working period of these men and brought them near the Minnesota and Wisconsin forests where many of them were employed in the winter.

The use of this machinery and the adoption of this harvesting practice so increased the acreage of wheat on many farms that the profits earned enabled many men to increase the size of their farms. Consequently holdings of from 300 to 1,000 or more acres were not uncommon. The profits were so great in many instances that

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[16] 8th Annual Report of Commissioner of Statistics for Minnesota (St. Paul, 1877), p. 36.

nearly every man in a community tried to own a piece of land. Storekeepers, shopkeepers, mechanics, and professional men bought farms which they partially worked themselves or rented "on shares" to farmers[17]. Quick returns led to speculation. Threshing outfits costing about $800 in some instances paid for themselves in two years[18]. Farmers ran store bills and bought machinery on time, and in many instances the returns from their crops more than warranted the outlay. There was small incentive for the farmers to use either their land or machinery carefully. Straw stacks were burned as the easiest way to dispose of them. Binders costing more than $200, and other machines and tools, in many instances were left in the field until wanted in the next season. As a result they rapidly depreciated in utility and value[19]. The prairie soils yielded so readily to the plow, wheat was relatively such an easy crop to grow, and yields were for the most part so satisfactory, that it is no wonder that farmers became a bit careless about expenses.

The acreage and production of wheat in southeastern Minnesota and elsewhere in the Spring Wheat Belt increased rapidly after certain developments in the marketing phase of the industry occurred. A notable one was the introduction of the "middlings-purifier" and other milling improvements which made it possible to produce a high-grade flour from the hard spring wheat[20]. The improvement of transportation to eastern markets was even more important. This was accomplished by (1) an increase of the number of steamboats on the river, (2) the introduction of river barges especially designed for carrying wheat, (3) the erection of warehouses and elevators along the railroads and at the steamboat landings, (4) the establishment of rail connection between the Mississippi and the Great Lakes, and (5) the construction of railroads westward from the Mississippi. The importance of these developments is reflected in the fact that in 1865, sixty-five per cent of the land under

[17] Schatzel, G. W.: Among the Wheat Fields of Minnesota, Harper's Magazine, XXXVI, January, 1868, p. 197.
[18] Ibid.
[19] Ibid., p. 200.
[20] Robinson, op. cit., p. 77.

cultivation in Olmsted County was planted in wheat[21], and that in 1870, Fillmore, Goodhue, Wabasha, and Winona Counties, each produced more than 1,300,000 bushels of wheat, and Olmsted County more than 2,000,000 bushels (Fig. 1). The relative importance of the southeastern counties is indicated by the fact that with one exception the counties mentioned were the only ones in the state to raise more than 1,000,000 bushels[22].

Climax of wheat raising. Bonanza farming in the southeastern counties culminated in the five years from 1875 to 1880. The largest acreage in the state as a whole occurred in 1878, when wheat was grown on 68.98 per cent of all cultivated land[23]. In the southeastern counties the largest crop was produced in 1875, when these counties produced 38 per cent of the state's crop. The production and distribution of the crop in that year by counties and townships clearly reflects the natural invironment. In that year, Wabasha and Winona counties each produced more than 1,000,000 bushels of wheat, Olmsted and Fillmore counties more than 2,000,000 bushels, and Goodhue County more than 3,000,000 bushels[24] (Fig. 1). The three counties last named owe their large production to (1) their large size, (2) their nearly level surface, being much less dissected than Houston, Winona and Wabasha counties, and (3) their fertile loess and glacial soils.

In Goodhue County wheat was raised on 30 per cent of its area and occupied 81 per cent of its cultivated land. Such a production led early writers to describe Minnesota as one continuous wheat field[25] and to claim that Red Wing was the "leading primary wheat market in the world[26]". Vasa, Belle Creek, Goodhue, Wanamingo and Zumbrota townships each produced more than 190,000 bushels of wheat in the year in question. All of them have a nearly level surface, a loess soil, and little waste land. In the northern part of the county the pro-

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[21] Annual Report of the State Auditor, Session of 1867, Minnesota Ex. Docs. for 1866, p. 61.
[22] 9th Census of the United States; Robinson, op. cit., pp. 260, 261.
[23] Robinson, op. cit., p. 79.
[24] 8th Annual Report of Commissioner of Statistics (St. Paul, 1877), p. 36.
[25] Geol. and Nat. Hist. Surv. of Minn., Vol. I, p. 337.
[26] Hancock, R. W.: Past and Present in Goodhue County, (Red Wing, 1893), p. 187.

duction was small, reflecting the dissected surface and less productive soils of that section. Likewise the acreage and production of wheat was relatively small in northwestern Olmsted County where the surface is dissected by the South Branch of Zumbro River, the drift is thin, loess is absent and the soil derived from the sandstone or limestone formations is poor[27]. The two leading townships in wheat production in the state in that year were Farmington township in the northeastern part of Olmsted County and Elgin township in Wabasha County, which joins it on the east, each of which produced more than 200,000 bushels. These townships cover a broad and nearly level stretch of prairie with a deep and fertile loess soil[28].

In Fillmore County the townships in which the yield was less than 100,000 bushels were in the dissected lands contiguous to Root River and its tributaries. In Winona and Houston counties the townships along the bluff lands of the Mississippi and Root valleys, and the upland ridges produced less than 100,000 bushels. The townships of maximum production were those occupying Wilmington Prairie in Houston County and Lewiston Prairie in Winona County[29]. In all of these counties, the townships in which more than 100,000 bushels of wheat were raised are on the uplands. In general, the greatest yields came from townships with a minimum of dissection, and from those which have loess over much of their surface.

After 1880 the acreage and production of wheat in southeastern Minnesota declined rapidly and the acreage and production of oats, corn, and barley, and the number of livestock increased. Although this change in the farm system was due to several conditions, the most important were the low price for wheat which prevailed after 1880 and a gradual decrease in the yield per acre.[30] The average yield per acre for the six counties in this area in 1875 was 18.6 bushels; by 1880 it had dropped to 11.5 bushels. Moreover, weeds became such a menace

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[27] Geol. and Nat. Hist. Surv. of Minn., Vol. I, pp. 337-338.
[28] 8th Annual Report of Commissioner of Statistics, pp. 29-34.
[29] Ibid.
[30] Robinson, op. cit., p.

on account of consecutive wheat crops on the same land, that it was necessary to plant other crops in order to get rid of them.[31] The locust plague, which partially destroyed the crop in the central and western parts of Minnesota from 1872 to 1877, did not affect the southeastern counties in any large way.[32] On the other hand, the chinch-bug appeared first in the southeast, and in 1877 destroyed two-fifths of the crop in Houston County.[33] The ravages of this insect were sufficient to make profits from the wheat crop uncertain.

By the middle of the decade, from 1880 to 1890, railroad mileage was extended so that most farms were within 10 miles, or nearer, of a station, and it was possible to market other farm products profitably. During the same decade, breweries began business in LaCrosse, Winona, Wabasha, and Red Wing, and a local market for barley was created. In addition, the losses incurred in wheat farming had led many farmers to mortgage their farms, so that progressive farmers realized that a change must take place. The Commissioner of Statistics and other state officials, the scientists from the State Agricultural College, the State Dairy Commissioner, the State Dairymen's Association and other agricultural societies combined with the state press in a protest against the old method of farming. Gradually the change to a more diversified crop system took place.

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[31] Bull, C. P.: Barley Investigations, University of Minnesota Agricultural Experiment Station, Bulletin 148, p. 7.

[32] Statistics of Minnesota, 1873, p. 192; 1874, pp. 7-9; 1875, pp. 19-22; 1876, pp. 49, 80, 88; 1877, pp. 17, 19; 1878, p. 9. Fifth Report of Agricultural Experiment Station, pp. 96-97.

[33] Statistics of Minnesota, 1877, pp. 18, 94.

THE COTTON INDUSTRY OF SOUTHERN ILLINOIS

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COTTON GROWING AN EARLY INDUSTRY IN ILLINOIS

While the exact date of the first cotton grown in Illinois is perhaps unknown, yet it could not have been many years after the first permanent English settlements. As proof of this, Governor John Reynolds, in speaking of the early cotton industry in Illinois says: "The first gin was established in 1813."[1] This statement of Reynolds is in complete accord with that of J. M. Peck, who wrote his Gazetteer of Illinois in 1837. In this book Peck says: "Cotton, for many years, has been successfully cultivated in this state (Illinois) for domestic use, and this branch of business admits of enlargement; and invites the attention of eastern manufacturers with small capital."[2] Peck further states: "A few factories for spinning cotton yarn have been put into operation in several counties on a small scale of from one hundred to two hundred spindles each."[3]

H. L. Ellsworth in his book, "Illinois In 1837," makes this significant statement concerning early cotton manufactures in Illinois: "Coarse clothing from cotton is manufactured in the southern portion of the state, where the article is raised in small quantities. Woolen cloth, and jeans, a mixture of wool and cotton, is made for ordinary wear, as is cloth from flax."[4] From these early writers it is clear that cotton was not merely grown in Illinois at a very early date, but cotton yarn and cotton cloth were made for commercial purposes in addition to that made and consumed in the homes of the early settlers.

It is also quite probable that available statistics do not show the entire amount of cotton raised, for the reports show the amount of lint by bales. Baled cotton was for

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[1] Reynolds, John: Pioneer History of Illinois. Page 398.
[2] Peck, J. M.: Gazetteer of Illinois. Page 22.
[3] Peck, J. M.: Gazetteer of Illinois. Page 32.
[4] Ellsworth, H. L.: Illinois in 1837. Page 59.

"export" and did not represent that used in the home, for such cotton was evidently not baled.

AMOUNT OF BALED LINT PRODUCED FROM 1839 TO 1880

In 1839	amount	of	lint	produced	in	Illinois	was	402	bales.
" 1859	"	"	"	"	"	"	"	1186	"
" 1860	"	"	"	"	"	"	"	1482	"
" 1865	"	"	"	"	"	"	"	7609	"
" 1870	"	"	"	"	"	"	"	465	"
" 1875	"	"	"	"	"	"	"	13	"
" 1876	"	"	"	"	"	"	"	about 1	"
" 1877	"	"	"	"	"	"	"	118	"
" 1878	"	"	"	"	"	"	"	6	"
" 1879	"	"	"	"	"	"	"	18	"
" 1880	"	"	"	"	"	"	"	95	"

While available statistics do not show the production for each year, yet they do show that cotton was probably continuously grown from the period of the early English settlements of Illinois to at least 1880. It is quite probable that cotton continued to be grown on a small scale till about 1910 or even later. The writer distinctly remembers seeing a field of cotton between Mound and Mound City about 1910.

COTTON INDUSTRY DURING CIVIL WAR

In 1865 cotton culture in Illinois reached its high water mark for the 19th century. This was due almost wholly to the changed economic conditions caused by the war itself. President Lincoln's proclamation closing the southern ports to all foreign trade, together with lack of labor on many southern plantations near the close of the

COTTON PRODUCTION IN 13 ILLINOIS COUNTIES IN 1865.

Counties	No. of acres planted	Yield per acre	No. of bales of lint	Price per lb. in seed	Amount realized
Jackson	3,280	800 lbs.	1,876	10¢	$378,065
Union	2,700	800 "	1,458	10¢	$199,757
Williamson	1,678	800 "	1,000	10¢	$141,750
Johnson	1,000	900 "	800	9½¢	$136,800
Massac	728	800 "	370	9½¢	$ 55,361
Perry	661	800 "	639	9¢	$ 56,563
Franklin	625	800 "	356	9½¢	$ 47,500
Jefferson	435	800 "	240	9¢	$ 27,920
Pope	350	800 "	190	9¢	$ 22,680
Alexander	310	800 "	250	9¢	$ 18,700
Gallatin	300	800 "	200	9¢	$ 21,600
Pulaski	123	1100 "	200	10½¢	$ 13,500
Hardin	45	800 "	30	8¢	$ 4,200
Totals	12,835		7,609		$1,125,396

war, caused a very serious shortage of raw cotton both in America and western Europe. Thus the price of cotton was high and many southern Illinois farmers found cotton the most profitable crop they could raise.

These statistics show some rather remarkable things. In the first place, the largest producing counties in 1865 were not the extreme southern counties of Alexander, Pulaski, Massac, and Pope, but Jackson, Union, Williamson and Johnson counties, somewhat farther north. Jackson county alone produced more than twice as much as the five southernmost counties combined. In the second place most of the cotton was not produced in the more fertile bottom lands of the Mississippi and Ohio Rivers, but on the warmer south and east slopes of the hill lands of Jackson, Union, Williamson, and Johnson counties. Even the hill county of Massac produced more than twice as much cotton as the two counties of Pulaski and Alexander with their much larger proportion of river bottom land. The explanation of this is that the river bottom lands in 1865 were still largely in timber, poorly drained, and not well protected from floods, while the hill lands still retained much of their virgin fertility of soil, were warmer, and much better drained. Cotton needs warm and well drained lands quite as much as lands of high fertility.

Owing to the fact that the Illinois Central railroad was the only road having a direct outlet to the north and thence east to New York City, nearly all the cotton was marketed in towns along the Illinois Central railroad. Of all these towns Carbondale was the most accessible to the chief cotton producing counties and as a consequence became the chief cotton market in Illinois. In 1865 there were 11 cotton gins in and near Carbondale. Carbondale was the shipping point for most of the cotton of Jackson, Williamson, Saline, Gallatin, northern Hardin, Pope, and Johnson counties.

The importance of Carbondale as a cotton market can be gained also from this statement of Newsome, who says: "At one time there were about a dozen cotton gins

[5] Pearcy, A. J.: Transactions of Ill. State Agr. Society. Vol. 6, 1865-6, Page 66.

in town (Carbondale), so in the autumn, the place had very much the appearance of a southern town, for the cotton was everywhere, and the bales were piled upon the depot platform ready for shipment. The price was high, money was plenty, and business lively[6]." It is quite probable that more than one-half of the 1,125,396 dollars worth of cotton shipped from Illinois in 1865 was shipped from Carbondale. For a few years after the Civil War cotton continued to be one of the leading money crops in several southern Illinois counties; but as the South gradually recovered from the war, cotton growing increased, prices grew less and Illinois being unable to compete with the southern cotton grower, the industry gradually declined and finally ceased entirely about 1910 or soon thereafter.

REVIVAL OF COTTON GROWING IN 1923 AND 1924

Perhaps at no time in the history of Illinois has more been said and done to revive cotton growing in this state than has been the case in the last two years. Bankers, farm advisers, lawyers, merchants, farmers and others have been persistently advocating the possibilities of cotton production, particularly in the counties of Pulaski, Alexander, Union, Massac, and Johnson. Bankers and lawyers have visited the southern cotton growing states to study how best to start the industry. Experienced cotton men from the South, and the national government have been brought to these counties where large and enthusiastic meetings with prospective growers have been held. At these meetings such questions as these have been discussed: the time to plant cotton, the type of soils, the best kinds of cotton for southern Illinois, manner of preparing seed bed and of cultivating cotton, the amount one man can plant, cultivate and pick, and finally how and when best to pick and how to sell the crop.

CHIEF CAUSES THAT HAVE PRODUCED THIS REVIVAL

Chief of the causes that have contributed to this renewed interest in cotton growing is the destruction due

[6] Newsome, E. "Historical Sketches of Jackson Co. Ill.," Page 124.

to the ravages of the boll weevil in the southern cotton growing states. Second, there is a general belief among experienced cotton growers that the boll weevil will not be a serious menace to cotton growing in southern Illinois, due to the colder winters of this section of the country.

The third reason for this revival in cotton growing is the development, by careful seed selection, of earlier maturing varieties of cotton that can mature a paying crop in these more northern regions with their shorter growing seasons. Such early varieties as trice, acula, delfos and express can mature an early crop of high grade cotton in latitudes of southern Illinois.

The fourth reason is that cotton has been successfully grown in southern Illinois for a great number of years. Added to this is the influence of the largely increased growing of cotton just across the state border, in southeastern Missouri. This rather large scale production in southeastern Missouri has been so pronounced that it has attracted the attention of business men and farm advisers in adjoining sections of southern Illinois.

There are other, but perhaps more temporary, causes for this recent activity in cotton planting. These last may even be the greater stimuli to many farmers who will plant cotton this season. The greatest of these stimuli is the present high price of cotton. Very closely connected with this is the fact that farmers generally have made but little out of wheat, corn, alfalfa, and live stock in the last few years and are as a consequence ready to listen to any suggestion of some farm product that promises better money returns than the present day staple crops. Experience alone must in the future determine whether these stimulating causes have sufficient merit to justify present expectations. They certainly seem to have. While there is still some uncertainty as to the cotton acreage for 1924, yet conservative estimates place the amount somewhere between 15,000 and 18,000 acres. It may go to 20,000. These estimates are based on amounts of cotton seed already purchased through farm advisers in the various cotton producing counties.

The accompanying table shows approximately the chief cotton planting counties for 1924 and the amount to be planted in each.

Pulaski and Alexander, together, estimated from 10,000 to 12,000 acres.

Union County	estimated	acreage	about	2,500	to	3,000	acres.
Massac	"	"	"	750	"	1,000	"
Johnson	"	"	"	1,000	"	2,000	"
Jackson	"	"	"	250	"	300	"

For Williamson, Pope, Saline, and perhaps other counties, no definite figures are available, but each will plant a small amount. Pulaski probably will have the largest acreage, which will be closely followed by Alexander county.

In contrast to the cotton growing counties of the Civil War period, it will be noticed that the extreme southern counties, with their larger share of bottom lands, will lead; and the more hilly lands to the north will take a decidedly lower rank. The explanation of this contrast with 1865 is that the river bottom lands are much more fertile, they are now much better drained than formerly, and the construction of levees in recent years gives greater protection from floods.

In the larger producing counties of Pulaski, Alexander and Union the labor in the cotton fields will be done chiefly by negroes from the South. These are experienced cotton raisers who have left the South because of the ravages of the boll weevil and are as a rule very poor. The land owners lease the land, furnish food, implements, seed, teams, and get one half of the crop. In the other counties the labor will be largely performed by native white labor on their own farms.

This seasons trial of cotton growing will be watched eagerly, particularly by southern Illinois farmers, and upon its success the future of cotton growing in this section will largely depend.

The chief hope of southern Illinois becoming again a part of the cotton growing region rests largely upon the oft repeated statements of experienced cotton growers from the South who declare to prospective Illinois growers, "You are on the same footing as we of the Gulf States because we must plant early maturing varieties to get the crop far enough advanced before the boll weevil becomes sufficiently numerous to effect the crop seriously." In other words, the growing season for these early maturing varieties is about the same in southern Illinois as in the Gulf States.

THE CORRELATION OF THE MAQUOKETA AND RICHMOND ROCKS OF IOWA AND ILLINOIS

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The rocks of Richmond age in southeastern Iowa have been called the Maquoketa formation, or Maquoketa shale, from the Little Maquoketa River in Dubuque County, Iowa, along which they are well exposed. Corresponding strata also outcrop in the northwest part of Illinois.

The lower strata of Richmond age in southern and eastern Illinois have been correlated with the Fernvale[1] limestone. They are exposed in a number of places along the Mississippi River in the southwest part of the State, for example, near Thebes in Alexander County, and near Val Meyer in Monroe County. Outcrops of this limestone also occur in adjacent portions of Missouri, as at Cape Girardeau. Strata of corresponding age also outcrop in Will and Kendall counties, in the northeast part of the State. One of the localities in which they furnish an unusual number of bryozoa and other fossils in an excellent state of preservation is in the banks of Kankakee River at Wilmington, Illinois, where the exposed section is as follows:

SECTION OF RICHMOND STRATA IN THE VICINITY OF WILMINGTON

2.	Shale, bluish-gray, with few fossils	35 ft.
1.	Limestone, shaly to subcrystalline, in irregular layers that contain numerous fossils	12 ft.

The Richmond sediments were deposited on an eroded surface so that in some places in northeastern Illinois a thickness of 40 or 50 feet or more of shale of Richmond age underlies the limestone member exposed at Wilmington. This limestone is also in places thicker than in the Wilmington section. There are no fossils in the shale beneath the limestone by which its age can be determined. However, as the two members do not appear to be separated by an unconformity, the shale probably represents the initial deposits of the formation to which the limestone belongs.

[1] Savage, T. E., The faunal succession and the correlation of the pre-Devonian formations of southern Illinois. Bull. No. 16, Ill. State Geol. Survey, pp. 315-318, 1910.

The more calcareous layers in the lower part of the section at Wilmington furnished the species of fossils listed below. In this list and those that follow the relative abundance of each species is indicated by the letters r—rare, c—common and a—abundant, placed after the name. If the species occurs in the Richmond strata of Indiana, the particular formation of the Richmond in which it is found in Indiana is indicated by the letters A—Arnheim; W—Waynesville; L—Liberty; Wh—Whitewater; and E—Elkhorn, following the name in the lists.

LIST OF FOSSILS FROM THE LOWER PART OF RICHMOND STRATA AT WILMINGTON

Anolotichia ponderosa Ulr. (a)
Anaphragma mirabile U. & B. (c)
Anaphragma mirabile n. var (r)
Arthroclema angulare Ulr. (c)
Atactoporella cf. schucherti Ulrich (r) W. Wh.
Batostoma prosseri C. & G. (c) W. L.
Batostoma variabile Ulr. (r) W. E.
Bythopora delicatula (Nich.) (r) W. L. Wh.
Bythopora meeki (James) (r) W. L. Wh.
Ceramoporella granulosa Ulr. (r) A. W.
Ceramoporella ohioensis (Nich) (r) Richmond
Ceramoporella whitei (James) (r) A. W.
Constellaria polystomella (Nich) (c) W. L.
Constellaria punctata (Whitfield) (c)
Crepipora hemispherica Ulrich (r)
Crepipora simulans Ulr. (r)
Cyclotrypa n: sp. (r)
Cyphotrypa stidhami (Ulr.) (c) Wh.
Cyphotrypa wilmingtonensis U. & B. (r)
Dicranopora emacerata (Nich.) (r) Richmond
Eridotrypa simulatrix (Ulr.) (c) W.
Favositella epidermata (Url.) (r-c)
Hallopora subnodosa (Ulrich) (r) Richmond
Helopora imbricata Ulr. (c)
Hemiphragma imperfectum (Ulr.) (aa)
Heterotrypa affinis (Ulr.) (c)
Heterotrypa prolifica Ulr. (r) W.
Heterotrypa singularis Ulr. (r) W.
Heterotrypa subramosa (Ulrich) (r) W.
Homotrypa cf. communis Bassler (r) W. L.
Homotrypa flabellaris Ulrich (r) W. L. Wh.
Homotrypa gelasinosa Ulr. (r)
Homotrypa cf. similis Foord (r)
Homotrypella rustica var. n. (c)
Mesotrypa orbiculata C. & G. (r) A.
Nicholsonella n. sp. (c)
Nicholsonella n. sp. (r-c)
Nicholsonella cumulata Ulr. (r)
Pachydictya elegans Ulr. (r-c)
Pachydictya fenestelliformis (Nich.) (a) W. L.
Pachydictya fenestelliformis corticula Ulrich (r)
Pachydictya firma Ulr. (a)

Pachydictya gigantea Ulr. (a)
Pachydictya hexagonalis Ulr. (r)
Pachydictya magnopora Ulr. (c)
Pachydictya splendens Ulr. (r)
Peronopora decipiens Rom. (a) A. E.
Phenopora wilmingtonensis Ulrich (r)
Phenopora wilmingtonesis var. (r)
Protocrisina exigua Ulrich (r)
Ptilotrypa obliquata Ulrich (c)
Rhombotrypa crassimuralis (Ulrich) (r)
Rhombotrypa quadrata (Rominger) (c) W. L. Wh.
Rhombotrypa subquadrata (Ulrich) (r) W. L.
Stigmatella interporosa U. & B. (r) W.
Stigmatella sp. (r)
Stomatopora arachnoidea (Hall) (c)
Dalmanella tersa Sardeson (r)
Dalmenella testudinaria (Dalman) (c)
Dinorthis proavita (Winchell and Schuchert) (c)
Dinorthis subquadrata (Hall) (c) L. Wh.
Hebertella insculpta (Hall) (c) W
Hebertella occidentalis (Hall) (c) Richmond
Lingulasma schucherti Ulrich (r)
Parastrophia divergens Hall and Clarke (r)
Platystrophia cumingsi McE. (c) W.
Plectambonites sericeus (Sowerby) (c) W. L.
Plectorthis kankakensis (McChesney) (c)
Rafinesquina alternata (Emmons) (c) Richmond
Rafinesquina kingi (Whitfield) (r)
Rhynchotrema capax (Conrad) (c) Richmond
Rhynchotrema perlamellosum (Whitfield) (c)
Strophomena neglecta (James) (c) W
Strophomena nutans (Meek) (r) W
Strophomena planumbona (Hall) (c) W. L.
Strophomena planodorsata Winchell and Schubert (c)
Strophomena wisconsinensis (Whitfield) (c)
Ambonychia sp (r)
Hormotoma sp (r)
Orthoceras sp
Endoceras proteiforme Hall (r)
Cyrtoceras sp (r)

* Note: The bryozoa in this and the following lists were identified by Professors E. R. Cumings and J. J. Galloway.

Of the fossils in the foregoing list that are present also in the Richmond strata of Indiana, 12 species occur there in the Waynesville formation and do not appear in younger Richmond strata. Eleven other species occur in Indiana in both the Waynesville and the Liberty formations. Twelve of the species range from the Waynesville to the Whitewater formations. None of the species are restricted to the Liberty formation in Indiana, and only one of the number is found in Indiana only in the Whitewater formation. Such species as Dinorthis subquadrata that is not present in Indiana in the Waynesville, but occurs there in both the Liberty and Whitewater formations, and Cyphotrypa stidhami that occurs in Indiana only in the Whitewater formation, are present in Illinois in the same layers that contain Hebertella insculpta and other species that in Indiana are restricted to the Waynesville formation. Such species do not indicate that the rock from which they come are Liberty or Whitewater in age, but they show that some of the species have a different vertical range in Illinois from what they do in Indiana. The range of the species indicated in the above list is conclusive evidence that the Fernvale limestone at Wilmington, Illinois, corresponds in age to that of the Waynesville more closely than to any other formation of the Indiana Richmond, and it is considered as Waynesville in age.

Another exposure of Richmond limestone occurs near the mouth of Rock Run, about six miles west of Joliet, where the section is as follows:

	Feet
Shale, bluish to yellowish, slightly sandy; few or no fossils	18
Concealed	4
Limestone, gray, subcrystalline, in rough layers 4 to 5 inches thick, alternating with bands of bluish-gray, calcareous shale. Fossils are numerous in the limestone layers	4
Limestone, gray, subcrystalline, in uneven layers 3 to 8 inches thick, containing many fossils	7

The fossils collected from the limestone layers at the Rock Run locality include the following species:

FOSSILS FROM THE RICHMOND STRATA ON ROCK RUN

Anaphragma mirabile U. & B. (r)
Arthroclema angulare Ulr. (r)
Batostoma prosseri C. & G. (r) W. L.
Bythopora delicatula (Nich.) (r-c) W. L. Wh.
Bythopora meeki (James) (a) W. L. Wh.
Coeloclema oweni (?) (James) (r)
Dicranopora emacerata (Nich.) (r) Richmond
Eridotrypa simulatrix Ulr. (r-c) W
Favositella epidermata (Ulr.) (r) Fernvale
Helopora imbricata Ulr. (r-c) Fernvale
Hemiphragma imperfectum (Ulr.) (r-c) Fernvale
Mesotrypa patella (Ulr.) Wh
Nicholsonella cumulata (r) Fernvale
Nicholsonella punctata (Whit.)
Pachydictya fenestelliformis (Nich.) (c) W. L.
Pachydictya firma Ulr. (c) Fernvale
Pachydictya gigantea Ulr. (a) Fernvale
Pachydictya sp. (c)
Petigopora sp. (r)
Rhombotrypa quadrata (Rom.) (a) W. L. Wh.
Dinorthis subquadrata (Hall) (c) L. Wh.

Dinorthis proavita Winch. and Schuchert (c) Fernvale
Hebertella insculpta (Hall) (c) W.
Platystrophia cumingsi McE. (c) W.
Plectorthis kankakensis (McC) (c)
Plectambonites sericeus (Sowerby) (c) W. L.
Rafinesquina alternata (Emmons) (c) Richmond
Rhynchotrema capax (Conrad) W. L. Wh.
Rhynchotrema perlamellosum (Whit.)
Strophomena neglecta (James) W.
Strophomena planumbona (Hall) W. L.

The species of fossils in the above list leave no doubt of the Fernvale age of the lower or limestone part of the Richmond section in the Rock Run locality.

Along the banks of Aux Sable creek for a distance of one and one-half to two and three-fourths miles northwest of Minooka, Illinois, fossiliferous strata belonging in the middle part of the Richmond, as there developed, are exposed in several places. They consist of alternating layers of shell limestone and calcareous shale in the lower part, grading upward into rather dense granular limestone; the strata are nearly horizontal, the entire thickness seen aggregating 10 to 15 feet. The species of fossils collected from this limestone along Aux Sable Creek are listed below:

LIST OF FOSSILS FROM LIMESTONE ALONG AUX SABLE CREEK, NORTHWEST OF MINOOKA

Amplexopora ampla U. & B. (r)
Batostoma sp. (r)
Bythopora delicatula (Nich.) (r) W. L. Wh
Bythopora meeki (James) (aa) W. L. Wh.
Bythopora striata Ulr. (r) W.
Eridotrypa simulatrix Ulr. (r) W.
Hallopora cf. onealli (r)
Hallopora subnodosa (Ulr.) (c) Richmond
Hallopora cf. subplana (r)
Homotrypella rustica Ulr. (c) W. L. Wh.
Homotrypella rustica var. (c)
Mesotrypa orbiculata C and G. (r-c) A
Stigmatella crenulata U. & B. (r) W.
Stigmatella interporosa U. & B. (r) W
Stigmatella nicklesi U. & B. (r)
Stigmatella spinosa U. & B. (r) W.
Stigmatella spinosa yorkvillensis (c)
Stomatopora arachnoidea (Hall) (c)
Dalmanella testudinaria (Dalman) (c)
Dinorthis subquadrata (Hall) L. Wh.
Dinorthis proavita (Winchell and Schuchert) (r)
Hebertella insculpta (Hall) (r) W.
Hebertella occidentalis (Hall) (r) L. Wh.
Platystrophia cumingsi McE. (r) W.
Plectorthis kankakensis (McC.) (r)

Rafinesquina alternata (Emmons) (c) Richmond
Rhynchotrema capax (Conrad) (c) Richmond
Rhynchotrema perlamellosum (Whit.) (c)
Strophomena neglecta (James) (c) W.
Strophomena planumbona (Hall) (c) W. L.
Strophomena planodorsata Winchell and Schuchert (c)
Zygospira modesta Hall (c) Richmond
Pterinea demissa (Conrad) (c) Richmond
Cyclonema sp. (c)
Calymene meeki Foerste (c) Richmond
Isotelus maximus Locke (c)
Synhomalonotus christyi (Hall) (c) W.

In the above list of fossils there are ten species that are not known to occur in Indiana in rocks younger than the Waynesville division of the Richmond, and all but one of these are there restricted to this division. There are no other species in this list that are confined to a single division of the Richmond in Indiana. There can be no doubt that they represent about the same time of deposition as the Waynesville beds of Indiana, and that the fauna corresponds with that of the Fernvale at Wilmington, above described. The species of trilobites, Isotelus maximus and Synhomalonotus christyi, occur in the lower more shaly strata, and are not found in the uppermost limestone layers.

A fauna similar to that occurring along Aux Sable Creek is present in the Richmond strata near Oswego in Kendall county, 15 miles farther north. A practically complete section of these strata, from the contact at the top with the Silurian limestone, is exposed along Fox River between Oswego and Yorkville. The detailed section is as follows:

SECTION OF RICHMOND STRATA BETWEEN OSWEGO AND YORKVILLE

	Ft.	In.
Silurian system		
Limestone, yellowish-gray, partly dolomitic in layers 2 to 4 inches thick	2	4
Ordovician system		
Richmond shale and limestone		
Shale, greenish, thin bedded, without fossils	..	3
Limestone, subcrystalline, in uneven layers 7 to 10 inches thick, with many fossils	6	..
Limestone, bluish, shaly	2	..
Shale, blue	..	3
Limestone, bluish, slightly shaly, in layers 1 to 8 inches thick, with occasional shale partings 4 to 6 inches thick	4	..

	Ft.	In.
Limestone, shaly, bluish, with bands of shale at different levels, containing many fossils....about	10	..
Shale, in bands 3 to 6 inches thick, alternating with limestone layers of about the same thickness, containing very many fossils.....................	12	..
Shale, dark, calcareous, containing many shells of species of Dalmanella, Rafinesquina, Pterinea, Isotelus, and Synhomalonotus..................	2	..
Concealed ....about	5	..

The fossils from the strata described in the last section are listed below:

LIST OF RICHMOND FOSSILS FROM ALONG FOX RIVER BETWEEN OSWEGO AND YORKVILLE

Arthropora shafferi (Meek) (r)
Batostoma prosseri C. & G. (r) W. L.
Batostoma varians (James) (c) W. Wh. L.
Bythopora delicatula (Nich.) (r) W. L. Wh.
Bythopora meeki (James) (r) W. L. Wh.
Bythopora striata Ulr. (c) W.
Hallopora,cf. onealli (r)
Hallopora subnodosa (Ulr.) (r) Richmond
Hallopora cf. subplana (r)
Homotrypella rustica (r) W. L. Wh.
Perenopora decipiens Rom. (c) A. E.
Stigmatella spinosa U. & B. (r) W.
Stigmatella spinosa var. (c)
Dalmanella testudinaria (Dalman) (c)
Dinorthis subquadrata (Hall) (r) L. Wh.
Hebertella insculpta (Hall) (r) W.
Hebertella occidentalis (Hall) (r) L. Wh.
Lingula deflecta Winchell and Schuchert, (r)
Plectambonites sericeus (Sowerby) (c) W. L.
Platystrophia cumingsi McE. (c) W.
Rafinesquina alternata (Emmons) (a) Richmond
Rhynchotrema capax (Conrad) (c) W. L. Wh.
Strophomena neglecta (James) (r) W.
Strophomena planodorsata W. and S. (c)
Strophomena planumbona Hall (c) W. L.
Zygospira modesta Hall (c) Richmond
Byssonychia radiata (Hall) (c) Richmond
Pterinea sp.
Tentaculites oswegoensis M. and W. (c)
Calymene meeki Foerste (c) Richmond
Synhomalonotus christyi (Hall) (c) W.
Isotelus maximus Locke (c)

In the foregoing list there are six species that in Indiana occur only in the Waynesville formation, and not a single one is present that in Indiana is diagnostic of a younger Richmond horizon.

About 35 miles still farther northwest, strata of Richmond age are exposed along a stream 1½ miles west and ¼ mile north of Kingston, in DeKalb County. The strata at this locality consists of impure shaly limestone which outcrops in the creek bank to a height of 8 to 10 feet. The horizon is not many feet below the base of the Silurian which was encountered in a water wall put down near the outcrop. The fossils collected at this locality include the species listed below:

FOSSILS FROM THE UPPER PART OF THE RICHMOND NEAR KINGSTON, ILLINOIS

Amplexopora sp. (c)
Arthropora shafferi (Meek) (r)
Batostoma sp. (c)
Bythopora delicatula (Nich.) (r) W. L. Wh.
Bythopora meeki (James) (a) W. L. Wh.
Bythopora striata Ulr. (r) W
Hallopora subnodosa (Ulr.) (a) Richmond
Hallopora cf. subplana (c)
Perenopora decipiens Rom. (c) A. E.
Stigmatella spinosa U. & B. (c) W.
Stomatopora arachnoidea (Hall) (a) W.
Lingula sp.
Dalmanella testudinaria (Dalman) (c)
Rafinesquina alternata (Emmons) (c)
Pterinea sp.
Calymene meeki Foerste (a)
Isotelus maximus Locke (c)
Synhomalonotus christyi (Hall) (a) W.

An exhaustive collection of fossils was not attempted at this place on account of their poor preservation, but the species indicate clearly the Waynesville division of the Richmond, and show also the close correspondence of the Richmond at this locality with that in the vicinity of Oswego, and northwest of Minooka. The trilobites, Isotelus maximus and Synhomalonotus christyi, came from a level a few feet below the upper, more calcareous strata from which the greater number of the bryozoa species were collected, as they did in the Fox River and Aux Sable Creek localities.

West of the LaSalle anticline in the northwest part of Illinois, the lower Richmond (Maquoketa) shale is well exposed in a cut along the Illinois Central Railroad a short distance west of the station at Scales Mound, in Jo Daviess County, where it is immediately underlain by Galena limestone. The detailed section is given below:

SECTION OF RICHMOND STRATA AT SCALES MOUND, ILL.

	Ft.
Maquoketa shale	
Shale, bluish-gray, without fossils	32
Shale, blue, with a reddish zone near the base, and another about 8 feet above the base; containing several small fossils.	11
Galena limestone	
Dolomite, yellowish-brown, in layers 6 to 18 inches thick	6

The following species of fossils were collected from the lower portion of the shale exposed in the railroad cut at Scales Mound. These are peculiar in that they are all of small size, and consist mainly of mollusks. Brachiopods, and especially bryozoa, are exceedingly rare.

LIST OF FOSSILS FROM THE LOWER PART OF THE MAQUOKETA SHALE AT SCALES MOUND

Dalmanella testudinaria (Dalman) (c)
Zygospira modesta Hall (c) Richmond
Ctenodonta fecunda (Hall) (c)
Ctenodonta obliqua (Hall) (c)
Clidophorus neglectus Hall (c)
Bellerophon sp.
Liospira micula (Hall) (c)
Lophospira pulchella Ulrich and Scofield (c)
Pleurotomaria depauperata (Hall) (c)
Orthoceras sociale Hall (a)

The fauna listed above is conspicuous in that it is not a typical Richmond fauna. Only one of the species, Zygospira modesta, is listed by Cumings from the Richmond strata of Indiana, and that has a wide range, both geographical and vertical, and is of no value in stratigraphy. The fauna resembles the lower Maquoketa fauna found near Graf, in Dubuque County, Iowa, and doubtless represents a corresponding horizon.

In the vicinity of Scales Mound, the Maquoketa formation, above the shale exposed in the railroad cut, consists of 50 to 75 feet of bluish-gray, non fossiliferous shale in which are occasional thin bands of earthy dolomite. This is overlain by about 28 feet of alternating layers of calcareous shale and limestone that contain numerous fossils among which are many bryozoa. These upper, calcareous and fossiliferous beds outcrop along the wagon road two and one-half miles northeast of Scales Mound, near the west side of sec. 19, T. 29 N., R. 3 E. from which locality the fossils listed below were collected.

LIST OF FOSSILS FROM UPPER MAQUOKETA STRATA 2½ MILES NORTHEAST OF SCALES MOUND

Amplexopora sp. (a)
Batostoma sp. (a)
Bythopora meeki (James) (r) W. L. Wh.
Constellaria polystomella (Nich.) (r-c) W. L.
Corynotrypa inflata (Ulr.) (c) Richmond
Dicranopora emacerata (Nich.) (r) Richmond

Eridotrypa sp. (c)
Hallopora ramosa (d'Or.) (c)
Hallopora subnodosa (Ulr.) (c) Richmond
Monotrypa sp. (a)
Nicholsonella sp. (c)
Pachydictya fenestelliformis (Nich.) (r) W. L.
Peronopora decipiens (Rom.) (r) A. E.
Rhombotrypa crassimuralis (Ulr.) (r-c) Fernvale
Stomatopora arachnoidea (Hall) (c)
cf. Glyptocrinus decadactylus Hall (r)
Dalmanella testudinaria (Dalman) (c)
Hebertella insculpta (Hall) (c) W.
Dinorthis proavita Winchell and Schuchert (c)
Plectambonites sericeus (Sowerby) (c) W. L.
Plectorthis whitfieldi (Winchell) near P. kankakensis (McC) (c)
Rafinesquina alternata (Conrad) (c) Richmond
Rhynchotrema capax (Conrad) (c) Richmond
Rhynchotrema neenah (Whitfield) (c)
Strophomena neglecta (James) (c) W.
Strophomena wisconsinensis Whitfield (r)
Modiolopsis concentrica Hall and Whitf. (c) W.
Hormotoma sp.

The species of fossils in the foregoing list indicate the same horizon as that which furnished the fossils from Aux Sable Creek, and that in the vicinity of Oswego, and Wilmington. Three of the species in the list are restricted to the Waynesville division of the Richmond in Indiana, and not one of them is confined to any other member of the Indiana Richmond. The only species in the list that were not found in the Wilmington, Oswego and Aux Sable Creek localities are Corynotrypa inflata, which ranges throughout the Richmond, Hallopora ramosa, which occurs in the Maysville of Indiana, and Modiolopsis concentrica, which is restricted to the Waynesville formation in the Ohio-Indiana region. These upper Maquoketa strata are thought to represent Waynesville time, and to correspond in age with the Fernvale limestone present at Wilmington, and in the vicinity of Oswego, and northwest of Minooka.

Another excellent exposure of the upper strata of the Maquoketa is in the north bank of Rock River, one and one-fourth miles east of the railroad station at Sterling, Illinois. The detailed section of the outcrop at this place is given below:

SECTION OF STRATA EXPOSED IN THE NORTH BANK OF RIVER 1¼ MILES EAST OF STERLING

	Ft.
Silurian limestone	
Limestone, yellow to brown, dolomitic, in layers 4-10 inches thick, with few fossils	28

Maquoketa shale	Ft.
Shale, bluish-gray, in layers 3 to 6 inches thick, alternating with calcareous, very fossiliferous bands	10
Shale, sandy with few fossils	18

The species of fossils collected from the upper member of the Maquoketa at this place are listed below.

LIST OF FOSSILS FROM 1¼ MILES EAST OF STERLING, ILL.

Anolotichia sp. (r)
Anaphragma mirabile U. & B. (c)
Batostoma prosseri C. & G. (c) W. L.
Batostoma varians (James) (c) W. L. Wh.
Bythopora delicatula (Nicholson) (c) W. L. Wh.
Bythopora meeki (James) (c) W. L. Wh.
Bythopora striata Ulr. (r-c) A.
Dicranopora emacerata (Nich.) (r) Richmond
Dicranopora fragilis (Bill.) (c)
Favositella epidermata (Ulr.) (r)
Hallopora subnodosa (Ulr.) (r) Richmond
Hallopora cf. subplana (Ulr.) (r)
Hemiphragma imperfectum (Ulr.) (c)
Mesotrypa sp. (r)
Nicholsonella sp. (c)
Rhombotrypa quadrata (Rom.) (c) W. L. Wh.
Stomatopora arachnoidea (Hall) (c)
Dalmanella testudinaria (Dalman) (c)
Hebertella insculpta (Hall) (c) W.
Hebertella occidentalis (Hall) (c) Richmond
Leptaena unicosata (Meek and Worthen) (c)
Platystrophia cumingsi McE. (c) W.
Plectambonites sericeus (Sowerby) (c) W. L.
Plectorthis whitfieldi (Winchell) near P. kankakensis (McC) (c)
Rhynchotrema capax (Conrad) (c)
Rhynchotrema neenah (Whitfield) (c)
Strophomena neglecta (James) (c) W.
Strophomena planodorsata Winchell and Schuchert (c)
Strophomena planumbona Hall (c) W. L.
Byssonychia radiata (Hall) (r) Richmond
Bellerophon sp.
Cyclonema sp.
Tentaculites sterlingensis (M. and W.) (c)

The species of fossils in the above list clearly represent a fauna that corresponds with that from the upper Maquoketa strata northeast of Scales Mound, and with those found in the Richmond strata along Aux Sable Creek, in the vicinity of Oswego, and at Wilmington. Four of the species do not occur above the Waynesville beds in Indiana, and not one of them is restricted to a post-Waynesville formation in the Richmond of Indiana. On the Mississippi River, at Savanna, Illinois, 30 miles northwest of Sterling, the Upper Maquoketa strata also consist of alternating shale and limestone layers which furnished fossils similar to the species listed from east of Sterling, and certainly represent a corresponding horizon. In some places in northern Illinois and northeastern Iowa the upper, very fossiliferous beds of the Maquoketa were removed by erosion before the overlying Silurian strata were deposited. In other places a thickness of 25 to 50 feet of non-fossiliferous shale overlies this calcareous, and very fossiliferous horizon. The latter can be traced clearly from northern Illinois across the northeast part of Iowa, in spite of the erosional unconformity at the top which results in different levels of the Maquoketa occurring immediately beneath the Silurian limestone.

An excellent outcrop of these upper Maquoketa strata occurs along a stream 7 miles west of Preston, in Jackson County, Iowa, where the following section was made:

SECTION OF STRATA EXPOSED 7 MILES WEST OF PRESTON, IA.

	Ft.
Silurian limestone	
Limestone, dolomitized, in rather even layers 4 to 12 inches thick, containing few fossils	40
Maquoketa shale	
Shale, bluish-gray, in thin layers. Those in the upper part alternating with limestone bands, containing many fossils	35

The following species were collected from the Maquoketa shale at this locality:

FOSSILS FROM THE UPPER PART OF THE MAQUOKETA,
7 MILES WEST OF PRESTON, IA.

1. Anolotichia sp. (r-c)
2. Anaphragma mirabile ? (c)
3. Batostoma sp. (c)
4. Bythopora meeki (James) (r) W. L. Wh.
5. Ceramoporella ohioensis (Nich.) (r) Richmond
6. Coeloclema sp. (r)
7. Corynotrypa inflata (Hall) (c) Richmond
8. Eridotrypa simulatrix (r) W.
9. Hallopora subnodosa (Ulr.) (c) Richmond
10. Hallopora sp. (c)
11. Homotrypella rustica ? (r) W. L. Wh.
12. Mesotrypa sp. (c)
13. Peronopora decipiens (Rom) (r) A. E.
14. Petigopora sp. (c)
15. Stigmatella spinosa (r) W.
16. Stigmatella sp. (c)
17. Stomatopora arachnoidea (Hall) (r)
18. Rhombotrypa quadrata (Rom.) (r) W. L. Wh.
19. Rhombotrypa subquadrata (Ulr.) (r) W. L.
20. Streptelasma rusticum Billings (r) W. L. Wh. E.
21. Dalmanella tersa Sardeson (r)
22. Dalmanella testudinaria (Dalman) (c)
23. Dinorthis subquadrata Hall (r) L. Wh.

24. Hebertella insculpta (Hall) (c) W.
25. Hebertella occidentalis (Hall) (c) Richmond
26. Leptaena unicostata (Meek and Worthen) (c)
27. Plectambonites sericeus (Sowerby) (c) W. L.
28. Plectorthis whitfieldi (Winchell) near P. kankakensis (McC) (c)
29. Rafinesquina alternata (Conrad) (c) Richmond
30. Strophomena neglecta (James) (c) W.
31. Stromphmena planumbona (Hall) (c) W. L.
32. Byssonychia radiata (Hall) (r) Richmond
33. Modiolopsis concentrica (Hall and Whitf.) (r) W.
34. Pterinea demissa (Conrad) (r) Richmond
35. Conradella sp.
36. Cyclonema sp.
37. Hormotoma sp.
38. Liospira sp.
39. Lophospira sp.
40. Tentaculites sterlingensis M and W. (c)

In the fauna from the upper Maquoketa beds seven miles west of Preston, Iowa, there are five species that in Indiana are restricted to the Waynesville formation of the Richmond, and not one of the species is diagnostic of a higher horizon in the Indiana and Ohio Richmond. The fauna clearly corresponds with that from the upper Maquoketa east of Sterling, and with the fauna listed from the localities above described in Illinois. These very fossiliferous upper Maquoketa strata are also well exposed in the bed of a stream where it joins the Mississippi River about two miles south of Bellevue, in Jackson county, and at Patterson's Spring, one mile north of Brainard, in Fayette county, and at several other places in northeast Iowa where they contain a fauna similar to that listed from seven miles west of Preston.

If this correlation is correct, the conclusion follows that the uppermost fossiliferous strata of the Maquoketa in Iowa and northwest Illinois are of Fernvale age, and they represent the time of Waynesville deposition in Indiana and Ohio. The earlier Maquoketa strata in Iowa lack many of the characteristic early Richmond species of fossils present in Indiana and Ohio, and they contain a number of species that are more distinctly northwest Richmond forms such as Dicranopora fragilis, Dinorthis proavita, and Leptaena unicostata, that do not occur in the Indiana-Ohio basin. It is thought that the sea in which the lower and middle Maquoketa strata were deposited advanced from the northwest into Iowa and northwest Illinois, and adjacent portions of Minnesota and Wisconsin. During upper Maquoketa time this sea was joined by the transgression toward the northwest of the Fernvale sea from the south during lower Waynesville time.

Foerste[1] has shown that the oldest Richmond deposits in the Ontario and Quebec region are of upper Waynesville age, and contain, among others, such species as Stromatocerium huronense, Tetradium huronense, Columnaria alveolata, Calapoecia huronensis, Catazyga headi, Strophomena sulcata, and Zygospira kentuckiensis. It is very significant that not one of these species occurs in the Fernvale or Maquoketa of Illinois, Iowa, Minnesota, or Wisconsin. It is thought that the great transgression of the sea in Waynesville time, in which the Fernvale sediments were deposited in the Mississippi valley basin, was from the south, and that it occurred before the oldest Richmond fauna of the Ontario-Quebec region had reached the Ohio-Indiana area.

CONCLUSION

The fauna of the uppermost calcareous strata of the Richmond in northeast Illinois, and of the Maquoketa in northwest Illinois, Iowa, Minnesota, and Wisconsin indicates that these strata are of Waynesville age. They also show that the Fernvale limestone of northeastern and southern Illinois is of practically the same age as the Waynesville. This Fernvale-Upper Maquoketa sea is thought to have advanced from the south, since strata of corresponding age are known to the south in Monroe and Alexander counties in Illinois, and in southern Tennessee, and they are not known in the northern part of the continent.

During early Richmond (pre-Waynesville) time, it is thought that a sea advanced from the northwest into the upper Mississippi valley, in which were laid down the sediments comprising the lower and middle Maquoketa strata of Iowa, Minnesota, northwest Illinois and Wisconsin. During lower or middle Waynesville time, a southern sea invaded the Mississippi valley and Ohio

[1] Foerste, Aug. F., Upper Ordovician formations in Ontario and Quebec. Geol. Surv. of Canada, Memoir 83, 1916.

basins in which there accumulated the sediments that make up the Fernvale limestone. This sea transgressed far to the north and northwest, overlapping the former areas of Maquoketa, and united with the northern sea in northwest Illinois, northeast Iowa, and Wisconsin and Minnesota. In this sea there was a mingling of the aboriginal or older Maquoketa faunas with the invading faunas from the south. However, the invading species were dominant and left the strongest impress on this youngest fauna of Richmond age in the Maquoketa basin. It is thought that these uppermost calcareous and very fossiliferous strata of the Maquoketa were deposited before the invasion of the sea from the northeast into the Indiana-Ohio basin which occurred during upper Waynesville time. A late Richmond sea advanced from the south into Illinois and Missouri, in which was deposited the Thebes sandstone which rests unconformably upon the Fernvale limestone at Thebes, Illinois, and Cape Girardeau, Missouri. This Thebes sandstone deposition may have taken place at the same time the sandy sediments of the Saluda member were deposited farther east, but it was probably somewhat later. The non-fossiliferous shale that in places overlies the calcareous and fossiliferous horizon in the Wilmington, Minooka, and Maquoketa areas described in this paper was probably deposited at the time of the Thebes submergence.

PAPERS ON MEDICINE AND PUBLIC HEALTH

HUMANIZING MEDICAL EDUCATION

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In one of his historical essays, John Fiske says that the increased geographical knowledge of the European world in the fifty years immediately following the discovery of America by Columbus was so great as to require the next two hundred years to digest, assimilate and utilize this knowledge. This statement may with equal truth be applied to our present-day knowledge of the human body and its diseases, their diagnosis, prevention, and treatment. In the last half century, modern medicine and surgery have developed. More has been learned regarding the human body and its diseases than in all the preceding centuries of civilization. Our profession has been so busy learning newly discovered facts that there has been little or no opportunity in this era of analysis and investigation for synthesis or generalization. New discoveries have crowded so fast on each other that there has been no time for taking stock or for adjusting educational methods to meet new conditions. The medical school has, through force of circumstances, become a part of the modern university. But the modern university has become something radically different from the university of yesterday.

In his *"History of Mankind"*, Dr. Henry Van Loon gives an interesting account of the medieval universities. "They were found", he says, "wherever a few teachers and a few pupils happened to find themselves together. Now-a-days, when a new university is built, the process is as follows: Some rich man wants to do something for the community in which he lives, or a particular religious sect wants to build a school to keep its children under supervision, or a state realizes the need of educating doctors, lawyers, and teachers. The university begins as a large sum of money which is deposited in a bank. This money is drawn out to construct buildings and laboratories and dormitories. Finally, professional teachers are hired, entrance examinations are held, and the university is on the way. But in the Middle Ages things were done differently. A wise man said to himself, 'I have discovered a great truth. I must impart my knowledge to others.' And so he began to preach his wisdom whenever and whereever he could get people to listen to him, like a soap-box orator. If he was an interesting speaker, the crowd came and stayed; if he was dull, they shrugged their shoulders and continued their way. By and by, certain young men began to come regularly to hear the words of wisdom of this great teacher. They brought copybooks with them and little bottles of ink and goose quills, and they wrote down what seemed to them to be important. One day, it rained. The teacher and his pupils retired to an empty basement or to the room of the professor. The learned man sat in his chair and the boys sat on the floor. That was the beginning of the university, the 'universitat'—a college of professor and students in the Middle Ages, when the teacher counted for everything and the building in which he taught counted for very little."

So the university was originally built around a man who had a new idea which he wished to impart to others. It was said in New England a hundred years ago that a college consisted of Horace Bushnell sitting on one end of a log and a student with a Greek textbook on the other. Here were all the essentials for the college of that day—the learned teacher and the responsive student, who by personal contact with his teacher absorbed his wisdom and profited by his experiences. But the modern college teaches more than the "humanities". With the development of the natural sciences in the latter half of the 18th century and the first half of the 19th, and the application of scientific discoveries to industrial life, came the demand for technical training in laboratories and workshops.

Naturally, this had a marked effect on our universities. Law and theology, which consist of principles, precedents and moral maxims, can be taught from textbooks today, just as they were two hundred years ago, but the development of the natural sciences and the addition to the university curriculum of courses in mechanical, electrical, and mining engineering and other technical subjects has made the university of today a great workshop instead of the quiet and secluded retreat which it was a century ago.

On no other profession has this development of modern science had so marked an effect as on the teaching and practice of medicine. In the last hundred and fifty years has developed practically all of our accurate knowledge of physics, chemistry, and biology, the three sciences fundamental to a knowledge of the human body its workings, and diseases. The modern microscope, as perfected by Lister and Amici in 1836, has, in less than a hundred years, developed the new sciences of histology, pathology, biology, and bacteriology. So that instead of a medical training of one or two short courses of lectures, the medical student of today must have the most thorough preparation and must undergo the longest, the most severe and the most expensive training required of any present-day profession.

Medical education has undergone a complete revolution and has produced changes not only in educational methods, but also in the character and type of physician, that have not as yet been fully realized.

During the Colonial period of our history, the only trained physicians in this country were men who had gotten their medical education in England or on the Continent and who had later come to this country. Naturally, such men were few in number. The scarcity of physicians in the growing colonies led to the custom of a young man who desired to become a physician "reading medicine" with an older and established practitioner and fitting himself to treat the sick through personal instruction by his preceptor and the study of the medical textbooks in the physician's library. Such an arrangement was not only the best that could be made under the existing conditions, but it was also by no means an ineffective system of training. The young man of seventy-five years ago who "read medicine" with his preceptor and who, incidentally, took care of the horses, put up and delivered the medicines, and acted as general office boy, while he received a quality of instruction along scientific lines which would not be recognized today by any medical school, also received something which the medical student of today lacks. He was in constant and every day contact with his preceptor. He saw the patients who came for diagnosis and treatment. He assisted often in their treatment. He rode for miles in the old-fashioned doctor's gig with his teacher, and from the older man, with his years of experience and trained observation, he acquired all of his scientific knowledge and in addition his knowledge of the practical or applied side of medicine as a profession. He learned how to handle not only the patient, but, what is often more difficult, the patient's relatives and friends. He learned not only all that the doctor knew of medicine as a profession, but also all that he knew of medicine as a business. He acquired, in a word, that personal knowledge based on individual experience that can not be taught in laboratories or by textbooks, but that can only be acquired from man to man.

It was this crude but essentially human training which made the old-time family doctor the confidant and father confessor of his patients, as well as the man of influence and leadership in the community, an essential factor in medical education which the highly scientific, thorough and exhaustive present-day medical curriculum has not yet been able to supply. The doctor of fifty years ago was essentially human, even if he was not always highly educated. The doctor of today, with his exhaustive and expensive training, his highly technical ability, his thoroughly equipped office and laboratory, and his equally fully equipped hospital around the corner, is not in as close contact with his patients, either individually or collectively, as his professional forefather of half a century ago who did not have one-tenth of the medical knowledge of today but knew far better how to use, effectively, sympathetically, and understandingly the knowledge which he did possess. The human element is lacking in the training and is consequently lacking in the product.

The story of the development of medical education in this country is an intensely interesting one. But it is not possible at this time to consider it in detail.

The problem today is not how to raise the standard of scientific instruction (that is practically solved), but how to adapt our present-day educational methods so that the medical graduate of today may be as capable and efficient along practical lines as was his professional forefather of two generations ago, who, with a far less comprehensive and adequate training, was able to exercise a far greater personal influence. Everyone agrees that physicians today do not have the influence or enjoy the public confidence of their predecessors, though they are much better educated and far more capable. How can this confidence be restored without sacrificing our high scientific standards?

The defects of our present-day medical education are widely recognized. At the alumni dinner of the Carnegie Institute of Technology, Dr. Thomas S. Baker, the president, said, "We are giving too much importance to methods and not enough to substance; too much importance to courses of study and not enough to the individual teacher. College and school executives are so enmeshed in a maze of administrative details that they are in danger of building up systems rather than in building up faculties. The greatest need of American education is simplification." Dr. Ray Lyman Wilbur, president of Leland Stanford University and president of the American Medical Association, says, "The social responsibilities of the profession are enormous. Are we going to fit in or be fitted? The social aspects of medicine are inevitable. We need to smash the present curriculum and revamp it to bring it up to the medical requirements of modern knowledge. Present medical courses are in some ways ridiculous. We now take twenty-five years of the life of the best young men in the country preparing them to become physicians. We standardize the work so that when they have finished they are all alike." Dr. Richard C. Cabot of Boston says, "The psychical side of practice is more than half of the practitioner's job and makes or mars him. Men intending to study and practice medicine must face the fact that medical schools give practically no attention to the psychic side of the doctor's work. How to deal with people,—that is the problem. The doctor must learn the psychology of human approach. This is absolutely necessary in his education, but he is never taught it."

Nor are such views confined to the leaders in medical thought in this country. Sir James Mackenzie, probably the leading English authority on diseases of the heart, in his recent book on "*The Future of Medicine*" says, "The chief difficulty is in the fact that there is no teacher with a broad outlook on medicine who can see all the different branches in their proper perspective. Fifty years ago, progress was being made on certain lines which tended to a clearer conception of what medical education was, because the teachers were men who had taken a broad outlook. At the present day, there is not a single teacher in a school of medicine capable of taking that broad outlook. When any attempt is made to modify the instruction necessary for the general practitioner, every kind of individual connected with education is consulted except the one individual capable of showing from his own experience where medicine fails, that is, the general practitioner himself."

The situation, today, is radically different from that of fifty years ago. In those days, the surgeon taught anatomy, operative surgery, surgical diagnosis, and operative technique. The medical student who worked with Sir Astley Cooper, John Hunter, Everhard Home, Syme, or any of the other great surgeons of that day, learned from them, not every anatomical fact regarding the human body, which it is not possible for anyone except the professional anatomist to learn or retain for any length of time, but those anatomical facts which are necessary and essential for the proper practice of surgery, and he learned them with an exactness and a thoroughness which remained with him through life. From the same teacher, he learned his surgical diagnosis and his operative technique. He stood beside and assisted him in the operations. He learned the after-care of his surgical patients but, most important of all, he learned from these great leaders not only how to handle surgical conditions, but also how to handle patients suffering from surgical conditions. Just as the student of the early days who "read medicine" with a preceptor learned the practical and applied side of medicine, so the student of surgery learned courage, self-control, and resourcefulness from the greatest men of his day.

Today, the medical student learns his anatomy from a bachelor or a master of science whose work has been limited entirely to the dissecting-room and the laboratory. He learns his histology from another laboratory man; his pathology from a teacher, most of whose time has been spent in the morgue and in the preparation-room; his physiological chemistry from a professional chemist; his X-ray diagnosis and treatment from the electrical specialist. The eye he studies under an ophthalmologist; the ear under an aurist; the throat and nose under a laryngologist and nervous diseases from a neurologist. Nowhere at any stage of his long, expensive and crowded course is there any opportunity for him to come in contact with some broad mind which will help him to digest this tremendous mass of information pouring in on him from all sides and many sources. Nowhere on the faculty is there a single man who is interested in the problems which will confront the doctor in the first few years of his professional career. Above all, nowhere in the curriculum is any attempt made to tell him anything about the practical, everyday problems which are going to confront him. He is taught all about the human body, but he is taught nothing about human beings.

As a result, he leaves his alma mater, even after an internship in a hospital, loaded down with the very latest knowledge of all the innumerable branches of present-day medicine and surgery, full of information given him by experts who are twenty or thirty years ahead of him in point of experience, equipped with all of the technical knowledge of tests, examinations, analyses, methods of diagnosis and methods of treatment, without having had a single hint during the entire six years of his course as to how he can secure patients on whom to exercise this enormous accumulation of knowledge, how he shall keep them after he has gotten them, or how he can collect enough money from them to pay his professional expenses and make a living for himself and his family. In a word, the science of medicine is taught today as never before, but practically everything that could possibly help the student to a knowledge of the practice of medicine has been eliminated. He is taught all about medicine except how to practice it.

The result is that the young medical man goes into practice without any clear ideas of the relations between himself and his patients individually; between the doctor and the public, either individually or as a class; between the doctor and his professional associates. No one has told him of such things in medical schools. He soon gets some amazing shocks. He believes that the so-called "regular" school, to which he of course belongs, is not only the only one which has a right to exist, but the only one which is accepted by the public as reputable or honest. Yet he sees great lawyers, judges and business men patronize osteopaths and chiropractors, Christian Science healers and nature doctors. Naturally, he is confused and irritated. He was taught nothing in his medical course regarding the history or development of his profession, and, of course, nothing regarding the numerous sects, cults and so-called schools of medicine which have always existed. He knows, in a contemptuous and superior way, that homeopaths believe in "similia similibus curantur" and that the only medicine they are supposed to give is little sugar-coated pills. He knows that Christian Science was founded by Mrs. Eddy. He knows that osteopathy and chiropractic consist in using massage or some modification of it in strange and wild ways, but who is responsible for these sects, how they originated and why intelligent people support them, he does not know. He has never been told anything about the history of sectarianism or its various manifestations. He regards all sectarians as quacks and fakirs and looks with contempt on any layman who would patronize them.

He feels, and rightly, too, that a medical man should be judged by the quality of his work, the standing of the college from which he graduated, and the hospital in which he served as an intern. He can not understand why intelligent laymen should pass him by and patronize a Christian Science healer or a nature doctor. He is amazed, hurt, and disappointed because no one has ever told him anything about popular psychology, the eternal appeal of the charlatan or pseudo-scientist. His college professors should have told him something about the various cults and sects and how to meet them, but they were all far too busy lecturing on pure science to waste time on such absurd subjects. So he has to learn by hard knocks because no one has ever told him how his own profession reached its present state.

When the young practitioner considers his legal status, he is also puzzled. He believes that his diploma, and especially his state license, constitute him a privileged individual, and that he is "recognized by the state," whatever that may mean. He believes that a medical practice act exists for the purpose of protecting him from competition by preventing everybody except regular physicians from treating the sick. He regards all health laws as commendable or desirable. If some of these laws impose compulsory restrictions on laymen, it is necessary for them to submit for the public good. He views compulsory vaccination and quarantine regulations as perfectly proper restrictions on the layman. So far he is right. But when the state or federal government imposes regulations or restrictions on him, in the form of laws for the restriction of the use of alcohol or habit-forming drugs, his wails of protest are heard afar, because his professional and personal liberty is thereby interfered with. No one ever told him in his medical course that medical practice acts are for the protection of the people and not the doctor, and that his cherished state license is in no sense a "recognition" or endorsement but is simply a police permit to do business and legally is in the same class with an automobile license. So again he has to learn by hard experience or remain in ignorance, because no one has ever told him anything about his legal relations.

Early in his practice, the young doctor comes in contact with some one of the many medico-social bodies which have developed so numerously in the last twenty-five years. The Red Cross, the National Tuberculosis Association, the Cancer Society, the Society for the Prevention of Blindness, ask him to support them or work with them. Again, he is confused. What are laymen doing in the field of medicine? What ought they to do? What should be the doctor's attitude to such bodies? What are the social relations of the doctor and the medical profession? What is State Medicine and what effect will it have on him? What are Health and Industrial Insurance? What is Contract Practice? What shall he do about all these things that surround him every day and that his teachers never told him about? He doesn't know because during all the years of his training he never knew there was such a thing as medical sociology —that great field that has developed so rapidly in the last twenty years. His teachers were all too busy to tell him anything about it. And again he has to suffer because no one has told him.

Then practical and financial questions arise. How much should he charge for his services? How can he collect his accounts? Who is liable, in complicated and perplexing cases, for payment for his services? How can he, an expensively and thoroughly educated technician, develop into a successful business man, as well? He has the technical training for his work. How can he succeed as a practitioner? Has any one told him? No. There is not a medical school in this country where any instruction is given on how to practice medicine as a business. Yet the most highly trained man will be a failure and a dead loss to himself and society unless he can make enough to support himself and family, pay his bills, and save enough for postgraduate work and invest enough to secure him for old age. Is any medical school teaching medical economics? If they are, it isn't mentioned in the catalogues. Yet the business side of a profession is quite as important as the technical side, if one is to be successful. The practical advice that the medical student formerly got from his old preceptor has no counterpart in the present-day medical curriculum. He not only makes mistakes but he loses money because no one has ever told him how to manage his business.

After the young doctor has been in practice for anywhere from one to five years, some other doctor asks him to join a medical society. This is the first time he has heard it mentioned. In the last twenty-five years, our medical organizations have increased in membership, efficiency and influence more than in the preceding seventy-five years. Has the medical student been told anything about medical organizations, their purposes and advantages, and that it is his duty and privilege to join the county, state, and national bodies just as soon as he is eligible? Not that I have ever heard. I recently had occasion to talk to a senior medical student of one of the leading medical schools of the country. In the course of the conversation, I mentioned the American Medical Association. To my surprise, he hadn't the slightest idea what it was. I said to him, "In the four years you have been in college have you never heard the American Medical Association mentioned?" He said, "No, Doctor, except I remember one spring one of our professors dismissed his class early because he had to catch a train to go the American Medical Association meeting, but I hadn't any idea what it was. That's the only time I heard it mentioned."

Christ said to his disciples, "The children of this world are wiser in their day and generation than the children of light." B. J. Palmer, the founder of chiropractic, may be short in science but he's long in common sense. Every student who matriculates at the Davenport Chiropractic School joins the National Chiropractic Association the day he enters the school. We let four thousand of the brightest and best trained of young men spend from four to seven years in school studying medicine, and send them out to become the doctors of the future and never tell them a word about our own organizations. After they have had four or five hard years of bumps and mistakes we go around and try to organize them. Brilliant idea! But why not begin to organize the medical profession at the door of the medical school? Common sense, isn't it?

Finally, after enduring all the knocks and rude awakenings incident to the first years of practice, comes the last straw. The young doctor is sued for malpractice. It may be inspired by a jealous business rival, stimulated by a firm of ambulance-chasing lawyers, brought by a dead-beat patient to scare the doctor from collecting his bill, or the consequence of an unforseen but unfortunate outcome of a complicated fracture or a wilful and disobedient patient. Does the doctor know his own rights, responsibilities, and liabilities before the law, so that he can protect his own interests? Not from anything he has learned in college. Yet the principles of the common law as applied to professional responsibility are comparatively simple and could easily be presented in such a way as to be of enormous value to the student. "But," you say, "most medical colleges give a course in medical jurisprudence." True. But most, if not all the time for such a course is devoted to criminal law and the legal aspects of insanity. Few doctors, even after they have been practicing for years, have any clear ideas regarding a physician's rights, obligations, and responsibilities as applied to the problems of everyday practice.

What does the student learn in our present-day medical school? He learns the science of medicine. Nowhere, so far as I know, has any attempt been made to teach him or even advise him on the applied art of the practice of medicine. When the University of Pittsburgh Medical School, a few years ago, decided, what was perfectly true, that their graduates were being turned out without any knowledge of the history of their profession, a course in medical history was added to the curriculum. But who gave the course? The professor of history in the University, a non-medical man, whose only knowledge of the history and development of the medical profession was gained from textbooks. In order to cure the danger of specialism, another specialist was added.

Our present-day medical curriculum, then, is deficient in that it lacks a humanizing influence at three points of contact.

First, the instruction, today, is exclusively by specialists, each interested in his particular line. The student does not anywhere come in contact with a broad, highly trained mind, capable of synthetizing the entire field of medical knowledge for him, adding the experience and practical knowledge that has been gained through years of effort, giving the medical student the sound, practical advice which he needs, especially in the first few years of his medical career. There is nothing in our present medical curriculum to bridge the gap between the medical student of today and the well-grounded medical practitioner of ten years from now.

Second, the student, both in college and in the hospital, looks on the patient simply as one unit in a large mass of clinical material. Himself a machine-made product, with but little individuality in his training, he regards the patient in much the same light. Nowhere is he taught to consider the patient in the hospital or in the clinic as an individual entity which he must learn to understand quite as thoroughly as he does the disease from which the individual patient is suffering. He is taught to treat diseases rather than human beings.

Third, and most important of all, the medical student at no time during his four-year course receives any instruction or even any advice regarding his own individual place in society, his relation to his patients, the public, or the medical profession as a whole, the personal relations of the medical profession, or how the present-day situation came about. Yet all this knowledge, which would make possible an entirely different social viewpoint from that now held by most physicians, could be made a valuable part of the present-day medical curriculum. Even if it were necessary to sacrifice some of the numerous specialties which now occupy so much time, such a course would be well worth the while. But such a sacrifice is not necessary. One hour a week, during the four-year course, is ample for this purpose.

During the first or freshman year and before the student has had his mind distracted by a multitude of other subjects, one hour a week, throughout the freshman year, should be given to the history of medicine. This important subject should be taught, not in the perfunctory and dry manner in which most historical matter is presented, not in the fragmentary and divided way in which some of the special departments present the history of their own subject. It should rather be given as a series of informal talks on the early history and development of medicine among primitive peoples; its growth among the Greeks, the Jews, the Egyptians, the Romans, and the Arabians; its condition and limitations during the Middle Ages; with a summary of the important advances which were made; an account of the development of the natural sciences in the 17th and 18th centuries and the influence of the development of physics and chemistry on medicine; an account of the slow development of the microscope and its final perfection; of the influence which this discovery had on biology; of the development of organic chemistry by Liebig; of cellular pathology by Virchow; of bacteriology by Pasteur; and of present-day surgery by Lister; of the marvelous development of the last fifty years and of the men who made this development possible, with a summary of the leading men in the different fields who are at present regarded as leaders. Such a course would not only be intensely interesting, if illustrated with lantern slides and moving picture films, but it would also give the young medical student the historical background which he is, today, entirely lacking.

In connection with each epoch or period of medical development, attention would be called to the different sects, cults, and schools which prevailed at that time. Most physicians, I have found, are familiar with and bitterly hostile to the cults of their own day, which they regard as entirely unique, present-day phenomena. They do not realize that every period in medicine has had its own peculiar brand of pseudo-medicine; that every generation has had its fads and its sects; that before the chiropractor was the osteopath; before the osteopath, the eclectic; before the eclectic, the botanical doctor and the Thompsonian; before that, the homeopath; before Hahnemann, the Perkins' tractors, Bishop Berkeley's tar-water, and the stone extractors of previous generations. There has always been the sectarian, the faddist, and the follower of fantastic cults. Attempt to suppress him is the breath of his nostrils and only gives him so much free advertising. The only way to combat him is to learn his own particular fad more thoroughly than he knows it himself so that he can be the more readily refuted and discountenanced. This would avoid the spectacle which we often see of learned physicians, known throughout the country, appearing before legislative committees and being made monkeys of by shrewd, adroit quacks who did not have a fraction of their knowledge but far exceeded them in ability to present a subject to a lay audience.

In the second year, an equal amount of time—one hour a week—should be devoted to a discussion of the social side of medicine. Under this head would be discussed the relation of the individual physician and the medical profession to society as a whole, both in previous generations and today; a discussion of the relation of the medical profession to other professions, as lawyers, ministers, etc.; the relation of the allied professions of dentistry, pharmacy, trained nursing, and the midwife; the growth of the social public health movement of the last twenty-five years, including such organizations as the National Tuberculosis Association, the American Society for the Control of Cancer, the American Child Health Association, and all of the other organizations, nearly one hundred in number, which have developed in this field since the beginning of the present century. The lack of reliable knowledge on these subjects has not only caused much confusion and division of opinion among physicians, but has prevented the profession from exerting its united influence for the guidance of public opinion and the protection of the public health, as well as its own legitimate interests.

In the third year, an hour a week should be devoted to the economic side of medical practice. Business methods, systems of bookkeeping, and cost accounting, correct methods of charging and collecting, as well as advice on investments, would be taken up. Here, also, would be discussed the advantages and disadvantages of government service, the Army, Navy, and United States Public Health Service, public health and industrial work, as well as such important economic problems as health insurance, contract practice, fee splitting, group practice, etc.

The fourth, or senior year, should have an hour a week devoted to the instruction of the graduating class in medical ethics and organization for half the year, the remainder to be devoted to a course of lectures on medico-legal problems of the physician, telling the men about to enter the actual practice of medicine what the law provides and the courts have ruled regarding a physician's rights and special privileges, liability for professional services, the law of expert testimony, of malpractice, of privileged communications, of birth, death, and marriage registration, of legitimacy, insanity and criminal procedure, so far as it touches the everyday problems of medicine. Only one who has followed the subject for many years has any idea how diverse and perplexing are the problems that arise in the physician's daily life, how sorely he needs advice on these problems and how to meet them, and how much annoyance he could be spared by practical instruction at the beginning of his professional career.

The adoption of such a course, covering a large and important list of subjects not found today in any medical curriculum, would only require one hour a week throughout the four years. It would not be necessary to omit or greatly curtail any of the courses now being offered. In the hands of a teacher who understood his subject and who put into it vitality and human understanding, it could easily be made one of the most valuable and popular courses in the entire schedule.

It is impossible to turn back the hands of time. The old preceptor with his wise, kindly, practical advice is gone forever. Our medical schools are today giving better, more scientific and valuable training than ever before. But with all their highly specialized courses, expensive laboratories, and expert teachers, they fail to provide any substitute for the old preceptor or any humanizing touch by which the medical graduate of today is qualified to deal with and solve not only scientific problems, but human problems as well. If to the thoroughness and accuracy of the present-day curriculum the saving grace of personality and human experience can be added, the medical graduate of tomorrow can begin his professional work with a far greater assurance of real success than is possible today.

Universities are something more than buildings; teaching is something more than laboratory equipment; professional training, in the highest sense, is more than technical instruction. Our medical schools must not be satisfied with anything short of that training which is not only of the highest scientific quality, but also of the broadest practical value. While the curriculum in our medical schools today is perhaps more crowded and overweighted than that of any other course of technical instruction, a place must be made in the four-year medical course for instructing the physician of the future in the spirit as well as in the letter of his work. He must be told the history of his profession, not in a perfunctory recital of names and dates, but so as to make him understand the heritage of effort, experience, knowledge and sacrifice which the great men of previous generations have handed on to him. He must be taught his duties and his responsibilities to his patients and to his community with as much care as he is now instructed in anatomy, bacteriology, and chemistry. He must be shown his duty and his responsibility to his profession and to his individual professional associates, and he must be given as sound instruction in the business of his profession as he is now given in its science. In a word, he must be taught the vastly increased scientific knowledge of today, plus the practical, personal inspiration of the old system, so that each graduate of our vastly improved medical colleges of today may be not only the best trained man in his community, but also the man with the largest, broadest, and deepest human understanding and sympathy.

REMARKS UPON THE TREATMENT OF PARESIS

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On June 30, 1923, there were 920 cases of general paralysis of the insane enrolled in the various state hospitals of Illinois. Of the 4770 patients admitted during the year of 1922-1923 for the first time to any institution, 560 were suffering from this same disease. Of the 1919 patients who died during this same year, 425 were cases of general paralysis. The average hospital life of patients admitted with this disease and who die in our state hospital is 1.11 years. Although over 500 patients were discharged as recovered, from the various state hospitals of Illinois during this same year, there was not one case of paresis—a shorter term for this same disease—among them.

The statistics of the state of Illinois are true for those of the United States in general, and even the enormous aggregate thus revealed does not account for all the ravages produced by this dread disease. Many patients doubtless die in private institutions or in the home before their conduct has become so bad as to necessitate hospitalization. Upon the average they are men in early middle life, men who have arrived at the most productive time of life, and have assumed the responsibilities of wife and children. In a recent study made by a social service worker in the East, it was found that the majority of the families of these patients became dependent upon charity or the earnings of the wife and mother who was forced to go to work when her husband went into the hospital.

Of the 560 patients admitted in 1922-1923 only 95 were women, thus leaving 465 men representing, at a valuation of $10,000 each, a loss to the state of Illinois of $4,650,000—aside from the cost of maintaining them in an institution for a year and a month, an expenditure which would run the total figure well up to $5,000,000.00!

This is a problem with which we have to deal in our state hospitals—a problem of the end results of syphilitic infections dating back from 10 to 20 years prior to the patients commitment as insane. It is said that about 5 out of every 100 syphilitics develop locomotor ataxia or general paralysis of the insane. Obviously the rational way in which to deal with this problem is along the lines of prevention; first, the prevention of infection, and secondly, the prevention of the involvement of the central nervous system. But the prevention of venereal disease is a problem of social hygiene, while the prevention of an involvement of the central nervous system belongs for the most part to the syphilographers. What the state hospitals must endeavor to do is to make what repairs are possible to the damaged human mechanisms committed to our institutions for care and treatment.

By general paralysis of the insane, or paresis, we understand a disease of the central nervous system especially affecting the cortex of the brain itself, as differentiated from other syphilitic conditions involving the meningeal coverings of the brain or the walls of the blood vessels or the production of new growths, gummata, in connection with the meninges or blood vessels. Formerly it was thought that while syphilis had something to do with laying the general foundation for paralysis, other factors such as over work conditioned its development. This opinion, however, has of late years been revised by the discovery of Moore and Noughchi (in 1911) of the spirochaeta pallida in the brain substance of these patients. There is still, however, considerable discussion as to what determines this invasion of the brain. Some, notably Levaditi, contend that there are strains of this organism which are neurotrophic, having a predelection for nerve tissue, while others, dermatrophic in nature, by preference locate in other parts of the body and produce visceral syphilis. Certain experiments of Levaditi would seem to corroborate his views. As a matter of fact, it is quite commonly accepted that patients developing paresis have suffered few if any of the secondary and tertiary lesions common to ordinary syphilitic infection.

It has been well established by many observers that about 20 per cent of infected patients show early in the course of the disease some changes in the spinal fluid, indicating an early involvement of the central nervous system, and it is probable that patients who later suffer from disease of the central nervous system are recruited from the ranks of those who suffer such early involvement; hence the necessity of examination of the spinal fluid in all cases of syphilis, with treatment especially directed to combating this invasion.

Unfortunately for our problem as to the treatment of paresis in state hospitals, the patients do not come to us until their behavior as the result of brain involvement has become so bad as to necessitate their separation from home and society. This means that, given an average duration of three years from the appearance of symptoms to the death of the patient, the state hospital has to deal with patients who are well along in the course of the disease, probably two years at least upon the average. Obviously considerable structural change has taken place and therapy is thus rendered so much the more difficult. The infected organism lies in the brain substance itself and is exceedingly difficult to reach with any drug known to us at the present time.

The history of the treatment of paresis is one of many therapeutic gestures and relatively small accomplishment. Fortunately for the paretic and unfortunately for the establishment of facts concerning cures, the disease is subject to spontaneous remissions in from eight to ten per cent of cases. Thus the patient who is apparently quite demented and about ready to die may without apparent cause or following an attack of erysipelas or other intercurrent infection, make a remarkable improvement which may last anywhere from a few months to many years, but inevitably the patient dies of his disease sooner or later—unless intercurrent disease carries him off meanwhile. For this reason statistics concerning the results of various treatments are unreliable unless observation is carried on over a long period of years, or a very high percentage of remissions are secured in a considerable group of treated cases.

It is unnecessary to recite the long history of the treatment of paresis here. Very naturally the discovery by Ehrlich of the arsenical known as salvarsan aroused great hopes, and many favorable reports were received following the treatment of patients in various ways with this and allied drugs. Of late years, however, pessimism has again evidenced itself in numerous reports of considerable numbers of cases in which the results have been disappointing. This is notably true of various observers working in the state hospitals of New York State, where the number of patients benefitted, as quoted by Mills and Vaux (Archives Neurology and Psy. Vol. 9, No. 4) was only 15.9 per cent in 1920 and 13.8 per cent in 1921. Intra-spinal treatment was taken up with great enthusiasm at the time of the announcement of Swift and Ellis that favorable results had been obtained by the introduction into the subdural spaces of the patient's own blood serum following the intravenous injection of salvarsan. At the present time, however, but few clinicians are using this form of treatment in state hospital practice—and it must be understood that in this discussion we are limiting ourselves to such cases. Only a trace of arsenic can be found in the spinal fluid following intravenous injections of the arsenicals, and none whatever in the brain substance (animal experiments and investigation of cases dead from arsenical poisoning).

In 1917 Wagner-Jauregg of Vienna began to treat paresis with malarial infection upon the theory that the violent reactions thus obtained in some manner mobilize the defense resources of the organism, and reports a number of patients treated at that time to be still out of the hospital and doing well. At the present time reports upon this method of treatment claim a high percentage of remissions especially in the more incipient cases.

In May, 1923, Dr. Lorenz of Wisconsin with a group of workers (Journal of A. M. A. May 26th, 1923) reported as high as 50 per cent of institutional cases showing great improvement after treatment with tryparsamid, an arsenical derived from arsenic pent-oxide. Eighty per cent of the blood Wassermanns and thirty per cent of the spinal fluid Wassermanns became negative,—results heretofore not obtained with any type of treatment.

These findings were later confirmed by Moore of Johns Hopkins (Journal A. M. A., Feb. 16, 1924).

Following this inspiring report letters poured into our state institutions from anxious relatives inquiring if this new treatment could not be given to their patients, and accordingly in July, 1922, arrangements were made through the courtesy of Dr. Lorenz for a supply of this new arsenical, not yet upon the market, which can be given in very large doses—three grams each week intravenously, associated with a mercury salicylate. At the same time another group of similar patients was placed upon a modification of arsphenamine known as sulpharsphenamine. It is mainly with the results obtained with these two groups that this report has to do, although various other modes of therapy are being tried. At this same time 60 patients are under intensive treatment at the Elgin State Hospital with these and other remedies, notably new mercurials that can be given intravenously, a new arsenical allied to tryparsamid and a form of non specific treatment less dangerous than malarial infection.

We let the slides speak for themselves as to the exact results obtained, and summarize them in general as follows:

Remissions thus far secured in either group do not surpass the percentage that may be expected in cases treated in the usual manner with arsphenamine. The improvement in physical health in the tryparsamid group has been notable and many negative bloods have also been obtained, but no negative Wassermann in the spinal fluid as yet.

Several cases of apparent early optic atrophy (one or two of them very evident) have been found in both these treated groups, though the patients in the tryparsamid group were the only ones examined at the beginning of treatment.

Some of the sulpharsphenamine treated cases have also made marked improvements (one remission) but 25 per cent are worse than at the beginning of treatment, whereas none in the tryparsamid group have apparently deteriorated.

Though somewhat disappointed in the present results, the reporters realize that they have had to do with very unfavorable types for treatment and that it is really too early to draw worthwhile conclusions as to the results of this effort. In justice to the remedies employed another six months must elapse before publishing results in detail.

The reporters are grateful to Dr. Hinton, Superintendent of the Elgin State Hospital for his most cordial cooperation, to Dr. Hughes of Elgin for his painstaking examination of the fundi, and to Dr. Lorenz through whose courtesy a supply of tryparsamid has been received until quite recently.

The writer is continuing, in collaboration with Dr. Paskind of the Elgin State Hospital staff, this rather intensive piece of therapeutic research and hopes in another six months to have some very definite conclusions for publication.

THE RELATION OF ANIMAL DISEASES TO PUBLIC HEALTH

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Springfield

"Man is his own worst enemy" in the spread of communicable diseases, but the lower animals are a close second. It is only necessary to cite bubonic plague, a disease of rats, which carried off 25 percent of the world's population not so long ago and which is today costing the United States Government large sums of money in preventive measures. Another instance is sleeping sickness, a disease primarily of animals and transmitted by the tse-tse fly, which makes certain parts of Africa actually uninhabitable for either white man or native. Some prominence has been given this question lately through the offer of the Germans to give to the world a cure for sleeping sickness in return for certain territory.

But to get nearer home, take our own domestic cow. Tuberculosis is by far the most serious problem, ranging in extent from 2 to 3 per cent of the cattle in the southern part of Illinois to 50 per cent or more of the animals in the intensive dairying districts of the northern part of the state. The hogs that follow the cows, and the chickens that follow the hogs may also become infected with bovine tuberculosis and be incidental sources of danger. The chief source of danger is through milk to children. In surveys made some years ago in several large cities about 10 per cent of milk samples were found infected with tubercle bacilli, and this figure probably holds good today in the average small city of Illinois. Efficient and compulsory pasteurization has eliminated danger in the large cities. While 25 per cent of tubercular children formerly were infected with the bovine type of the disease, recently bone and gland tuberculosis (evidence of the bovine infection) have been rare occurrences in cities like Chicago. Dr. Lorenz on his last visit to this country cried, "Where is your bone tuberculosis?"

Two other diseases, anthrax and foot and mouth disease, may be spread not only by cattle, but also by the other domestic animals which are subject to infection. There occurred during the calender year 1922 in the United States 89 cases of human anthrax, of which Illinois had four. The disease is well under control, although present in various parts of the country. Foot and mouth disease is rather rare in man, due principally to the immediate destruction of infected animals. Milk is a possible source of danger, but proper pasteurization will prevent infection.

Contagious abortion among cattle is very prevalent, but its relation to human welfare is not yet settled. Huddleson has shown the presence of abortion bacilli in milk from infected cattle, and Park and others have shown as high as 25 per cent of individuals giving agglutination reactions to this organism. In several states the problem is considered of public health importance and tests for the disease in cattle are performed by the laboratory of the State Board of Health. The writer at one time observed a herd of cattle badly infected with contagious abortion where the wives of three successive herdsman gave premature births to children. Pasteurization of milk is a proper safeguard to the public.

Trichiniasis, primarily a disease of hogs, has played a considerable part in the world's history. The old Jewish law against eating pork was in all probability the result of havoc wrought by this disease. Great epidemics in Europe have been caused by the parasite, trichinella spiralis, and some forty years ago it caused international complications between this country and Germany, with the result that American pork was barred from German markets. The danger from eating raw pork is today common knowledge, yet from 0.5 per cent to 2 per cent of the population of civilized countries show trichina embryos at post mortem examinations.

Glanders, very common in horses, is rather rare in man. The two classes of persons likely to be infected are hostlers and laboratory workers. Recently a case in Illinois was drawn to the attention of the writer through laboratory examinations. The disease was not suspected previous to this time. Often the symptoms are very obscure, and it is possible many more cases may occur than are recognized.

Rabies is spread usually by our good friend, the dog, though all other animals are susceptible and if infected are sources of danger. The disease for centuries was the dread of all peoples, in some communities the unfortunate person bitten by an infuriated animal being put to death immediately. Not till fifty years ago did Pasteur discover a preventative which has greatly reduced the mortality. In 1922, 50 deaths were reported in the United States. At the present time there amounts to what is almost an epidemic of rabies among dogs in the southern part of Illinois.

Of all useless animals on earth, the rat is the most detestable. As a marauder he is bad enough, as a murderer he excels. Reference has already been made to bubonic plague, which has swept the world in three great pandemics. The first authentic epidemic originated in 542 A. D. in Pelusium, Egypt. It spread by trade routes over the then known world, till at its height the morality was 5,000 persons a day and rose to 10,000 persons some days. According to Procopius, a witness of the epidemic, "It spared neither island nor cave nor mountain top where man dwelt—. Many houses were left empty and it came to pass that many for want of relatives and servants were left unburied for several days. At that time it was hard to find any one at business in Byzantium. Most people who met in the streets were bearing a corpse. All business had ceased, all craftsmen had deserted their crafts." The second epidemic, known in history as the Black Death, originated in Mesopotamia about the middle of the eleventh century. Again the disease spread by trade routes over the entire known world, carrying off 25,000,000 people, or one-fourth the population of Europe. The third epidemic had its origin in China in 1871, coming to the ports of Europe and America. Due to advancement of the sanitary sciences and their strict application in war upon rats and fleas, the world epidemic never reached beyond isolated cases at seaports in Europe and America. The disease is of especial importance to Illinois because of the water ways from the two coasts, and will be of increasing importance as these waterways are improved for ocean-going vessels.

Of lesser importance are infectious jaundice and rat bite fever. Rats in many cities in the United States have been shown to harbor the Spirocheta icterohemorrhagiae, causing infectious jaundice in man. In Illinois several epidemics have been reported. Rat bite fever is less prevalent in this country than in other parts of the world, though some cases have occurred here. The causative agent is Spirocheta morsus muris harbored by rats. Very recently the United States Public Health Service has been making an extended investigation of tularemia, a disease of rats transmitted by the rat flea to man. Man seems very susceptible to the disease. The bacteriologists in Washington who were working with the causative agent, Bact. tularense, one after another became infected till everyone connected with the problem had had the disease. The Lister Institute in London then requested a culture of this virulent organism, which was sent, together with a warning that great care must be used in handling it. In spite of this warning, word was received two months later that the bacteriologist working on tularemia had contracted the disease. Added interest was lent to the subject when many rabbits for sale in Washington markets were found infected with tularemia.

Goats are subject to a disease known as malta fever, which may be transmitted to man through goat milk. In Texas considerable trouble has been caused in this manner. Guinea pigs usually are harmless little creatures, but recently an epidemic of "guinea pig plague" was reported in man. The infection was spread to bakeries by rats.

The domestic fowl is especially subject to a disease known as "white diarrhea". The writer some years ago found the disease especially fatal to young rabbits, young kittens and young guinea pigs. The eggs from infected hens contain large numbers of the organisms,—Bact. pullorum,—which are not destroyed by usual methods of cooking eggs. The relationship of the disease to man is problematical, but there is little doubt that a severe gastro-intestinal upset if nothing worse might be caused by a young child eating infected eggs. This disease is very prevalent in poultry in Illinois.

Another problem that keeps recurring is the relation of paralized animals to poliomyelitis. In Illinois a few years ago the writer had the opportunity to study several outbreaks of paralysis among animals which epidemiologically were closely related to poliomyelitis among children. Laboratory studies however were negative. The animals included in these studies were colts, hogs, and chickens.

Brief mention should be made of intestinal parasites. Tenia saginata, the beef tapeworm, Tenia solium, the pork tapeworm, and Dibothriocephalus latus, the fish tapeworm, all infect man. Belascaris mystax is a common parasite of the dog and cat and hence found in children.

Some of the arthropods are subject to diseases quite fatal to man. Among these are ticks, transmitting relapsing fever and rocky-mountain spotted fever, lice which spread typhus fever, mosquitoes whose bite causes malaria, yellow fever, dengue and filaria, and the flies especially in regard to sleeping sickness.

This paper must not be closed without including an animal disease which is not fatal to man, but which has actually been the means of saving a countless number of human lives. This is cowpox, infection with which will prevent the fatal smallpox in human beings.

MOSQUITO AND MALARIA CONTROL IN ILLINOIS

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All counties in Illinois suffer more or less from malaria and mosquitoes. In the northern and central portions of the State where much of the land has been fairly well drained for agricultural and other purposes, malaria is much less prevalent than in the southern counties, and the mosquito pest has been greatly reduced except in certain special areas. The death rates from malaria are especially high in the southern counties, and that portion of the State has been termed the "malaria belt of Illinois".

The accompanying map of Illinois shows the malaria death rates by counties for the fiscal years from June 1, 1919, to June 30, 1922. When it is considered that for each death from malaria there are approximately 300 cases of that disease, the case rate in the southern counties will be seen to be quite high. Moreover, many deaths are caused by illnesses which would not have been incurred if the individuals had not previously been infected by malaria and left in a weakened physical condition. This is especially true of children, for if children are infected by malaria in their growing years their growth and vitality are probably greatly reduced.

As an example of the economic loss from malaria, reference may be made to Jackson County. Vital statistics show that there are occurring in Jackson County between 2,700 and 3,000 cases of malaria a year. Assuming that the economic loss per case is $100, which would be a conservative figure, and include the cost of medicine, doctor bills, and loss in productive earnings, the economic loss to Jackson County is over $250,000 yearly. Thus that county and other similar counties could well afford to spend considerable sums yearly until mosquito-breeding places have been eliminated.

Drainage work that has been going on for many years in Illinois to reclaim land or make it more productive for

Malaria death rates in counties in Illinois.

agricultural purposes has resulted in a great decrease in the amount of malaria among the inhabitants because malaria is spread only by the bite of a certain type of mosquito, and this mosquito, like all types of mosquitoes, can breed only when stagnant water is available in which to lay eggs and in which the wiggler stage of the mosquito's life can be passed. The economic saving from decreased sickness and deaths from malaria, and also other diseases which may have attacked individuals when in a weakened condition from malaria, is not generally taken into consideration in drainage projects, but it really should be included as a benefit as well as the increased productiveness of the land. In some instances the economic saving from decreased illness alone has been undoubtedly far in excess of the cost of the complete drainage work.

In 1916 the chief sanitary engineer of the State Department of Health called attention in an article in "Health News" (the monthly publication of the department) to the heavy economic losses caused by malaria in Illinois, especially in the southern portion. No systematic malaria-prevention work by mosquito eradication was undertaken in Illinois, however, until 1922, but in the meantime the matter was given consideration by the Southern Illinois Medical Society, and as the result of a resolution of that society, studies of mosquito-breeding places and the types of mosquitoes prevalent in some southern Illinois communities were made by entomologists of the State Natural History Survey.

With the 1916 report of the State sanitary engineer, the resolution of the Southern Illinois Medical Society, and the studies of the State Natural History Survey entomologist as a background, the question of systematic malaria-mosquito eradication was presented on several different occasions, as opportunity offered, by the State Division of Sanitary Engineering to the city officials and interested civic organizations and citizens at Carbondale. It was considered that Carbondale presented, for various reasons, the best place to demonstrate what could be done in the way of mosquito eradication and that cities would benefit by such work.

As a result the Lion's Club of Carbondale went on record on January 27, 1922, guaranteeing to raise a fund of $2,000 in order to carry on systematic malaria-mosquito control during 1922. The International Health Board had previously tentatively agreed to furnish $1,000 and the Illinois Central Railroad had given favorable consideration to the draining of many acres of swamp land adjoining the city on the north. The State Department of Public Health had agreed to provide the services of a sanitary engineer to supervise the work, and the assistance of the State Natural History Survey and the U. S. Public Health Service were also assured.

Proposed and recommended by the State Department of Public Health, sponsored by the Lion's Club of Carbondale and receiving financial assistance from that club, the International Health Board, and the Illinois Central Railroad, and directed by the Sanitary Engineering Division of the State Department of Public Health, Carbondale carried on systematic mosquito-control work for the season of 1922, and for the first time in the history of the city enjoyed practically complete relief from the pestiferous insects. The results from the standpoint of reduction in malaria cases were equally gratifying. Vital statistics and house-to-house canvasses had shown that prior to 1922 the city suffered an average of over 250 cases of malaria a year (267 during 1921). Following the close of the mosquito-control work for 1922 it was found by a house-to-house canvass that only 19 cases of malaria had occurred during that year in the entire city. It is quite probable that some of those few cases were recurrent cases or may have received their infections elsewhere.

The results were so satisfactory to the city officials and civic organizations that had participated in the work, and the economic saving to the community was so apparent that arrangements were made to carry on similar control work during 1923. During 1923 the city was again practically free from mosquitoes and only 11 cases of malaria were found by a house-to-house canvass. With these two successful seasons' work as a practical example of what can be done, the city is making arrangements to carry on mosquito control during 1924 and provision will probably be made in the city budget for such work each year in the future. The work has been found to save lives, to eliminate the pestiferous mosquito, and to make a considerable economic saving to the community. The cost of the work at Carbondale for 1922, not including the supervision by a State sanitary engineer, was about $2,600. At least 250 cases of malaria were prevented, and considering the economic loss as $100 per case, the net economic saving to the community for the mosquito-control work was over $20,000. The cost for the second season's work (1923) was only about $800 and thus the economic saving was even greater.

Following the example set by Carbondale, the city of Belleville undertook complete malaria-mosquito control during 1923. The work was assured by the interest and financial assistance of the local Lion's and Rotary Clubs, the Board of Trade, and the city officials. Financial assistance was also given by the International Health Board and a State sanitary engineer directed the work. From vital statistics for previous years and a house-to-house canvass at the beginning of the control season of 1923 and another canvass at the end of the year, it was found that the mosquito-control work reduced the malaria in the city to about one-eighth of what had existed in previous years.

Malaria had not been quite as prevalent in Belleville as in Carbondale, but nevertheless the control work resulted in preventing at least 110 cases and made the city practically free from the bothersome mosquito. The season's control work cost $3,020 and from the record of the number of malaria cases during previous years and during the control year it is conservatively estimated that the net economic saving to the community was over $8,000. The cost of control work for future years will be less because of some permanent work done during the first year, and thus the economic saving will be correspondingly greater.

The work at Belleville was locally considered very beneficial and profitable and provision is being made in the city budget, with some additional financial assistance by interested civic organizations, for the 1924 season's work and probably for future years the city may finance the entire work.

Malaria and mosquito surveys have been made by State sanitary engineers at Herrin and Pekin in response to requests from interested citizens and organizations and at a few other Illinois communities. Herrin will undertake systematic control during 1924 the same as Carbondale and Belleville. The work at Pekin may be delayed until 1925 because of certain local conditions.

It is unwise to spend money for mosquito control unless the control is planned in a systematic manner and will extend over a suitable area, and such work can not be really successful unless a community is thoroughly interested and the individual citizens cooperate. The State Department of Public Health is desirous of assisting communities in malaria and mosquito control, and will arrange to have a survey made of malaria and mosquito conditions in any community and direct the control work wherever a community is sufficiently interested.

Before discussing the control measures used at Carbondale and Belleville it may be well to review the life history of the mosquito, the manner in which malaria is spread by one type of mosquito, and then outline the various methods that can be used to eradicate malaria and to prevent mosquito breeding. Because many of the persons attending this meeting are undoubtedly somewhat familiar with the life history of the mosquito the matter will be presented very briefly.

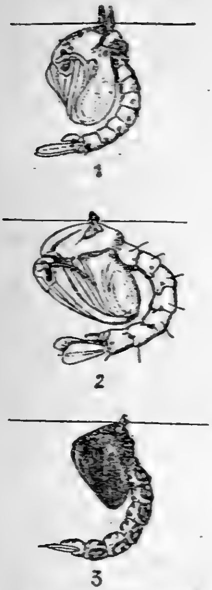
Two types of mosquitoes may be mentioned: the Anopheles, the female of which can spread malaria, and the Culex or ordinary pestiferous mosquito. The life cycle of a mosquito is divided into four stages, the first three of which are entirely dependent upon water for their continuance. The entire cycle from the egg to the adult requires from 7 to 10 days, depending upon climatic conditions and water temperature.

The mosquito lays her eggs on water. The eggs of the Anopheles are laid singly, as distinguished from the eggs of the ordinary Culex which are laid in rafts, each raft containing from 200 to 300 eggs. In two or three days' time, the eggs hatch into the larvae or "wigglers". Anopheles wigglers swim horizontally on the surface of the water and when disturbed, dart laterally. Culex

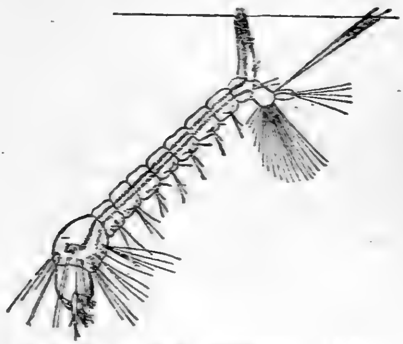
Patterns assumed by Anopholes ova. (After Deaderick.)

A raft of culex ova. (After Deaderick.)

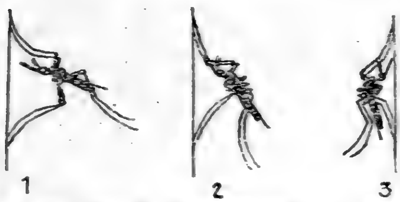
Larva of Anopholes mosquito. (Castellain and Chalmers. Modified after Howard.)



Pupae; 1, Culex; 2, Anopholes; 3, Aedes colspus. (After Howard.)



Larva of a culex mosquito. (After Howard.)



Resting posture of mosquitoes; 1 and 2, anopholes; 3, culex pipiens. (After Sambon.)

Fig. 2. Life cycle of Anopheles and Culex mosquitoes.

wigglers hang head down, with their tails protruding through the surface, their bodies at an angle of about 60 degrees with the surface, and when disturbed, dart downward. Although living in the water and feeding on small organisms and plant life, the wigglers are at all times true air breathers, securing their supply of air through respiratory siphons located on their tails. In two or three days, the wigglers or larvae develop into pupae. Both types of pupae resemble very closely the figure of the comma (,). In two or three days the shell of the pupa splits and the adult mosquito emerges.

The Anopheles mosquito may be distinguished from other types of mosquitoes by the definite markings on the wings and by the position it assumes when resting or feeding. When resting or feeding its proboscis and body are in the same line, and at an angle from 45 to 90 degrees with the surface upon which it is resting. The ordinary Culex mosquito has transparent wings and when resting, keeps its body parallel with the surface.

The life habits of the two types of mosquitoes are different in a great many respects. The Anopheles apparently has the better taste and will not breed abundantly in sewage-polluted water. Anopheles crucians breed most abundantly in swamps and fresh marshes; Anopheles punctipennis prefer slowly moving streams, while Anopheles quadrimaculatus choose woodland pools and the shallow portions of lakes and ponds. The Anopheles mosquito very seldom bites in the daytime and its song is much quieter and less annoying than that of other types. It does most of its work between the hours of sunset and sunrise. The Culex mosquito is very annoying both as to song and bite, and will make its attacks in the daytime as well as at night.

Only Anopheles mosquitoes, and only the females of that species, can spread malaria. In the "dark ages" of malaria it was commonly believed that the disease was caused by breathing or contact with air in low places or which had passed over swamps or stagnant ponds, especially at nighttime. Whence the name malaria from two Latin words, "mal" meaning bad and "aria" meaning air. There was a grain of truth to this unscientific but popular understanding of the cause of malaria, for it is true that the Anopheles mosquito that can spread malaria breeds in swamps and stagnant waters and flies almost entirely after dusk or dark.

To spread malaria, the female Anopheles must first bite and suck the blood of a person infected with the disease. Then after the parasites of the disease have undergone certain changes while in the body of the mosquito and have passed through its stomach walls and reached its salivary glands, the mosquito can spread malaria to the persons it thereafter bites.

Malaria is caused by the animal parasites that are injected into the blood stream by the biting mosquito. The chills and fever accompanying the disease are the result of the multiplication of these parasites and the simultaneous liberation of millions of daughter parasites from their parents.

Malaria control may be conducted along three general lines, any one or combination of which will meet with a fair measure of success: (1) by the prompt and proper medical treatment of infected persons so as to eliminate sources of infection for the mosquitoes; (2) by screening houses and the sick bed and otherwise preventing the mosquito from becoming infected, or an infected mosquito reaching well persons; and (3) by eradicating the mosquito primarily through the destruction or proper treatment of mosquito-breeding places. The eradication of mosquitoes is the most effective, and besides preventing malaria gives relief from annoyance. It is a problem for the sanitary and drainage engineers.

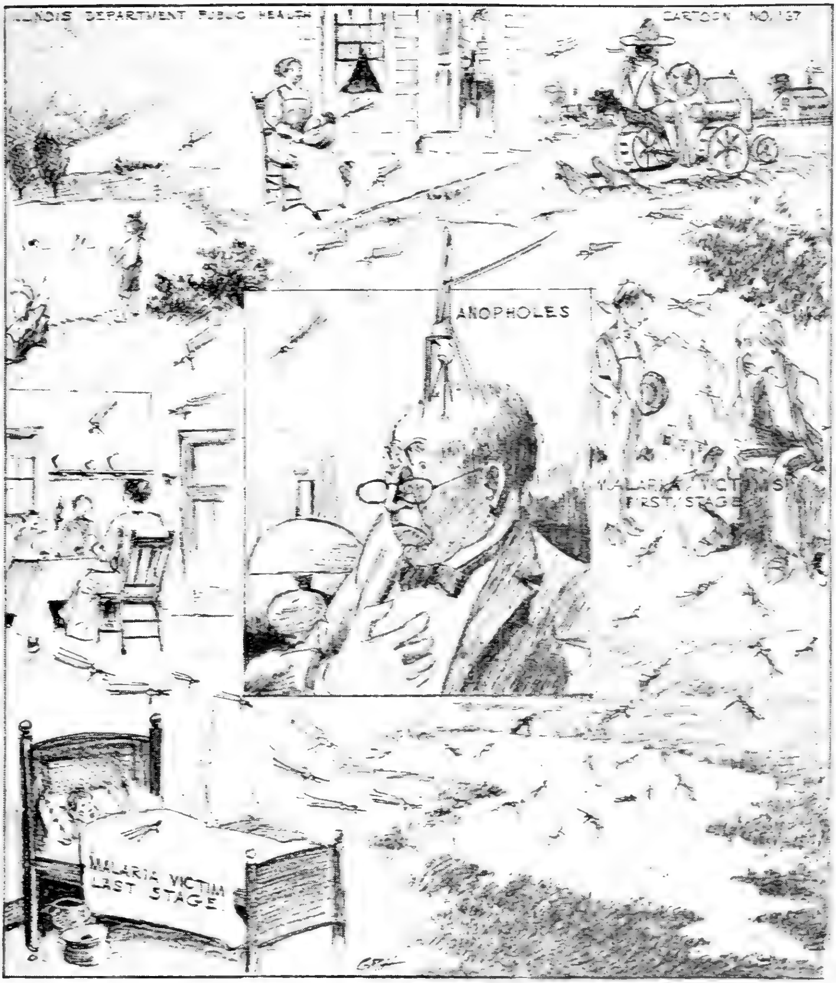
The fight against the mosquito must be directed against its water stages, particularly against the wigglers. The mosquito must be killed while in the process of developing and before it takes the wing. All types of mosquitoes invariably make use of all the natural protection afforded for breeding. Along streams the wigglers may be found close to the shore, among the protecting grass and weeds, in the vicinity of drifts, close to logs, among fallen leaves and other accumulations of a like character. The same is true of ponds and pools, the wigglers always being found in the shallow portions among the marginal growths that furnish such excellent protection.

Drainage as an antimosquito measure is the most effective. To remove the water is to eliminate the breeding place. Drainage of swamps, marshes and ponds can be effected by the construction of open ditches or tile drains, preferably the latter because of their permanency. In some cases ponds can be drained by vertical drainage. Old ditches with numerous potholes should be regraded and cleared in order to drain the potholes and keep the grass and weeds away from the water. A small trench cut in the bed of an old ditch or stream will confine the dry-weather flow and do much to keep the grass and vegetation from encroaching. A tile laid in the bed of an old ditch will remove the trouble entirely. Small depressions and pools can sometimes be more economically filled than drained.

The work of clearing as an antimosquito measure can not be over-emphasized. The work appears of little consequence perhaps, yet in many instances at least 90 per cent of the breeding can be destroyed by this work alone. If stagnation of the water is prevented and the marginal vegetation removed, there can be but little breeding.

Places that can not be drained or filled in should be treated in some manner. Oil is the most efficient as well as the cheapest larvicide known at the present time. In some cases lime, hog dip, niter cake, and other compounds can be used to good advantage. The oil, in addition to creating a thin film over the water surface through which the wiggler can not penetrate its breathing tube, acts as a poison and kills the wiggler much more quickly than by suffocation. Kerosene is effective and easily spread, but evaporates comparatively rapidly. Kerosene mixed in the proportion of about 4 to 1 with crude oil makes the best mixture. The oil may be applied by sprinkling oil-soaked sawdust along the edges of lakes or streams, by oil drips, swabs, or sprayers. The sprayer is considered the most effective implement, the Panama knapsack sprayer being the one more widely recommended. Because the oil evaporates or after a while separates so as not to form a continuous film over the surface of the water, oiling must be done at regular intervals of about 7 days.

Paris green is strictly a malarial mosquito larvicide. When mixed in the proportions of about 2 parts Paris



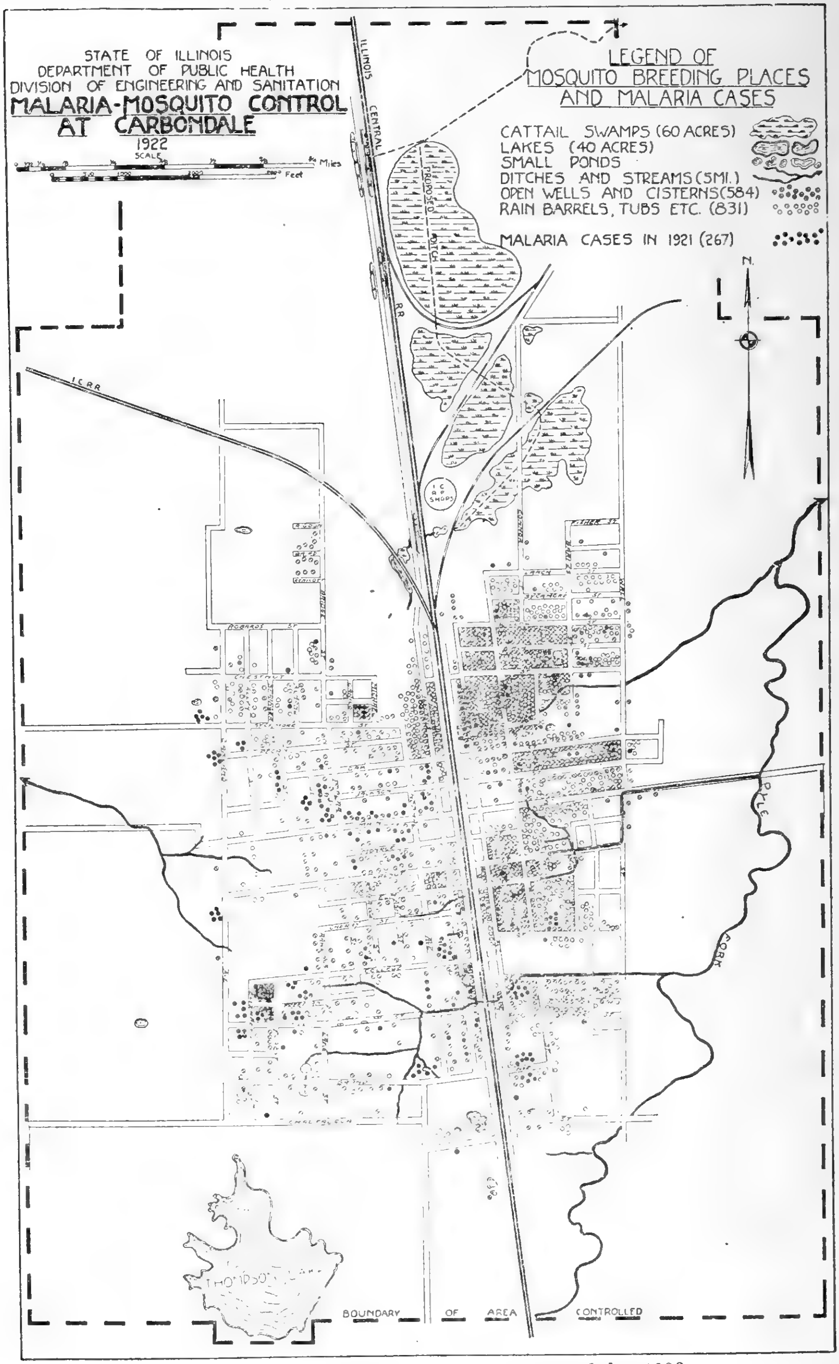
The vicious circle. Mosquitoes breed in water: they become infected from sucking the blood of malaria victims: they then spread malaria by biting well persons: and thus the vicious circle continues. To break the circle eradicate the mosquito.

green and 100 parts of road dust, and strewn with the wind over marshes and swamps, a great reduction in anopheline breeding can be noted. This is explained by the fact that the Anopheles wigglers or larvae, swimming on the water surface, come in contact with the arsenic flakes, while the other larvae do not.

The stocking of ponds and lakes with the top minnow known as Gambusia affinis, is an important means of control, for these little fishes swimming near the surface of the water and near the banks devour the mosquito wigglers. If the fish are present in sufficient numbers, namely, about one minnow for each yard of shore line, and no protection is afforded the wigglers by grass and other growths through which the minnows can not penetrate they will establish complete control. Rain barrels and other man-maintained mosquito-breeding places in cities can be controlled by rigid house-to-house inspections, by the passing of mosquito ordinances and educational measures.

For the control work at Carbondale a working map was prepared showing all ditches, streams, lakes, ponds, depressions, and other possible mosquito-breeding places in the area to be controlled. The area comprised all land within the city and one mile in each direction from the city limits. The mosquito-breeding places included about 60 acres of cat-tail swamps on the north side, a 40-acre lake on the south side, a number of small ponds and about 6 miles of ditches and streams, all within mosquito-flight distance of the city. The trouble was augmented by an enormous number of rain barrels and open wells and cisterns.

The control of the natural breeding places was comparatively easy, and the greatest difficulty was the breeding in rain barrels and other man-maintained places. Control was carried on by means of drainage, clearing of existing ditches, oiling, use of top minnows in ponds, open wells and cisterns, and the scattering of Paris green and road dust. The Illinois Central Railroad constructed by use of dynamite 9,000 feet of ditch for the drainage of the swamps. The first estimate of cost for draining and clearing the swamps was $8,000, of which $2,500 was



Malaria-mosquito control area at Carbondale, 1922.

for the ditch to be constructed by hand labor. By use of dynamite the ditch was actually constructed for about $1,200.

The 40-acre lake on the south side was abundant with cat-tail growth and pond lilies in a number of small bays, and there was also a fine growth of grass around the edge of the lake, making it an ideal breeding place for mosquitoes. The water level in the lake was dropped 18 inches by cutting the outlet wall, and a great reduction in breeding was at once apparent. The bays were cleared of the cat-tails and pond lilies, and portions of the surface and the edges oiled throughout the season. A careful examination in September failed to find any breeding, when in May before the work started as many as 200 larvae could be secured in a single dip with a small dipper. All ditches and streams in the area were carefully regraded, cleared and kept in a proper condition throughout the season for oiling. All ditches and other collections of water in the area were oiled once each week. Frequent inspections showed that almost perfect control was established on natural breeding places.

The most troublesome part of the campaign was the control of rain barrels and other man-maintained breeding places. In June, out of 664 open wells and cisterns, breeding was found in 391, and 584 were immediately stocked with Gambusia. A later inspection of 60 wells and cisterns showed that the fish were performing their duties well, only two cisterns being found breeding, and the fish had apparently been removed from these. The control of rain barrels and tubs was accomplished by regular house-to-house inspections. In June the first inspection showed 1,030 containers, 831 being rain barrels and tubs which were found breeding mosquitoes. The second inspection in June caught 296 containers breeding, the third inspection 154, and the fourth inspection 206. For the fifth inspection every container holding water in the city was oiled. The sixth inspection caught 19 containers breeding, the seventh 7, and the eighth 11. By the height of the mosquito season, almost perfect control had been established.

The control work at Belleville was somewhat similar to that at Carbondale. The greatest trouble at Belleville was a sewage-polluted stream flowing through the city. The city is now planning a sewerage improvement which will remove the pollution from that stream and thus greatly reduce Culex mosquito breeding and also make possible the clearing and maintaining of the stream in such condition as to promote the development of top minnows, and thus the control of all mosquito breeding.

In addition to the mosquito-control work in southern Illinois carried on under the supervision of the Division of Sanitary Engineering of the State Department of Public Health, mention should be made of the mosquito-control work carried on during 1922 along DesPlaines River, within the limits of the Chicago Sanitary District. At the request of persons residing in some of the communities in the towns along that river, a preliminary inspection was made of mosquito-breeding conditions and it was decided that the greatest source of the trouble was the sewage-polluted DesPlaines River. Because of the pollution carried by that river the mosquitoes breeding in it were Culex and thus not malaria carriers.

Mosquitoes were found to be breeding in the river by the millions, and the interested parties were advised that satisfactory control would not be possible unless the various adjoining communities joined together in a systematic control program. At this time the Chicago Sanitary District agreed to undertake mosquito-control work in that area, and although the mosquito-breeding season had already started before the field-control work could be started, Joseph F. Base, engineer engaged by the Sanitary District to supervise the work, carried on a very successful season's control and decreased the mosquito nuisance in that area to a very small fraction of what had prevailed during the previous years. The control work was not continued by the Sanitary District during 1923, but some work was done by the communities and it is understood that the Sanitary District will possibly carry on the work during 1924.

The mosquito-and-malaria-control work in Illinois has been merely an application of the scientific knowledge

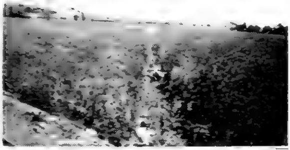
Ditch before and after being cleared so it could be oiled.

Stagnant sewage-polluted ditch before being cleared. A prolific breeding place for mosquitoes.

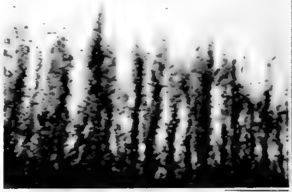
Oiling a cleared ditch to kill mosquito wigglers.

Malaria-mosquito control at Carbondale, 1922.

One portion of Thompson Lake covered with lilies and another portion after clearing out lilies and cat-tails. By clearing out such vegetable growths fishes, especially top minnows, have access to and devour the mosquito wigglers, thus preventing development of adult mosquitoes.



Placing dynamite in path cut through cat-tail swamp for blasting a drainage ditch.



Blasting 700 feet of ditch with dynamite at one shot.

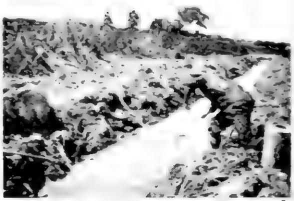
About 30 acres of cat-tail swamps near Illinois Central Railroad shops at north edge of city were prolific breeding places for mosquitoes that spread malaria among persons working in shops or living in the northern part of the city.

Close-up view of path cut through part of cat-tail swamp before blasting ditch.

Ditch immediately after blast filling with water.

Ditch made with dynamite; no hand clearing yet done.

Interested spectators of ditch just blasted.



Catching top minnows (Gambusia affinis) from ditch blasted through cat-tail swamp for use in rain barrels, cisterns, etc.

Malaria-mosquito control at Carbondale, 1922.

that has been developed by entomologists, biologists, physicians, sanitary engineers, and other scientists, and many cities in Illinois would do well to make use of similar knowledge. Mosquito-control work, when properly planned and carried out, not only prevents sickness and deaths from malaria, but eliminates the mosquito pest and actually benefits a community financially by reducing the large economic loss suffered because of sickness and deaths from malaria. The mosquito-control work already done is an instance of what really can be accomplished by the proper application of scientific knowledge, and the malaria death-rate map of Illinois shows the large amount of work remaining to be done and only awaiting the realization of the communities and counties of the benefits to be derived from such work.

PRACTICAL VALUE OF FULL TIME HEALTH OFFICERS

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It seems superfluous to attempt to advance any arguments in favor of a proposition that is obvious to any one that will give it a moment's attention. Unfortunately, however, people are so constituted that they will not give serious consideration to the apparent, simple things of life whose results stand for everything that we would like in the way of better health, increased longevity, greater physical efficiency, and more happiness. Probably the reason for the great indifference of the people at large is due to the fact that the ordinary individual depends upon the State or the Municipality to provide whatever protection is necessary. While this is now true, in the main due to our more thorough knowledge of the cause of deteriorating conditions, it has become a question of individual as well as State responsibility. The individual, however, does not like to sacrifice his convenience for the public good; therefore the Public to defend itself must resort to preventive measures, making observance of well known rules and regulations compulsory, and for the better carrying out of these principles men trained specifically to this work emphasize the practical value of a full-time health officer.

That this condition has been appreciated is proven by the fact that many colleges now give special courses and training in public health work, many societies have been organized whose deliberations are only on this line. Many journals now devote all of their pages to preventive medicine and to public health endeavors. Yet with all of this we are woefully lacking in sufficient good material to present the message properly. Public health service for years and years has been dealt with in a haphazard sort of fashion, and because of the fact that we are not daily threatened by an epidemic that takes a large toll of lives, we become indifferent, and the custom has grown to employ some man with a slight knowledge to carry on this work. This means the part-time man.

I know whereof I speak, as at one time I enjoyed this position at the munificent salary of $300 per annum, and now I know that I was overpaid. I am safe in saying right now that the same is the case anywhere where a part-time man is employed; in other words, there is no value under these conditions. Owing to the fact of remarkable discoveries being made of the causes of disease, especially of communicable diseases, and also owing to the fact that the laity reads and digests this knowledge, a demand has been created for Directors who will devote their entire time and energies in this field: hence the full-time man, and just now physicians are beginning to appreciate this work because more men are entering this field than ever before.

Physicians have been very slow to do health work; first, because the compensation has been very small; second, the prospect of advancement beyond a certain point has also been small; but we are beginning to realize that a good salary regularly received is worth more than the general compensation of an uncertain practice. Another factor may enter into this problem and that is the absence of mathematical demonstration of the results, nor have we patience enough to allow a period of years to elapse to prove the benefits received. As an example, and this has occurred often, a case of infectious disease arrives in a town, is laxly controlled and fifty other cases result. In a neighboring city the same original case arrives, is thoroughly controlled and no other case results. Is there a benefit credited or claimed? Now this is going on all the time.

Dr. McCullough of Ontario in an address recently read before the American Public Health Association says, "Considering the situation at the present time, the conclusion has been reached that our greatest need is a competent full-time directing head of a health department with an efficient organization, whether it be in the state, the county or the municipality. Public health is a large business, and some of us at least may be of the opinion that the advancement of public health is one of the most important if not the most important business of the state". According to the figures collected by Dr. Ferrell in 1914, there were but three full-time health officers in the United States. At the present time there are close to 250, and the figure is being added to rather rapidly. In Illinois the County Health Officer Bill failed of passage in the last Legislature. In spite of that we now have two, Morgan and Jacksonville combined and Cook County. There are only three full-time municipal health officers, exclusive of Chicago, in the state. These figures taken collectively prove that the sentiment in favor of full-time men is being rapidly appreciated.

The trend of medicine today is toward prevention, and it depends upon the trained hygienist and sanitarian to spread the knowledge that is necessary in this preventive work. What was formerly considered the ravages of time we now know are the ravages of bacteria and an unphysiological manner of living. With the adoption of safety measures, thus avoiding accidental conditions including those producing malignancy, it would be interesting to note just what the limit of life would be. To this particular phase of work the full-time man should devote considerable attention. Seven years ago I devoted considerable time to training trees with results that were remarkably gratifying, and we all know what Burbank has done both by careful selection and cultivation. As the secret of our education is to begin with the young, it is evident that the Hygienist and the Sanitarian should be ones who can impress upon impressionable minds the lessons of prevention and proper methods of living. A full-time man proves his value in proportion to his knowledge and application of it to the oncoming generation. The part-time man has neither the ability nor the inclination and certainly not the time if he is in active practice. Therefore he is not to be considered in this connection at all.

There are two problems, and very serious ones, in the appointment of full-time health officers; one is the tenure of office and the other is his political associations. It is apparent that any full-time man who must rely on political influence to continue in office is not the man who should be employed. It is unfortunate that at the present time most of the appointments are political, and as Ruhland of Milwaukee has observed, "Under these circumstances it is not difficult to see that those who are asked to take the responsibility of public health service will treat that appointment somewhat as a side issue and not as *the* issue."

The great objection to the employment of full-time men has been the supposed inability to pay a requisite salary. This objection is overcome in the State of Illinois and in several other States by the adoption of the law wherein two or more towns can join together and form a public health district and levy a small tax for the maintenance of the health department. If this is properly presented there should be very little difficulty in securing public health departments in any number of communities, for the benefits conferred are far greater than can be had by any other investment. To nullify as much as possible political influence, the law of Illinois provides that appointments should be made from a list of eligibles from the State Department of Public Health, and this list is made up by a competitive examination.

The law that I refer to was caused to be placed upon our statute books by the late Mr. F. W. Matthiessen of LaSalle, a man of remarkable vision and fortunately associated with it the ability to determine its expediency. He endowed the Hygienic Institute for LaSalle, Peru and Oglesby with sufficient funds, the income of which pays the necessary expenses. The Hygienic Institute is a corporate body operating solely for the benefit in public health service for the three cities mentioned. The Institute employs a Director who is Health Commissioner of each city and a member of the board of health of each respective city. The Hygienic Institute is controlled by a Board of five Trustees and is perpetual in character. Besides the Director it employs necessary assistant Health Commissioners, Bacteriologist and Chemist, three school Nurses and an Infant Welfare Nurse, a Veterinary for inspection of dairies, Stenographer and assistant Technician, and owns and operates one of the finest Isolation Hospitals for contagious diseases. All of these at its own expense, and the price is not prohibitive to any community of our size. Our records prove that our morbidity and our mortality and our longevity are of a better percentage than communities who do not operate with a full-time health officer.

SOME COMMENTS ON THE PHYSICAL FINDINGS IN HIGH SCHOOL GRADUATES

J. Howard Beard, M. D., University Health Officer, Urbana

The generalizations made herewith are based directly upon 2955 medical examinations of high school graduates made in September, 1922, of which 885 were of women and 2070 were of men. They are further supported by similar approximate findings in a total of 12,000 medical records of high school graduates, of which 9000 are of men and 3000 of women. As one group of 26 physicians and 18 specialists and dentists assisted in examining the men, and another of 11 physicians and 4 specialists assisted in examining the women, the total defects considered represent a composite opinion rather than that of one individual with a preconception or a fixed idea.

The most important deduction, in my judgment, to be drawn from the findings of the medical examination of high school graduates is that physically, mentally, and morally, they are unsurpassed by any group of similar age of which there is record for comparison. It should be pointed out at the outset that a large proportion of the mechanical defects noted are minor and are not, in reality, a serious handicap in civil life. Impairments of the special sense organs and of the teeth are to such a large degree correctible, as, in the vast majority of cases, not to interfere markedly with effective living.

GENERAL DEVELOPMENT

Slightly more than one-half of the high school graduates examined in 1922 received a classification of good in their physical development at the time of their physical examination. About one-third were recorded as fair, 3.2% of excellent development, and 5.2% of poor development.

The relative general development of men and of women differs but little. A slightly larger per cent of the men are classified as good; a somewhat greater per cent of women than of men, as fair. This difference in physique of men and of women may be influenced, in a measure, by the opinion of different groups of examiners, but it has tended to become less each year. This decrease in the variation in classification in the physical development of men and women parallels the progress of physical education in the grammar and in the high schools.

The general nutrition of the group is very close to average, but with a slight tendency towards thinness. Men are more apt to be average than women, who seem to show a slightly greater tendency to approach the extremes of either slenderness or obesity. The finding of a greater tendency of women than of men toward either overweight or underweight when registered is consistent with a similar finding of girls and boys from nine to sixteen years inclusive. The causes of underweight considered broadly may be classified as those of race and those of malnutrition. There is a greater general tendency for high school graduates from the city to be underweight than from the rural districts. This is chiefly due to the fact that such small races as southern Europeans and Polish Jews tend to locate in the towns rather than in the country. Shortness of stature is largely independent of environment. It is a characteristic of the above races, and in this country has a geographical distribution similar to them.

Unhealthy environment, bad habits of eating and exercise, and physical handicaps are productive of underdevelopment. Defective vision, deafness, large tonsils, adenoids, nasal obstruction and communicable disease are also preventives and deterrents of growth.

It is the general observation, however, that high school graduates presenting themselves for physical examinations at the time of registration are yearly showing better posture and general physique. The publicity of the physical findings of the draft and the consequent growth in interest in Hygiene and Physical Education is now bearing fruit.

DEFECTS OF THE EYES

Without the use of a cycloplegic, 25% of the men and 32% of the women applying for registration in the fall of 1922 were found to have errors of refraction of a handicapping severity at the time that they were examined. About 91% of the men and 92% of the women with defective eyesight had their condition uncorrected. Myopia was the most common error of refraction observed. It is more frequent in students from the city. This is due primarily to the racial constitution of the population of large cities, and secondarily to the excessive eyestrain incidental to study, and to clerical and industrial occupations.

As causes of impaired vision, uncorrected astigmatism, short-sightedness and squint aggravated by close work are of the first importance. Dufour has shown that the number of pupils with myopia and the average degree of short-sightedness increases from class to class and with the addition in school demands. This form of myopia is usually primarily due to congenital astigmatism, a very common condition, and to the consequent strain upon the accommodation of the eye in the effort to see. Risley has reported a series of cases in which astigmatic eyes had passed, while under his observation, from hypermetropic to myopic refraction.

Neglected squint is an important factor in the serious impairment and destruction of vision. The bad advice to parents that the child beginning to squint will grow out of it, frequently has led to delay until the eye was practically blind. If the serious consequences of procrastination were known, children would be no more neglected than if they had appendicitis or diptheria.

EAR

Excessive wax in the ear, ceruminosis, was rather a common finding, being present in 16% of the men and 8% of the women. Chronic suppuration of the ear was found in the total of ten cases. This is a very important finding since the condition impairs hearing, is a center of infection that may produce serious complications, and is rarely cured without a surgical operation for the removal of decayed bone.

Middle-ear disease, which causes eighty-five to ninety per cent of all deafness, usually has its origin in the nasopharynx and the Eustachian tube. Approximately thirty per cent of the deafness in the United States is due to the suppuration of the middle-ear during childhood. Ten per cent of the discharging ears of children are complications of scarlet fever, measles, or other communicable diseases; in ninety per cent diseased tonsils and adenoids are predisposing causes. In a systematic oral examination of patients with adenoids, Tomlinson found some grade of ear involvement in seventy-five per cent.

Where the function of hearing is impaired, the mentality of the child suffers. He becomes inattentive, in many instances diffident, and frequently a class repeater. Partial deafness, especially when it dates from childhood, is a disadvantage that seldom permits the individual to attain the efficiency of which he would be otherwise capable.

Much deafness would be avoided if disease of the ear were promptly treated by specialists and if parents would see that the adenoids and enlarged tonsils of their children received proper attention. Medical inspection of schools and free treatment for children with disease of the nose, throat and ear whose parents are unable to provide medical care for them should be an important part of any program for the prevention of deafness.

NOSE AND THROAT

Twenty-six and two-tenths per cent of the students examined showed some abnormality of the nose. In the vast majority of cases the conditions were not of pathological significance. Approximately 43% of the defects were due to deviation of the septum and 33% to nasal spurs. Enlarged adenoids showed a very low instance due to removal before examination at registration, the age of the individual, and possibly to being overlooked in rare instances by examiners when rushed. Of the 2955 students examined 17.6% had had their tonsils removed. This is an indication of the greater knowledge of the danger of diseased tonsils. This large per cent of the removal of the tonsils is a preventive measure of great economic, social, and hygienic significance.

The public is beginning to appreciate more and more that although tonsillitis is generally a mild disease it is not one whose effect upon the patient is always local and one from which the victim always recovers quickly. If it is as Felty believes, a specific streptococcus disease caused by the hemolytic strain of this bacterium, it is a menace to health locally, by extension through the blood stream, by way of the lymphatics, and through the respiratory and intestinal tracts.

Bloomfield and Felty have shown that 40% of the individuals of a large group examined by them when tonsillitis was not prevalent were found to be carriers of the hemolytic streptococcus. Later when certain members of the group developed tonsillitis, the investigators were surprised to find that the ill were among those of the group who were not carriers of the organism. These carriers seem to enjoy immunity during the period of harboring the streptococcus. Spontaneous termination of the carrier state is followed shortly by relatively hypersensibility to tonsillitis. The organisms present in the tonsils of carriers seem to have produced a protective immunity which lasted but a short time after the removal.

From the standpoint of resistance individuals may be divided into two groups; those naturally resistant, who rarely have the disease, and susceptibles who have frequent recurrences with intervals of immunity due to a previous attack and its associated carrier state.

The 17.6% of the prospective students examined who had their tonsils removed had not only gotten rid of a menace to their health but had made conditions in the throats less favorable for the growth for the hemolytic streptococcus. Removal of the tonsils, therefore, would seem to be justified under two conditions; namely, repeated attacks of tonsillitis, and possibly to prevent the individuals from remaining carriers and infecting others. The mere appearance of the tonsils would not necessarily be an indication for excision.

TEETH

The dental examination revealed that every third man examined had defective teeth. In most instances these defects were only slight cavities requiring filling. In a few cases a number of teeth had been lost and consequent facial asymmetry was present. The findings of the dentist emphasize the importance of the care of the teeth to insure proper alignment of the permanent set. It is indeed a rare thing to find perfect teeth in high school graduates. Most of them give their teeth proper attention; a very small per cent are careless of their oral hygiene.

While dental caries is primarily due to bacteria of the mouth acting in the presence of food debris and to certain elements in the saliva which lead to the formation of acid which attacks the enamel, many other factors are predisposing causes. The teeth may have little resistance to decay because of developmental defect, faulty diet, neglect as result of ignorance of parents, cost or lack of dental facilities so common in rural communities.

The ill effects of carious or defective teeth reach beyond the mouth. Decayed teeth may prove the gateway through which pathogenic bacteria reach the blood stream and a root abscess may be the source of arthritis, valvular heart lesions or Bright's disease. Poor teeth are often the cause of indigestion and improper assimilation of food.

With the exception of certain professions and a few individuals in whom the sense of the cosmetic is highly developed, the majority of men and women do not seek their fortune through their faces. The average man or woman, however, desires a symmetrical face. Yet, few parents give sufficient attention to their children's first set of teeth to prevent asymmetry by insuring proper alignment of the permanent set.

GOITER

Thirty-one and eight-tenths per cent of the women and 4 per cent of the men high school graduates showed some enlargement of the thyroid gland, when examined in the fall of 1922. This gland tends to enlarge during adolescence, but as this swelling seems to be influenced by the locality from which the individual comes, a particular age is not the important factor responsible for the increased size of the thyroid observed. It has been known for a number of years that in certain regions of the world swelling of the thyroid gland was common, and it has been known for a century or more that in America this enlargement is pre-eminently a disease of the Great Lakes' Basin, and its greatest incidence corresponds rather well with that of the hard waters of the Niagara limestone. It is only comparatively recently, however, that this enlargement of the neck was known to occur so extensively in this region and to be common in men, although much less frequent than in women.

Goiter is a disease usually characterized by the enlargement of the thyroid gland which occupies the lower portion of the neck, anterior-laterally. There are two forms of this disorder; simple goiter which is primarily a swelling of this gland, and exophthalmic goiter, an enlarged thyroid accompanied by a distention of the eyeballs, anemia, overactivity of the heart, tremor, muscle weakness, mental irritability, and general organic disturbance.

In the three groups of men and women examined in the falls of 1920-21-22 simple enlargement of the thyroid gland was found to be a health problem of importance in this state. As it is due apparently to iodine insufficiency, it is preventable by the administration of this element, either through such foods as cereals, beets, potatoes, and sea-water salt, or of iodine or its compounds. Prevention of goiter reduces the death rate, increases resistance of the individual to disease, improves his economic status, and promotes his mental, moral, and physical efficiency.

HEART DISEASE

If the hearts of individuals of high school age are carefully auscultated both in the erect and recumbent position and before and after exercise, definite murmurs that are not cardio-respiratory in origin may be heard in from

10 to 15 per cent of those examined. In the great majority of such cases the heart is of normal size, reacts properly to exercise and position, and the diastolic and systolic blood pressure will be found to be within the range of normal. Such individuals enjoy the usual activities of their age without inconvenience or without showing cardiac symptoms of any kind. If this group is carefully observed and repeatedly examined, it will be difficult in most cases to discover anything more indicative of heart abnormality than the murmur. Such conditions are probably functional.

There are, however, of all those examined from 2 to 4 per cent with definite organic heart disease. This latter group is showing a small increase year by year and undoubtedly will eventually go to make up a part of the increasing death rate from organic heart disease in early middle life, unless measures are adopted to protect their hearts.

Heart disease is generally a reminder that entire recovery from infection is often only apparent. The great destruction of life caused by it is usually not the immediate result of acute infection, but rather a slowly progressive failing of the cardio-vascular mechanism due to injuries received originally from such diseases as rheumatism, chorea, tonsillitis, scarlet fever, diphtheria, influenza, or pneumonia. Dublin, in comparing the life expectancy of those who have had typhoid fever, for the three years immediately following the disease, with those who have not had the disease found the death rate in the first group doubled as compared with those who have not had typhoid. It was remarkable that 14.8% of the deaths were due to heart disease, showing that although recovery was apparent the heart was so injured as to cause death in a few years. Lues, of course, plays a great role in the production of heart disease in middle life but was not an apparent factor in any of the cases that came under our observation.

The prevention of heart disease in youth is largely a problem of the elimination of communicable disease. The general adoption of the usual means for the control of epidemic diseases whose complications are involvements of the heart would undoubtedly be followed by a decrease in the number of cases of this disease found in high school graduates. The high death rate from organic heart disease demands renewed emphasis upon the importance of routine medical examination of the heart and chest. Much will be done in the prevention of this disease when parents, as well as physicians, appreciate the close relation of rheumatism, chorea, and tonsillitis to endocarditis.

It should be generally understood that the symptoms of rheumatism vary in severity from so-called "growing pains" to obvious acute rheumatic fever with an immediate, impending dissolution. The publiic must be so educated as to understand that repeated sore throat and St. Vitus' dance are truly menaces to life, because of the frequent damage to heart valves and to the cardiac muscle.

Both parents and physicians should be on the alert for diseased or permanently enlarged tonsils and adenoids, and should have them removed. The child complaining of tiredness, aching limbs, or who is fidgety or does not desire to work or play should be given a medical examination. Children with even the mildest attack of rheumatism or chorea should receive medical attention and should be watched most carefully to prevent, if possible, the development of inflammation of the heart. The child with an impaired heart should be given close supervision and special school work. Finally, parents as well as the victims of heart impairment should know that a damaged heart, properly treated and cared for in its earliest stages and guarded intelligently through life, is not incompatible with old age and many useful years of service.

HERNIA

The average incidence of hernia among the men graduates of high school registering at the University for the first time over a period of four years is approximately one in twenty-five examined, or 3.7%. A number of these cases observed are of congenital origin or are superinduced by anatomical abnormalities. This condition is also in evidence of the inability of the lower abdominal muscles and fascia to withstand the extraordinary abdominal strain of modern civilization. It may also be considered an indication of man's imperfect adaptation to the erect position.

Chronic constipation, faulty posture, lack of exercise and improper clothes, with the resulting flabby abdominal musculature and sudden strain, are factors in its production. Hernia, to a considerable degree, is preventable. Its presence in young adults is proof of neglected surgery.

SPINAL CURVATURE

While heredity may produce conditions favorable to the development of curvature of the spine, faulty posture is the most frequent cause. Abnormalities of the spine are more common among girls than boys, due, to a large degree, to the differences of dress and the manner of living. Curvature of the spine is part of the price paid by man for the ability to stand erect. The force of gravity is both a predisposing and an exciting cause. Curvature may be secondary to disease and deformity, both of the spine and of other parts of the body.

As only a very small per cent of the cases under consideration are structural in origin, we wish to call attention to them, particularly, as defects of carriage and posture. Happily, the great majority of abnormalities are correctible by physical training and individual attention. Only about 10% of the women and 7% of the men show anatomical abnormalities of the spine that are correctible by gymnastics with difficulty, if at all.

There has been a slight tendency to increase in curvature of the spine among high school graduates during the last four years. This rise, we believe, to a considerable degree is explainable by more careful record of slight deviations from normal. Many of these postural deformities might be described as a slouch or sag and are correctible by the individual himself when his attention is called to it. As his musculature is weak, he needs exercise, otherwise he will resume his old position as soon as his attention is diverted.

In the comparison of the relative frequency of lateral curvature, stooped shoulders, and swayback, scoliosis is by far the most common deviation of the spine. It constitutes about two-thirds of all spinal abnormalities noted among high school graduates. The comparison also shows that lordosis, or swayback, is more common than kyphosis, or stooped shoulders.

FLAT FEET

While our records show that 35% of the high school graduates examined have some abnormality of the feet, it should be noted that only about 7% of the men and 10% of the women have frank flat feet. Undoubtedly, our statistics include some instances of flat feet that are normal, as it is characteristic of certain races to have flattened arches. It should also be borne in mind that this large per cent is more apparent than real, because it includes a large number of cases of defects in standing and walking that are potential, and not actual signs of pes planus.

We have attempted to discover and to treat flat feet with reference to their predisposing causes by recognizing pes planus as weak feet before flattening of the long arches has developed and the usual train of symptoms are present. The body weight normally passes slightly to the inside of the center of the knee, through a line prolonged from the crest of the tibia, through the ankle, over the dorsum of the foot to the second toe. With the beginning of eversion of the foot and the change of direction of the body weight, it is only a question of time before the symptoms and signs of flat foot become evident.

The importance of muscle insufficiency, improper nutrition and communicable disease in the production of flat foot are shown in the following table, taken from the statistics of Ehrenfried:

Children under twelve years of age examined	1,000
Children with debility of the feet	440
Congenital—club-foot	18
Idiopathic—physical debility	95
Secondary, due to some other condition	327
A. Rickets	200
B. Cases of unsuspected infantile paralysis	107

No comment upon the occurrence of flat feet is complete without emphasis upon the relation of the wearing of ill-fitting shoes to pes planus. The necessity of education directed toward the use of hygienic shoes, proper posture, and of correct methods of walking, is obvious. A study of the geographical distribution of defects of the feet found by Examining Boards under the draft reveals that abnormal feet were comparatively rare in the southern states, due to the practice of the rural part of the population going barefoot and to the negroes, whose feet are not commonly pathologically flat. In the northwest part of the country flat foot is due, presumably, to the large size of the immigrants in this territory. This finding is confirmatory of the role of weight in the causation of flat foot.

Biologically, the relatively high instance of flat foot in young adults indicates that civilization is making demands for adjustment of the feet to modern conditions faster than it can meet them.

The physical and clinical examination of a portion of so representative a group from our population as high school graduates is, in reality, a partial inventory of the physical assets and human liabilities of the nation. Approximately only 7% of all children who enter primary school reach the point in their education where they are about to enter an institution of higher learning. A survey of the physical, mental, and temperamental health of a part of such a group is of great educational, social, economic, and public health interest.

Such a survey gives some indication of the physical, mental, and moral fiber that shows the endurance, persistence, and capacity to meet the increasing requirements of modern education. It reveals something of the ability that, in many instances, overcomes social and economic handicaps to push forward in pursuit of high ideals. It serves as a barometer of the failure and success of man to make complete adaptation to the rapidly advancing requirements of a highly artificial civilization and is, therefore, of biological, racial, and eugenic significance.

Such an inventory provides a rough index of the efficiency of child welfare, and of the care of children during the pre-school age. It gives a rather clear insight into the efficiency of the departments of physical education, and of medical inspections in the community and in the schools from which these graduates come. It gives more than a hint of the social conditions and the progressiveness and effectiveness of medicine in the various communities in which these graduates live. It is an admirable review of the physical results of competitive athletics upon the adolescent. It is a relatively accurate estimate of the proportion of men in a select group available for military service. It reveals the physical defects which handicap the individual, and justifies itself by increasing his efficiency through correction or alleviation of his condition.

A physical examination is of social and industrial significance since it gives some conception of the suitability of the population for the various occupations which our complex social organization requires. It teaches the laity the nature and value of a good medical examination and stimulates interest in hygiene and sanitation. It gives physicians an opportunity to acquire greater skill in recognizing potential and incipient disease when prevention and cure are most likely to be successful. They get a broader outlook upon disease and have their judgment quickened in the evaluation of symptoms. It benefits society by lengthening the period of activity of those who, by training and experience, will be best fitted to serve it.

A physical examination reveals something of the size and nature of the task before those who seek to raise the physical status of the population to a level more nearly commensurate with the possibilities of attainment. According to the actuarial and medical departments of certain insurance companies, a periodic medical examination has a potential life-saving value of about $30.00 for each such examination.

DISEASES AND FATE OF TWINS

DR. I. A. ABT, CHICAGO

It is with the modern biological, rather than with an anthropological, study of twins that the present paper is concerned. Grassl expresses the opinion that multiple pregnancies are neither atavistic nor the result of variation, but simply indicate an excess of the natural or usual fertility.

A. Orgler recorded some observations on twins from his examination of twenty-six pairs. The weight was the same in only five pairs. The difference in weight was more marked when the twins were of different sex. They usually increased in weight at the same rate, though frequently one continued to be heavier than the other for a considerable time, unless one or the other fell ill. He also observed that if both twins fell ill, one of them usually lost more markedly in weight than the other, and when they regained health, both increased in weight at the same rate, though the original disproportion continued for some time.

In a number of cases the heavier child is more resistant and becomes less severely ill when attacked than the lighter one. In a number of cases this does not hold. Frequently there is a difference in the length of the children at birth. While many of them seem to increase at the same rate, in a certain number the increase in length occurs at different rates, so that the one shorter at birth may reach the height of the longer one or even overtake him.

The average weight of twins is approximately equal to the weight of a single newborn. The average weight of uni-sexual twins was 3960 grams, though the female pair weighed 840 grams less than the male. The average weight of the male pairs was 4380 grams, of female pairs 3540 grams, and the average weight of one twin was 1980 grams, though there was a difference in the weight of the sexes. Thus, boys weighed on the average 2190 grams, girls 1770 grams.

Concerning the height of newborn twins, it may be noted according to the statistics of N. Miller that the average length was 43 cm. and that the girls averaged 3 cm. less than the boys. The average height of boys was 45.5 cm., that of girls 41.5 cm. Newborn twins, especially those of the same sex, may be approximately of the same height and weight.

On the other hand, there may be great disparity in their weights, varying from 200 to 800 grams and, in extreme cases, even 1000 grams. Differences in height are also noted. Sometimes one infant is 2.5 cm. longer than his mate.

Differences in the development may be accounted for at times on a purely mechanical basis. In some instances the nutrition of the two fetuses is unequal. In one case the umbilical cord may be short and straight, in the other one, long and winding. It is evident that in the former the blood supply would be greater and the nutrition would be better. At other times, one placenta is located favorably on the uterine wall, and the other one is attached in an unfavorable position. The greater the respiratory surface of the placenta, the better the fetus develops. In other words, the larger the placenta, the more closely it is approximated to the uterine decidua, and the more favorable are the conditions of the fetus.

Newman states in his "Physiology of Twinning" that there is a popular impression that in human twins one is usually stronger and more vigorous than the other. Practical experience tends to bear out this impression. Even in identical twins, there is usually a more vigorous twin who is the dominant member of the combination. One twin tends to gain a physiological ascendancy over the other to the slight or very great detriment of the latter. Spaeth found no evidence that the twins of either type had any definite physiological effect upon each other, though he grants as an evidence of inter-influence the condition of *situs inversus viscerum.* Newman points out the disadvantages of twinning by saying that when two or more fetuses come to occupy the space usually filled by one, the twins, whether of the one egg or two egg type, crowd each other and compete for the common food supply. In the case of two egg twins, the competition is for placental surface.

The period of uterine gestation is at best a hazardous one. In addition to those hazards that are met by single embryos and by two egg twins, there are certain very serious special dangers that fall upon one egg twins by reason of their close genetic relationship. One egg twins vary according to the period when the placenta is developed, and consequently one may receive more nutriment than the other. Moreover, on account of the difference in the blood supply to the two fetuses, one is more favored than the other, a condition which may even lead to the death of the less favored. Because of these variations in food supply and as a result of one fetus crowding upon the other, there is not only a disproportion in size and weight of the two infants, but malformation and conditions of arrested development may be noted in the weaker twin. Thus, one of the pair may be strong and healthy at birth, the other weak and delicate physically and defective mentally.

In my practice I have such an instance. The weaker one was extremely difficult to nourish, was very much retarded physically, and has remained defective mentally, while the other child developed rapidly and normally. The twins are now fifteen years old, the one a tall, bright, well-developed girl, while her sister is infantile in size and has attained no mental development. I recently saw a pair of male twins, three years old. One was bright, well grown, and his development was perfectly normal. The other weighed only twenty pounds at three years, teeth developed late, and his static development was markedly delayed. He was mentally much retarded and unable to talk. The normal twin's birth weight was six pounds, the other's three pounds. Instances of this kind must be very frequent.

Dentition may occur at different periods in the two infants, and this does not always depend on the severity of the rickets. In one pair that seemed free from rickets, the first dentition occurred at the seventh month, while the other infant developed his first teeth two months later. At ten months the first infant had eight teeth, while the other had only two. The difference between the eruption of teeth in the two babies may be as long as four months.

Francis Galton made a study of twins from the biologic and genetic aspects, and hoped to be able to differentiate between the effects of tendencies received at birth and of those that were imposed by the special circumstances of their afterlives. He sent questionnaires to persons who were either twins or near relatives of them. He received eighty replies, thirty-five of which entered into instructive details. In a few of these not a single point of difference could be specified. The color of the hair and the eyes was almost always identical. In many instances the twins were of the same height, weight, and strength. In others there was a notable difference in these factors, though the resemblance was in other respects close.

Gesell reports twins who showed superior intellect. They both sat up at six months, walked and talked at eleven months, learned French at three years, and were in the seventh grade at the age of nine. They resembled one another, both physically and mentally. In fact, there was no noteworthy distinction between the two. Their physique, countenance, demeanor, conversation were completely similar.

Homologous twins usually show marked similarity physically, as well as mentally. They resemble each other in weight, body structure, voice, and gait. They may learn to speak and walk at the same time. Not rarely they show the same anomalies and faults of development. They may become sick at the same time and die almost at the same time.

Ganther and Rominger studied the finger prints of five pairs of one ovum twins and forty-two pairs of two ovum twins.. They found that in the five pairs of one ovum twins there was marked similarity in the finger prints, and in the system of lines of the hands. In the two ovum twins there is a certain similarity of structure, but never the striking correspondence of the system of lines. They conclude from their studies that a striking similarity of the structure of the lines of the hands indicates that the twins are uni-ovular.

Miller describes 247 pairs of twins of the same sex which he studied at the Moscow Findelhaus. He assumed that thirty were homologues. Twenty-three showed similar or analogous malformations. In five pairs the twins had hypertrophic umbilicus. Four had dolicocephalic skulls and four others congenital phimosis. Two had congenital depressions of the sternum. Two other pairs had marked shortness of the frenulum of the tongue.

Some of the twins showed anomalies occurring in both during the early days of life as a result of acquired disease. Thus, two boys had simple pemphigus. Two other male twins both developed mastitis on the left side, followed by erysipelas. They both recovered practically at the same time.

The temperature of twins sometimes varies at birth. One infant may show two- to three-tenths of a degree higher temperature than the other. As a general rule, well-developed twins have a slightly higher temperature than those who are weakly.

Prematurity. Twin pregnancy is a relatively frequent cause of premature birth. Ylppö's series of prematurity showed that out of 688 cases, 19.2 percent, or 128 cases, were twin babies.

The prematurely born, whether singly or in pairs, are predisposed to a variety of disorders. The susceptibility of prematures to rickets is a common observation. Huenekens found that of seventy cases of premature twins, fifty-eight developed definite signs of rickets. He observed that the condition appeared sometimes before the fourth month of life. Craniotabes, an early symptom, may be present in the sixth week of life.

Other rachitic manifestations occur in premature twins as well as in prematures of a single birth. Among the early symptoms may be mentioned rachitic rosary and rickets of the long cylindrical bones. In premature infants there is a deficiency of the calcium content, as well as of other mineral substances. By the third or fourth month, there is a lowered phosphorus and calcium content, and rickets and its sequelae result.

Premature or underweight newborn twins frequently manifest spasmophilic diathesis and tetany. Evidence of spasmophilia may be found in these infants even if they are born at full term. An instance is cited where, in a pair of twins, the one developed laryngismus stridulus, facial phenomenon, and electrical over-excitability, giving all the symptoms of spasmophilia, while the other remained free from this disorder. It has also been observed that craniotabes may be present in one infant and absent in the other.

Langstein reports a case of twins in whom convulsions always appeared when artificial food was used as a substitute or complement for breast feeding. It should be noted, however, that the twins did not develop the tetany at the same time. One pair developed spasmophilia within seven to twelve days after the administration of artificial food, the other eighteen to twenty days thereafter.

A pair of twin girls, nine weeks old, came into my service on the 19th of July, 1922. The first one had convulsions lasting three days. The other twin had convulsions which lasted a week. They both had marked craniotabes, Harrison's groove, slight rosary, and protuberant abdomen. The Chvostek sign, as well as carpopedal spasm, were present in both. Both were breast fed. Thus, it is evident that these nine weeks old infants had almost similar attacks of tetany with florid rickets.

In twins not prematurely born, rickets and spasmophilia in both children is a frequent occurrence and is commonly observed. Orgler records in his series a case of rachitic twins where the degree of intensity was different. The one was severely affected, the other only moderately. He also recorded a case in which one child had developed scurvy, the other had not. Alfred Hess says that twins have a special tendency to develop rickets, and this is partly due to a sub-normal quota of anti-rachitic constituents stored in their tissues and also to the variable susceptibility of infants to rickets.

Anemia. The anemias of prematures may be of a high degree and may be prolonged into the second and third year, though this condition may occur in children born at term.

A pathological anemia occurring in twins may affect one or both. The hemoglobin is usually low and the reduction may be observed during the first days of life. Occasionally one or both parents show marked debility or anemia. Charles Herrman states that twins and single infants born prematurely come into the world with an imperfectly developed blood forming system and, if some injurious external agent affects the infants, this latent inferiority soon manifests itself. He says that some of these infants show their anemia from birth, some not until later. Von Jaksch's pseudo-leukemic anemia may occur in one or both twins. Finkelstein reports twins who developed a clinical type of pseudo-leukemic anemia after infections.

Chlorotic anemia has been described from Finkelstein's clinic by Kunkel as occurring in prematures and twins. Kunkel's investigations considered the blood changes in premature and feeble children. Among this group were seven pairs of twins, sixty prematures, seven feeble children. He found that most of them suffered from a chlorotic type of anemia characterized by oligosideremia and slight diminution of the cellular elements of the blood. Spleen and lymph nodes are not enlarged. This form of anemia occurs very early in life. This is particularly true of the prematures. Kunkel gives several instances where the twins were much below normal in weight and the anemia continued until one infant was four months old. At that time his hemoglobin was forty-three per cent. When the children were taken out of doors, the condition improved, though at the sixth month the hemoglobin content had reached only sixty per cent. Occasionally only one of the infants becomes anemic, though as a rule both are affected, but there may be a difference in degree. Senator reported a case of splenic leukemia which developed in twin sisters of eighteen months; both died about the same time.

Mental Affections. Mongolian idiocy may occur in one or both twins, though in the majority of the cases only one of the pair is affected. Halbertsma quotes sixteen instances where one of the twins was a mongol and two where both were mongols.

The mental affections of twins do not differ in form or in frequency from those of other individuals. A limited number of psychic disturbances have been reported which do not differ from those encountered in children of single birth

Epilepsy of both children with mental deficiency is reported. A few cases of dementia precox have been recorded. Hydrocephalus occurred in a pair of twins. One was delivered by craniotomy, the other was born spontaneously. There was no syphilis or alcoholism in the parents. The father was by occupation a painter, but did not suffer from lead poisoning. The second infant died on the twelfth day.

Soukhanoff made an analysis of thirty-three cases of insanity in twins in 1900. In some there were congenital mental defects, in one dementia precox, in one general paralysis. In most cases the twins were uni-ovular, alike in appearance and mental character, and the form of insanity in each pair was the same.

Infections. According to Orgler's observations, the behavior of twins towards infectious and nutritional disturbances was not always the same in both. One twin became ill with bronchitis, while the other developed whooping cough. The first recovered in two weeks, while the latter remained ill for two months.

They often reacted differently to infectious diseases. One twin died of generalized miliary tuberculosis, while his mate developed tuberculides and a strongly positive Pirquet reaction and the disease ran a more protracted course. In those instances where one twin developed rickets or exudative diathesis, the other had it also, though the intensity of the manifestations was frequently variable, the disease being intense in one child, mild in the other.

There is also recorded a case of single ovum twins who seemed to be similar physically and mentally, but who showed some difference in their resistance to infection. Whether this difference in resistance is peculiar to one ovum twins cannot be definitely stated. It may be assumed that there has been an unequal division of the germ plasm in the uniovular variety which might account for the variable behavior to infection.

Three sets of double ovum twins, observed by Orgler, showed uniform behavior to infection. However, in the case of twins of opposite sex who were admitted to the hospital at the age of five weeks and remained there for a considerable length of time, the boy, at the age of six months, developed measles, while the girl remained free from the disease, notwithstanding the fact that they occupied adjoining cribs.

Ballantyne in his "Antenatal Pathology and Hygiene" records a case where both twins acquired variola from their mother. In another case, one was affected while the other escaped. In a third, both fetuses exhibited the eruption. One presented many pustules, while the other had only a few.

During infancy and early childhood, twins, like other siblings, develop almost simultaneously intestinal upsets, grippal infections, measles, mumps, chicken pox, scarlet fever, and other infections.

Syphilis. Where one or both parents are syphilitic, the twins, as a rule, suffer the same fate as does the fetus in a single pregnancy. There are cases recorded, however, where one of the twins presents evidence of manifest lues while the other seems to remain immune. Grete Singer reports twins, a girl and a boy, one of whom was clinically and serologically luetic, the other normal. The non-infected infant showed negative Wassermann reactions during a period of two years.

Finger reports cases of dissimilar severity of syphilis in twins, i. e., one was more severely affected than the other. There are numerous corroborative reports in the literature, in which one case was syphilitic, the other healthy. Rosinski reported syphilis in twins. The boy showed severe symptoms of hereditary lues. The girl, who was observed for twenty-four years, remained entirely free from the disease. No satisfactory explanation can be found for this inequality in the distribution of the disease. Why one child should be infected and the other remain free is difficult to conceive. It has been suggested, however, that the difference in the severity of the disease is due to different modes of infection. It is thought that this is more probable than that there is a difference of immunity in the two fetuses.

Mortality. Twins in general are characterized by low vitality. The death rate is much greater than in single newborns. In the first weeks the mortality is forty percent. It is generally stated that twins have thirteen times less chance to live than ordinary newborn babies. In the report of Miller's cases at the Moscow Infant Asylum, 3883 pairs of twins were observed among 277,902 children. 62.9 percent of these died during the first weeks of life. In half of the cases, both twins died on the same day. In the remainder, the one lived one or two days longer. Septicemia and syphilis were frequent causes of death. The greatest mortality of those infants who survived the first few weeks of life seems to concentrate in the first and second year. After the fifth year of life, the mortality of twins and non-twins is about the same.

It has been estimated that out of a hundred pairs of twins born there are eighty pairs who survive. In fifteen pairs, only one child survives; in five pairs both children die. According to Hecker, fifteen percent die during the first eight days. It has also been said that twin girls seem to have greater viability than twin boys.

Since Galton's memorable studies no investigation has been conducted on the pathological aspect of twins. The British Medical Journal of 1912 contained a very interesting and suggestive editorial on twinship and fame. The editorial was suggested by the remarks of Doctor Kaiser, of Dresden, who stated that he knew of no famous man who had a twin brother. A similar query had been raised by Doctor Simpson in the Edinburgh Medical Journal of 1862. Simpson was not aware of a single instance in which a twin had distinguished himself intellectually. The editorial writes takes issue with these gentlemen, and goes on to show that there were several twin brothers who had won more or less fame. In attempting to collect information on this subject, it was found that no records of morbidity or mortality in twins were available.

It is to be regretted that there are not more data at hand concerning the development, physical and mental, of twins during their later lives. To make such data available, it would be important for obstetricians to record in every instance whether the twins originated from one or two eggs, which information should also be supplied to the families. Parents, physicians, teachers should be able to furnish significant information. Twins themselves, or their friends, might in some instances contribute important biographical sketches, and life insurance companies and bureaus of vital statistics should furnish details about the causes of death. Information of this kind would be of great interest, if not of practical value, to a great number of people. Knowledge of such facts would constitute a noteworthy contribution to medical science.

ALLERGY OR PHENOMENA OF HYPERSENSIBILITY

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Hypersensitiveness in man may follow after both the enteral and parenteral introduction of many and varied substances. These inducing substances may be antigenic or non-antigenic in character, i.e., those which stimulate or those which do not stimulate the production of demonstrable antibodies. The response to these substances in man are usually thought of as due to personal idiosyncracy and the symptoms, however diverse the inciting agents may be, have a great deal of similarity. The term allergy, meaning literally altered energy or work, was first introduced by Von Pirquet after whom the well known skin test in tuberculosis has been named. Coca[1] has suggested that this term allergy be applied only to the phenomena of hypersensibility in which the reaction is not due to antigen-antibody combination, or at least where the antigenic property has no direct bearing on the reaction.

Symptoms elicited in man by the introduction of serums with or without antitoxin may, according to Parke[2], be divided into those following *first* the initial injection and *second,* those following the second or later injections. These reactions have nothing to do with the antibody content of the injected serum. Following the first injection three types of reactions may be noted:

(a) Collapse with or without fatal outcome;

(b) A symptom-complex termed "serum sickness", and finally—

(c) Local necrosis.

Each of these forms of response may also follow the second or later injections.

Collapse or Death.—This accident is rare and nearly always occurs after the first injection. The symptoms appear quickly after administration. According to the most reliable statistics, about 1 in 20,000 primary injections of antitoxin results in alarming symptoms (in about 1 out of 50,000 injections death occurs), the outstanding features being those of extreme dyspnea and collapse. The dose may be small, in one instance reported about 1 c.c. (500 units) of antitoxin having been given subcutaneously. Kerley[3] reports a case of known-hypersensitiveness where the dose was gradually increased until 5 minims were given, resulting in alarming shock. Persons showing this type of reaction are frequently found to be subject to asthma or hay fever, being subject to the former particularly in the vicinity of horses or stables. Nearly all children dying after serum-shock are cases of "status lymphaticus".

After the intravenous injection of low-potency antitoxin even when the material is warmed to the body temperature and the injections given very slowly, chills more or less severe in character are observed in nearly half of the cases. Park[2] suggests that this is probably due to a special form of the protein possibly in the state of a fine flocculent precipitate. According to his experience less than 1 per cent of intravenous injections produce a chill when the best products are employed, whereas this undesired symptom occurs much more frequently when less perfect serums are used. In some instances the intravenous administration of antitoxin or other serum several weeks or longer after an initial injection which caused marked reaction, results in alarming symptoms of collapse. This effect is said to almost never follow a second subcutaneous injection. In other instances frequently repeated intravenous injections of serum develops instead of desensitization a hypersensitiveness so marked that even small amounts of serum give a sharp reaction. Such conditions are, fortunately, known to be relatively very infrequent.

Serum Sickness.—The occurrence of this type of reaction according to Park[2] varies considerably in different series of cases, from ten to sixty per cent or more, the size of dose influencing this incidence. Concentrated globulin preparations of antitoxin cause a relatively low incidence. Following the first injection of antitoxin or other serum there occurs an incubation period varying from three hours to twenty-four days (more commonly from three to twelve days). The symptoms primarily consist of a skin eruption, edema, slight albuminuria, enlargement of the lymph nodes with pain and tenderness and pain in the joints. The eruption is variable in character, a local eruption usually appearing earlier than the general eruption. On the second or later injections the period of incubation may be absent or shortened (immediate or accelerated reaction). This does not, however, always occur. This condition is not considered serious and in many instances gives no greater discomfort than that of an itching rash. Some samples of antitoxic or other sera quite uniformly cause a skin eruption. The earlier rashes are usually scarlatinaform, while those occurring later are more frequently of an urticarial nature. Von Pirquet and Schick believe that this reaction is due to antigen-antibody combination, owing to the fact that the average incubation period coincides with the time of first appearance of precipitins in experimental animals. It is known, however, that precipitins may be present without any manifestations of allergy whatever.

Local Reactions.—The primary injection of antitoxic or other sera may lead to local necrosis. When repeated injections are given, a final subcutaneous injection will more frequently result in a sharp local reaction, which may terminate in necrosis. This may also occur with rabies vaccine as well as with serum and is thought to constitute a striking parallel to the so called Arthus phenomenon in rabbits. It has been shown that such necrosis is not due to bacterial contamination, but the necrotic area may become infected and serious or even fatal consequences follow.

In connection with these serum reactions, there are certain preventive measures which should be mentioned briefly:

(1) *Desensitization to Serum.*—It is a well known fact that different lots of antitoxic or bactericidal sera will vary widely in their rash and temperature-producing qualities. This may have a bearing on the development or non-development of untoward symptoms. The administration of small doses of serum prior to the first injection or previous to subsequent injections of those known to be sensitive to the same is frequently resorted

to in order to desensitize. This procedure in man does not, unfortunately, give the same uniform results as noted in experimental animals. It may be said, however, that divided doses, although they may fail to give the reaction, or repeated small doses may induce a tolerance, but this is not considered proof that we are inducing the mechanism of desensitization so uniformly observed in experimental animals.

(2) *Prevention of Serum Reactions.*—Persons who give a suspicious history should be tested cutaneously for evidences of hypersensitiveness. The appearance of a wheal at the site of injection indicates that the person so tested will show a fairly immediate serum reaction, such as rise of temperature or urticarial rash, but is no indication of the probable severity of the same. The absence of such a skin reaction indicates, but does not prove, that there will be no undesired results following the administration of the serum. The procedure usually followed and recommended is to inject the antitoxin or other serum in divided doses every 20 to 30 minutes, starting with 0.1 c.c., until symptoms are observed or until sufficient is given. If symptoms develop one can then attempt repetition of smaller doses which previously did not cause symptoms. Where serum is to be administered intravenously, dilution and exceedingly slow administration in the beginning will tend greatly to prevent undesirable results. Intraspinous injections should also be given slowly, especially the initial portion following a recent previous injection. Hypodermic injection of atropin or epinephrin will usually relieve the less severe attacks of serum shock. In cases of extreme collapse, artificial respiration should be resorted to.

Allergy to Foods, Pollens, Etc.—After the ingestion of specific foods, rashes and other forms of reaction occur in a small percentage of individuals. These may follow the eating of eggs, certain kinds of meat, including fish, fruits, etc. As stated above, the inducing substances may or may not be antigenic in character. Hay fever is an example of mucous membrane hypersensitiveness. Persons suffering from this condition may also show skin sensitiveness and even develop rashes or other symptoms when the inciting substance is injected. Such hypersensitiveness may be manifested toward certain pollens, dust from the hair or skin of animals, powders of various kinds, etc.

Experimental study of pollen extracts appears according to Park[2] and others to show that they do not stimulate antibody production nor will they sensitize experimental animals. One might infer from this that hay fever (and probably food allergy also) is not due to sensitization of the individual, but possibly to some inherent or early acquired predisposition. Where hypersensitiveness toward a specific agent exists, the same is not necessarily an inherited condition. Increased tolerance to these classes of allergy may frequently be developed through the repeated use of small doses of high dilutions of the inciting substances. This is, however, only relative and is not comparable to the regularly induced and quantitatively greater resistance of desensitized animals. Varieties of dermatitis due to poison-ivy, sumac, etc., are claimed by some to be caused by similar hypersensitiveness. This, however, is questioned by many.

Drug Allergy or Idiosyncracy.—Allergic symptoms due to drugs follow a dose or doses which are not appreciably toxic for most individuals. The symptoms resulting are said to be due to idiosyncracy, because they are different from those obtained with larger and uniformly toxic doses. Substances which usually give rise to this kind of allergy are mercury in various forms, salvarsan, iodides, quinine, morphine, antipirin, salicylic acid, turpentine, cubebs, sandal-wood oil, etc. The symptoms usually observed are quite severe, with or without chill, skin eruptions, local edema or gangrene at the site of injection, swelling of the joints and lumph nodes.

Speaking of human allergy in general, there appears as already intimated to be little or no evidence that the basis of these phenomena is an antigenic-antibody reaction. The dominant feature in human allergy rather appears to be that of idiosyncracy. A condition resembling anaphylaxis has been observed only in a small number of cases. We refer here particularly to symptoms of collapse after a second injection and local necrosis after repeated injections. Failure to get in man the typical picture frequently observed in experimental animals may be due to the relatively smaller doses given, the usual dosage being much lower per unit body weight than necessary to cause shock in animals such as the guinea pig. In case of intravenous and intraspinous injection in man the factor of quick absorption must not be lost sight of and guarded against.

Hypersensitiveness and Infection.—In many communicable diseases there develop varying degrees of hypersensibility to causative agent. The most extensively studied and best known examples of this are infections due to the tubercle and the glanders bacillus. Tuberculin, which consists of the soluble products found in a broth culture of the tubercle bacillus, is only toxic for an infected animal, i.e., infection results in hypersensitiveness. Such hypersensibility may be demonstrated in the skin, mucous membranes and also by a systemic and focal reaction (site of lesion) when injected in sufficient doses. Too large a dose may result in death of the sensitive animal. Tuberculin is highly resistant to heat, and is specific but not anaphylactogenic. A relative tolerance may be induced in the tuberculous animal by gradually increased doses. This substance differs further from all similar substances in that animals cannot be rendered hypersensitive by its injection experimentally. On the other hand, the proteins of the tubercle bacillus are anaphylactogenic. This is a distinctly different phenomenon. The real mechanism of the tuberculin reaction is still obscure.

A similar skin reaction may be obtained in a considerable proportion of syphilitic cases by the intracutaneous injection of "luetin," an emulsion of the Treponema pallidum. Indications of hypersensitiveness have also been noted in typhoid fever or following the injection of typhoid vaccine. Likewise, positive skin reactions have been found to follow the injection of the genococcus and in such conditions as Leprosy, Sporotrichosis and other diseases caused by fungi and in pregnancy. All these reactions are relatively specific but have been observed mostly in experimental animals.

Vaughan[4] believes that the parenterally administered protein excites the release of specific ferments that are capable of splitting the protean molecule in such a manner as to give rise to a toxic product. In a similar manner, he contends that the symptoms in the acute stage of the various contagious and infectious diseases are produced, the protein of the various bacterial growths being split by the ferments set free from body cells. The term albuminal he applies to these diseases. The comparatively few bacteria gaining entrance into the body must multiply, and this is accomplished during the so-called period of incubation. There is no apparent resistance during this time on the part of the body cells. The latter must be sensitized before they can begin their combat with the invading organisms and it is not until this actually takes place that active disease symptoms manifest themselves. This theory is dependent on the assumption by Vaughan and Wheeler[5] that the process which results in the production of protein poison causes a splitting of all of the molecules in the material subjected to it. This assumption they consider proved by the observation that the non-toxic residues sensitize animals against the original protein but not against itself. This opponents claim is fallacious because the amount of protein required to sensitize a guinea-pig is but a minute fraction of that necessary to intoxicate or desensitize the sensitized animal.

Hypersensitiveness and Immunity.—Sir Edward Jenner observed that the reaction following vaccination after a previous typical vaccinia (cowpox) appeared earlier and ran a shorter course that is the case in typical primary vaccinia. Of recent years this observation has been studied by Von Pirquet, Tieche, Force and others, and the evidence clearly indicates that such an accelerated response to vaccination is an indication of immunity. In case of tuberculin the reaction is also said to be indicative of immunity to reinfection. The disappearance of the reaction in a person with a latent lesion, during measles for instance, is not infrequently followed by extension of the lesion and active tuberculous disease. Professor Gay[6], of the University of California, attempted to show that the appearance of a positive skin reaction to typhoidin is an indication of immunity to typhoid fever. This, however, is not exactly the case, since this reaction is absent or disappears at a time after infection or vaccination when immunity is still known to exist. More recently an intracutaneous method of diagnosis of whooping cough[7] during the first weeks of this disease was advocated. This, however, has been shown not to be a specific reaction. In fact attempts to duplicate published results by Hull and Nauss[8] show conclusively that identical reactions may be obtained through the injection of quite different inciting substances.

Within a few months also an intracutaneous method of diagnosis of scarlet fever based on recent investigations of the etiology of this disease has been published[9]. This, if satisfactorily confirmed, will prove to be a great boon not only to the practicing physician but also to the health administrator. It may be pointed out further that the possibilities of development in this field have not by any means been exhausted. The exact and rapid laboratory diagnosis of both infection and immunity in many other communicable diseases offers sufficient stimulus to both investigator and hygienist as to warrant the most exhaustive researches.

As a recent development of the application of this principle, the Schick test in diphtheria deserves special mention. Similar to most allergic reactions in man, this is not of the nature of anaphylaxis. In fact, it may be looked upon as a comparatively simple case of a biological chemical reaction confined for the most part to the site of injection of the active diphtheria toxin. The Schick test runs quite a definite course, which will be illustrated in connection with a series of lantern slides, which are to be thrown upon the screen, showing various local manifestations of allergic skin reactions.

As aids to the diagnostician, these various local manifestations of allergy may be divided into two general classes; namely, those which serve as *indices of infection* and those which serve as *indices of immunity*. To recapitulate, among the former are the tuberculin, mallein, luetin and other similar and theoretically possible tests. Among the indices of immunity, the principal ones are the accelerated and immediate responses to vaccination against smallpox, the serum test preliminary to the administration of antitoxic and other sera, the Schick test in diphtheria, and the many and varied tests utilized in the determination of sensitiveness in food idiosyncracy, hay fever, asthma, etc.

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MANUFACTURERS' INTEREST IN PREVENTIVE MEDICINE AND SURGERY

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When the United States decided to build the Panama Canal, the first great problem confronting our Government was, "How can our workmen endure the diseases prevalent in this section until the stupendous task of engineering can be accomplished?"

The French did not realize in 1877 when Ferdinand de Lesseps, a great French engineer, attempted to dig the Panama Canal, nor did they realize when they tried again in 1884 to 1889, that the "stegomyia mosquito" was the chief reason why they could not progress with this wonderful undertaking. The United States, recalling the experience of France and the great engineer who had previously built the Suez Canal, realized that it was necessary for the Government to find a means of eradicating not only yellow fever, but bubonic plague and malaria in order to go on with this great piece of engineering and do something France had been unable to do up to that time.

Our Government at once realized that the first step was to clear this zone of disease so that our men could work and live in reasonably healthy surroundings. After a survey of our possibilities, the surgeon general's office was called upon. General Gorgas was ordered to report to the Commission as Chief Sanitary Engineer for the Isthmus. Our Government had to be convinced first that it would be necessary to conquer the mosquito before any work in the Panama region could be undertaken safely. It required quite a sum of money for the Commission, composed of General Gorgas, Dr. Carlos Finlay, Dr. Antonio Albertini, and Dr. Juan Guiteras, who cooperated with the Walter Reed board, to go on with their work, but with General Gorgas' enthusiasm and his staunch belief in his proposed methods, his immediate initiative, and his great industry overcame all obstacles, and between the time of the announcement of the plan on February 1, 1901 and September 15, 1901, a period of less than eight months, he eradicated yellow fever from

Panama where it had extended continuously for over one hundred and fifty years.

If sanitary conditions had remained as they were previous to 1901 and we had lost, as did the French, 200 of our employes out of every thousand on the work, we would have lost 7,800 men each year, and 78,000 during the whole construction period; thus, the Gorgas sanitary program saved the difference between 78,000 estimate of deaths under the old regime and the actual 6,630 deaths under the new, or a total of 71,370. General Gorgas estimated that the saving to the United States Government, due to the work of sanitation, was a total of $80,000,000.

The Walter Reed board, working under General Gorgas, not only conquered the "stegomyia mosquito", and the "anopheline mosquito" which produced malaria, but also conquered the rat flea which transferred from the rat to the human being the dreaded disease known as "bubonic plague."

"The Canal Zone," says General Gorgas, "for the past 400 years, ever since it has been known to white man, has been one of the most unhealthful spots in all the tropical world and now it is one of the garden spots of our civilized world, with a health condition excelled by no land."

Many of the great problems were brought to the attention of the medical profession at a time when progress was impossible. Did you hear of typhoid, malaria, or yellow fever epidemics during the great World War? No. You say, "We did hear, though, of the flu epidemic which caused a death rate nearly as great as the number killed and wounded in battle." How our laboratories worked during this epidemic to find the direct cause! Eventually, we will find a way to conquer influenza as we did typhoid and malaria.

When the different Workman's Compensation laws went into effect a few years ago, there was a material increase in the number of accidents, due largely to the fact that all accidents had to be reported. Only a short time before, employers realized that by active safety prevention a marked saving in time and suffering of the employe could be produced. Immediately, safety devices, guards of all descriptions were utilized to prevent accidents. What has been the result of this universal movement to establish safety, not only in industry, but upon the public highways?—Reduction in the number of accidents to employes and making our streets safe for pedestrians.

The Division of Factory Inspection of the Illinois Department of Labor reports that preventive measures are more rigidly and widely used by employers than was the case when factories were merely under police power of the Factory Inspection Department. Furthermore, employes are certain of immediate benefits, employers escape expensive court procedures with large sums for damages in some cases, and the public is benefited by actual reduction in sickness, as health measures are more generally adopted.

One of the constructive measures adopted by the Illinois General Assembly of 1923, upon which employers and employes were able to agree, was placing occupational diseases under the provisions of the Workman's Compensation Act. In order for science to progress, there must be individual cooperation with public efforts. The making of laws without interest and cooperation of parties prevents current efforts from being effective to any adequate degree.

We must admit there is much economic waste in industry as the result of absence from work, caused largely by avoidable illness and physical disability. Employers realize the necessity of physical examinations of workmen and, where indicated, medical service is a part of the routine equipment of the personnel management of industries. The employer may, however, ask if these remedial measures pay. It is not a mercenary question, but one upon which the future generations depend. If need be, the cost of the article manufactured could be increased sufficiently to cover additional expense, so that the workman and his family might be protected.

There are approximately 42,000,000 gainfully employed persons in the United States. More than 25,000,000 of this group have defective vision of sufficient degree to handicap them in their work. A large number are employed in Illinois. We all know defective vision is a liability. Correct these defects and the procedure would result in increased production, better workmanship, minimized waste, smaller number of accidents, greater individual comfort and efficiency.

The economic value of good eyesight to the industry of this country, although difficult to measure, can hardly be overestimated. Careful examination shows that above 60 percent of employes have defective eyes. The fact that this can be almost entirely remedied makes its continuance inexcusable. Frequently a person is found to be practically blind in one eye without being aware of it. A person so afflicted, if injured, may claim compensation that is not justifiable.

Over one hundred years ago Dr. Benjamin Rush, after whom Rush Medical College was named, wrote a book on medical practice, and in the first chapter cites many cases in which patients suffering from rheumatism and other maladies either were cured or greatly improved by the extraction of teeth.

More than a century ago in England examination of the teeth of school children was considered a routine procedure.

Teeth of the average adult appear to have been neglected, judging from the evidence of 6,000 x-ray pictures taken a few years ago of the mouths of 600 adults of the average age of twenty-eight years. These pictures showed over 1,500 treated teeth and an average of 5½ teeth missing for each person. Allowing for a few who never had wisdom teeth, we might say that an average of four teeth for each person had been extracted because of neglect of cavities of decay. These same x-ray pictures showed that 51 percent of these 600 adults had infected areas at the ends of roots of one or more teeth, and 53 percent had parts of the bone along the sides of the roots destroyed by the infective process known as pyorrhea. Of the entire 600, 78 percent had one or the other or both types of infection. Nearly every leading physician will tell you that infections of the teeth are by far the most frequent causes of secondary infections elsewhere in the body. The lack of attention to the teeth of our children and adults results in a series of disabilities which is without doubt cutting short the lives of many people.

What has been accomplished in Illinois to reduce tuberculosis, can be done with respect to cancer, heart disease, eye strain, kidney disease, and many of the preventive disturbances.

During the days of epidemic and pestilence it was considered good evidence of normal health to avoid death. People would expose themselves and their children to mild cases in the hope that they might contract a mild form of the disease. It never occurred to those people that they might entirely avoid pestilence. Their only thought was not to die of it. There was a great improvement during the first part of this century in the avoidance of certain infections, those infections especially referring to infancy.

Our struggle in this age is not only to prevent infections and contagious diseases, but toward perfecting health. A healthy body can be made a positive asset. It is one of the necessary foundation stones, not only to prevent disease, but also for development.

A statistician published figures showing that in 1921 there was expended in the United States an average per capita of $10.00 for candy, $9.00 for education, 50 cents for chewing gum, and 29 cents for health.

We must not forget that the power of our nation and the happiness of our people depend upon the health of individuals.

A NEW PRINCIPLE ESSENTIAL TO CORRECT SPEECH IN THE TREATMENT OF COMPLETE CONGENITAL CLEFT PALATE

TRUMAN W. BROPHY, M. D., CHICAGO

The subject of defective speech due to congenital defects of the lips and palate claimed the attention of surgeons as early as the beginning of the Christian Era, the lip being operated upon by Celsus, who lived during the period of 42 B. C. to 37 A. D., but history does not record any operation on palatal deformities until 1764 when La Monier, a French dentist, performed the operation.

There is no more prevalent misunderstanding of the functions of the various organs of the body than regarding those which enter into the production of speech. It is almost universally believed that the tongue is the principal organ of speech. On the contrary, while the tongue, lips, teeth, cheeks, vocal cords, pharynx and palate are all important vocal organs and do their part in clarifying enunciation, in the distinct articulation of consonant sounds, in the perfection of vocal resonance, the *palate* is supreme. In 1887, the late Dr. G. V. Black said: "There is a peculiar fact in connection with the phenomenon of cleft palate. We may cut away the lips, the teeth and the tongue and the patient may talk plainly after all, but if we cut away the soft palate, it seems to be utterly impossible for the patient to speak perfectly."

To corroborate the above, I quote from the late Dr. G. Hudson-Makuen: "The vowel sounds may be articulated when the palate is defective, but their resonance is so much impaired that they are scarcely recognizable and their pitch cannot be changed with any degree of accuracy. It is in the articulation of consonant sounds, however, that the palate is especially essential. .

"Of the twenty-three consonant sounds, only two, the "m" and "n", can be given intelligibly when the palate is not intact, and even in these the resonance is somewhat impaired. All those consonant sounds in the enunciation of which the tongue is a conspicuous factor, as s, z, t, d, l, etc., as well as those in which the lips and teeth are used—the p, b, w, f, etc., are impossible to a person with a defective palate. This is true because, in the enunciation of these sounds, the palate is necessary to confine the breath to the oral channel and to prevent it from passing up through the nasal chambers.

"It will be borne in mind that the consonant sounds are made by impeding the moving column of breath at certain points above the larynx. The points at which the impediment takes place have been called the stop positions. These have been divided into the anterior, the middle and the posterior stop positions. * * * For all these sounds requiring an impediment in the outgoing column of breath, whichever stop position may be used, it is necessary to have a freely movable and normal palate.

"The soft palate has a wide range of movement. Its function in vocalization is to assist in controlling the action of the vocal cords and regulating the size and shape of certain important resonance chambers, and its function in articulation is to shut off the nasal from the oral cavity during the emission of the explosive and fricative sounds, and to form contacts with the tongue in the formation of the so-called posterior linguo-palatal sounds." Again he says: "Not only are the tongue contacts important, but in the production of many of the consonants there is a damming up, so to speak, of the breath in the mouth and a slight explosive effort as the sound is emitted. When this takes place in the normal mouth, the velum rises and shuts off completely the oral from the nasal cavities, and this is one of the things which the velum of a cleft palate cannot do and which it must be made to do before we can get the best results from the standpoint of speech. The velum of a cleft palate, therefore, must be united in such a manner that it will be as large and as loose as possible with its muscles in their normal positions and relations, and then the patient should be given such exercises as will have a tendency to develop in these muscles their normal physiological functions."

A thorough understanding, not only of the importance of speech, but of its mechanism is most essential to success in palatal surgery. The surgeon must have always in mind the goal of correct speech and he must know how that speech is attained by normal organs so that he may use every means to conserve and build up a normal mechanism from the defective parts which he finds in a cleft palate.

All surgery of cleft palate should have for its ultimate object perfect function, which is perfect speech. The test of success is the quality of enunciation resulting. Two phases of palatal surgery have especially to do with this: the union of the separated bones of the palate, including the management of the premaxillae; and the control of the tuberosities in their relation to the soft palate. Without a proper conception and execution of these fundamentals in palatal surgery, there is small hope of securing satisfactory form or function. I wish today to emphasize the control of the tuberosities.

I present to you briefly the course which I am convinced gives the nearest approach to normal form and function in the palate. That course provides for operation in early infancy; it contemplates the establishment of a normal palatal arch and the prevention of the spreading of the tuberosities; it calls for three stages in the treatment of typical double cleft of the lip and palate, and sometimes four, if complicated by protruding premaxillae. These stages are as follows:

1st. The freshening, approximation and immobilization of the cleft bones so that union may take place.

2nd. The closure of the lip.

3rd. Operation upon the soft palate.

4th. Elevating the nose which may have become flattened by the moving backward of the premaxillae.

The first step should be taken as soon after birth as expedient,—the 4th to 10th week, or after the functions of the body have become well established.

The second step, the closing of the lip, should be done in from 6 to 10 weeks after the union of the bones.

The third step, the closing of the soft palate, should be deferred until just before speech is attempted, usually about the 18th month.

The fourth step is to elevate the nose, if necessary.

The progressive surgeon no longer waits until a child is from 3 to 12 years of age before operating, or after bad habits of speech have been acquired, but now agreement is fairly general as to the wisdom of early operations. Closing the lip first, depending upon the traction of the orbicularis oris muscle to approximate the bones, or passing a single wire through the anterior part of the separated maxillae and bringing them together thus, cannot produce the best results.

The closing of the lip and the resultant traction of the orbicularis oris muscle *will* gradually move the anterior part of the cleft bones into contact, but the bones will not, as a rule, be normally approximated nor united. The bone carrying the premaxillae protrudes beyond the maxilla of the opposite side, leaving an ugly malformation of the nose and arch. Besides, there cannot be union of the bones with the muco-periosteum intervening. They only meet, remain malposed and leave the patient deformed throughout life.

I have time here only to say, with regard to the premaxillae, that they should always be preserved and utilized to maintain the normal dental arch, the facial contour and the full complement of teeth. They should *never* be excised, for an irreparable deformity is the unfailing result.

SPREADING OF THE TUBEROSITIES

I have spoken of the closing of the lip first, as a means of approximating the separated bones of the palate. When the anterior part of the cleft is brought together by the lip traction plan or by the single wire, the surgeon fails to give consideration to the consequent separation of the bones posteriorly. Every surgeon experienced in this work realizes that oftentimes these bones are widely separated posteriorly, due to the moving together of the anterior part of the cleft and the action of the muscles; and they cannot assume a normal position unless measures are employed to overcome this separation. With muscular force applied anteriorly and with no restraining force posteriorly, the maxillae act as levers, the malar processes becoming the fulcra; and as the anterior ends of the maxillae are drawn together the posterior ends, aided by the upward pressure of the mandible, move apart.

Unless steps are taken in early infancy to prevent the tuberosities from spreading (which is accomplished by the use of wires not only anteriorly but posteriorly), the bones will separate widely and the palate will be shortened to such an extent that perfect speech will seldom be secured. When the tuberosities are abnormally separated the soft palate, when united, will be put on the stretch and consequently shortened so that it cannot reach the post-pharyngeal wall; it will be like a drumhead, without flexibility or resilience. If lateral incisions are made through the soft palate in an attempt to relieve tension, a great mass of cicatricial tissue will result which makes it thick, unwieldly and inflexible.

The horizontal plates of the palate bones are elevated; the tuberosities are widely separated; consequently the hemispheres of the soft palate are also widely separated. The soft palate may be to some extent atrophied for want of normal use, but the width of the cleft is not due so much to atrophy as to the malposition of the parts.

It must be remembered that lateral incisions oftentimes divide the fibers of the tensor palati-muscle, which has a two-fold function—to make tension on the palate and to dilate the pharyngeal orifice of the Eustachian tube. The division of this muscle leads to early defective hearing, due to the destruction of the continuity of the muscle and consequent failure of the normal dilation of the pharyngeal orifice of the Eustachian tube. When introducing the posterior wire in operating on the soft palate, it should be passed as nearly as possible through the center of the tensor palati muscle as it swings around the hamular process, thus suspending the contraction of the muscle until the hemispheres of the palate unite.

I regret that I have not time to discuss the treatment of the defective lip and nose, for this phase of plastic surgery is most important in rounding out the work of making normal these patients who come in such distressing condition. But what does it avail, to produce the most careful and painstaking operation on the lip, if underneath there is an improper foundation for this superstructure? There must be first provided a normal, well-rounded arch upon which to build a well shaped lip, and there must be a normal position of the tuberosities of the maxillae in order that a flexible, resilient soft palate may be produced, to carry out this "New principle essential to correct speech in the treatment of complete congenital cleft palate."

PAPERS ON PSYCHOLOGY AND EDUCATION

RELATION OF QUICKNESS OF LEARNING AND RETENTIVENESS

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From many different points of view educators are working to individualize teaching. Investigations of individual differences in learning abilities and in retentiveness of learners should result in differentiating the length of the study period for different members of a class, and the amount and frequency of reviews needed to fix permanently in mind what has been learned. Educational and psychological tests have furnished innumerable curves showing the distribution of learning abilities in a homogeneous group of learners, but apprehension is only half the story. Retention must be secured. What is the relation of speed of learning to retentiveness?

Norsworthy, Pyle, Lyon, and others have studied the relation of the rate of learning to retentiveness. They agree that those who learn quickly retain a larger number of units than those who learn slowly, and in some cases, as large a proportion of what has been learned, as those who learn slowly. Lyon finds some exceptions to the last statement. In the case of meaningful material (prose or poetry) the quick learners sometimes retain an even larger percentage of what they learn than the slow learners, while in the case of mechanical material, such as numbers, the quick learners do not retain as large a percentage of their gains as the slow learners do of theirs.

The present investigation is confined to one kind of subject-matter, prose, and goes beyond the results of the investigators mentioned: first, by using longer selections; secondly, by using larger groups of subjects; and, thirdly, by attempting to define more precisely the relation of rate of learning to the amount retained. Another purpose was to ascertain whether the material is suitable for use as laboratory experiments for college classes.

To a normal school class of 56 students a geographical selection of 250 words was given in mimeograph form.

It described the character of the Philippine Islands and people. The first five lines will suffice as a sample:

(1) The Filipinos as a race are not vicious. / (2) Their common crimes are rather slight offenses, such as the theft of articles of small value. / (3) Gambling is perhaps the chief vice, / (4) and a Filipino will risk his last penny on a cock fight / (5) or a horse race./ (6) Americans are apt to think the Filipinos are lazy. / (7) This is partly true. / (8) For centuries they have learn-

The numbers and the oblique lines were not on the learning sheets, and are inserted here merely to aid in explaining the methods of grading employed later. The students were given two and one-half minutes in which to study the selection, and then reproduced as much of it as they could in their own language immediately and again a week later. The first is taken as a measure of what was learned; the second, as a measure of what was retained. The learning was with knowledge that the reproductions would be called for.

The selection was then divided into 36 "facts" or ideas, as shown by the numbers and oblique lines in the sample above, and the ratio of the number of facts which each retained to the number which he had learned was found. This is called the percentage of retention. The group was then arranged in the order of the number of units learned, and divided into quartiles. The results for the different quartiles follow. The figures in the second and third columns give the average number of facts learned and retained respectively. The fourth column gives the average ratios of retention to learning by quartiles.

RATIOS OF RETENTION TO LEARNING IN THE FIRST SELECTION

Rank of quarters	Av. learning score	Av. retention score	Av. p'c't. retained	Standard deviation
1	25.5	22.2	88%	3.6
2	19.1	15.3	80	6.0
3	14.9	12.7	85	5.3
4	9.1	7.9	88	5.5
Avs.	17.1	14.5	85	5.1

In general the four quartiles retained about the same percentage of what they had learned, viz., from 80 to

88%. Inasmuch as the quartile which learned the most learned about two and one-half times as much as the quartile which learned the least, the advantage is clearly and decidedly with the more rapid learners. If it be thought that the differences in the retention ratios of the quartiles is significant, the idea is soon dispelled, for repeating the experiment five times, each time with a new group, showed very small average deviations for each quartile from the average of all 24 ratios. The average of all the ratios is 82; the average deviations of the four quartiles from this average is +2.3 for the first quartile, —0.3 for the second, 0 for the third, and —0.8 for the fourth.

With the same group of subjects a much more difficult selection, "The Policies of Labor Unions," was next tried. It dealt with the theory of labor unionism, and was taken from Readings in Economics by C. J. Bullock. It contained about 900 words. The first ten lines of the selection used are:

Collective Bargaining. 1. *Its purpose.* If the whole body of workers of a given kind can be brought into the union, so that the union can meet the employers as the representative of the whole, the position of the worker will be greatly strengthened. The fear that if he refuses to accept certain terms, another man will be employed in his place is removed. His ignorance of the market conditions will be partly remedied both thru the combination of the knowledge of all the workers of the union, and in some cases, by the broader outlook which the union officials, partly or wholly exempted from daily application to manual work, may be able to obtain. The whole matter of bargaining can be put into the hands of the most—

Two changes were made in method. First, on account of the greater length of the selection, the subjects answered questions about it instead of reproducing it. Secondly, each subject determined his own length of learning time, knowing that the length of the time he took was an element in determining his score. The learning scores and retention scores of different subjects were made comparable by calculating the amount learned and the amount retained per minute of time invested in learning by each subject. A summary of the results follows: The figures in the second column give the average learning scores of the quartiles. If all the questions had been answered correctly, the score would have been 100%. The figures in the third column give the average retention scores after one week; those in the fourth column, the average learning times in minutes. The figures in the fifth and sixth columns give the average learning and retention scores per minute of time spent in learning (M. L. T.), and those in the seventh column give the average percentages of retention.

RATIOS OF RETENTION TO LEARNING IN THE SECOND SELECTION

Quarters.	Av. learning score	Av. retention score	Av. time	Av. L. S. per M. L. T.	Av. R. S. per M. L. T.	Av. p'c't retained	Stand. dev.
1	74%	68%	9.5	7.8%	7.1%	91%	11.5
2	57	47	10.5	5.4	4.5	83	11.7
3	40	37	12.2	3.3	3.1	94	25.3
4	21	20	12.9	1.6	1.5	94	28.4
Avs.	48	43	11.3	4.5	4.0	90	19.2

The quartile which learned the most took the least time for study. So far as quartile averages go, the higher the learning ability the less time needed for study, in spite of the greater gains from study. With the increase in the difficulty of the material the range between the best and the poorest learners increases. Whereas in the first selection the fastest quartile learned two and one-half times as much as the slowest, in the second selection the fastest quartile learned nearly five times as much as the slowest. The second selection was intentionally somewhat difficult for the class. An idea of how difficult it was may be gained from the fact that the average mark of the whole class in learning was 48%, 100% being a perfect answering of all questions. We are most interested in the percentages of retention, however. The first, third, and fourth quartiles retain about the same percents, 91, 94, and 94; the second quartile retains 83%. The standard deviations are large in the two slowest quartiles because when a person learns very little, an ability to answer one question more or less greatly changes the ratio of retention to learning.

The correlations between learning and retention, based on the absolute numbers of units, i.e., numbers of "facts" in the first selection, and percentile marks in the second selection, are very high. For the first selection the correlation is .87±.02, and for the second selection, .94±.01. Lyon's correlations are much lower, "seldom going above .4 and averaging only .25" [1] when prose was used as the material, and recall without any re-learning was the method employed. His method of measuring quickness of learning was not as exact as the method here employed. He used the amount of time needed to secure a perfect recital, and when a subject failed to give a perfect recital, he was obliged to resume learning, and this time was of course added to the learning time.

Summarizing our results we may say that differences in the rate of learning between the best and the poorest in a group increase with increase in the difficulty of the subject matter. By difficulty is meant thought difficulty. In this investigation at least it is true that when persons are allowed to determine the length of their learning time, or time spent in study, those who learn the most take the least time. Concerning the relation of retention to learning, there is a decided tendency in this investigation for fast and slow learners to retain about the same proportion of what they learned, and this is true whether they reproduce what they learned in their own language, or answer questions on it, and whether the subject matter is easy or difficult. Lastly, the material is very well suited for laboratory experiments in educational psychology.

Some corollaries for teaching practice are, that teachers should ascertain the relative learning abilities of their students early and assist them to become conscious of their rates of learning, and to adapt the length of their study periods to their abilities, or else teachers must expect less of the slower learners. Secondly, in class reviewing fast learners can review their larger learning in about the same time as slower learners review their smaller learning, and with equal effectiveness.

[1] Lyon, D. O. Relation of Quickness of Learning to Retentiveness, p. 49.

THE ABILITY OF MEN AND WOMEN TO JUDGE INTELLIGENCE

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The problem investigated in this study is the relative values of the judgments of men and women in rating the intelligence of the same people.

There were one hundred four students in one of my classes, fifty-three men and fifty-one women. The names were printed and sent to the faculty with the following instructions:

"Consider all the students whom you know. Divide them into ten groups basing your judgment upon their intellectual ability; the students of the highest ability to be in group ten, the next highest in group nine, and so on to the poorest students who will be in group one. Will you look over the following list of students; in the column, *Rank,* place opposite each student's name the number from ten to one according to which group you think he belongs as per the ten relative intellectual groups mentioned above."

The students employed the same method in judging the intelligence of one another. The purpose of the project was fully explained to the students and they were urged to rate only those students who were well known to them.

Three intelligence tests were given to the students: Army Alpha and two tests devised by Thurstone labeled A and B. The complete scholastic record of each student was secured from the Registrar's office. Fifty members of the faculty rated the students. However, only eighty-two students were judged by the faculty while ninety-seven were rated by the students. Forty-one men and forty-one women were rated by the faculty. The men students judged thirty-two women as against fifty men; women passed judgment on the intelligence of forty-four women and thirty-five men. The rating of no student was used unless he was graded by at least three people. The range of the number of judgments on each student was, in the case of the faculty, 3 to 15, while that of the students was from 3 to 68; the average number of ratings per student in the former instance was 6; in the

TABLE I.

Men's Judgment of Men Versus Women's Judgment of Men

	1 Men of men	2 Women of men	3 Faculty of men	4 Sch. of men	5 A	6 B	7 A B	8 Alpha
Average...	65	70	63	63	52	63	57	46
Range....	45–87	41–87	39–94	43–95	33–82	39–94	41–81	13–85
A. D.......	7.33	8.26	11.42	11.35	9.00	11.42	9.57	19.81
S. D.......	9.70	10.68	12.93	13.66	11.15	12.93	11.29	22.91
Q. D.......	9.25	8.50	12.00	11.75	8.25	12.00	10.25	20.50

TABLE II

Men's Judgments of Women Versus Women's Judgments of Women

	1 Men of women	2 Women of women	3 Faculty of women	4 Sch. of women	5 A	6 B	7 A B	8 Alpha
Average..	72	69	68	70	53	69	62	54
Range....	40–90	40–97	35–93	46–96	29–81	42–96	37–87	16–94
A. D.......	8.48	10.42	10.46	10.82	8.23	13.60	10.00	16.00
S. D.......	11.08	13.02	13.58	13.38	10.89	15.15	12.30	18.85
Q. D.......	9.00	10.50	13.50	13.50	7.50	14.75	9.62	16.75

latter case 27. The range of the number of women rating men was 3 to 38; when judging women it was from 3 to 40. The average in the first case was 13.9, while in the latter instance it was 18.8. The average number of judgments of the men when rating men was 18, the range 3 to 37; when they rated women the range was 3 to 29 and the average 13.4. The results of this study are presented in four tables given above.

In Table I. the ability of men and women to judge the intelligence of men is compared. According to our rating scale numbers from 10 to 100 are obtained. All the other scores with which the judgments are compared were reduced to a similar basis in order to facilitate comparison. In this table the average of the judgments of the men and women are given together with the range, A. D. S. D., and Q. D. The results of the faculty judgments of men are presented, also the scholarship record and the score of men in tests A, B, average of A and B, and Army Alpha.

It will be noted that the judgments of the women run slightly higher than do those of the men. The same results obtained when the women's ratings were compared with the other average. The variability of the score of the men and women is slightly less than is any of the other instances. This is probably due to the fact that there is a larger number of figures combined in case of men than in any of the other columns.

Table II. compares the judgments of men and women passed upon the intelligence of women. In this instance it is discovered that the men tend to rate the women higher by only a very small margin. The differences in this table are not so marked as those in Table I.

When the results in the two tables are compared it is observed that women tend to rate men higher while men show a partiality in judging women. Their judgments of women are higher than they are of men. Women placed a slightly higher value on the intelligence of the men than they did upon that of women. Columns three to eight in Table II., which are the records for the women, are somewhat higher than the corresponding columns in Table I, which are the scores of men.

The second method by which these data were studied is that of correlation.

In Table III. are given the Correlation values of the judgments of men and women of men, when compared with the various criteria. The correlation values are arranged somewhat in groups; the first group has to do with the Thurstone Tests, the second gives the results when using the Army Alpha test scores; and the third group shows the correlation values with scholarship and faculty judgments. The values in the first two groups were also averaged.

With the Thurstone test, women have higher correlation values in three of the four cases of comparison. The ten values obtained by using Army Alpha show the women to have a higher correlation in five instances, lower in two, and practically the same in three instances of comparison. In the last group, the men show higher correlations for both items. Considering the entire sixteen correlations, the women have 8 higher; the men 5.

TABLE III

Correlation of Men's and Women's Judgments of Men with Various Criteria

	Men of men	Women of men
Thurstone A	.350 ± .084	.335 ± .102
B	.310 ± .087	.411 ± .096
A + B	.340 ± .085	.402 ± .097
Average	.33	.382
Army Alpha 1	.077 ± .098	.307 ± .104
2	.423 ± .080	.422 ± .093
3	.407 ± .082	.450 ± .092
4	.477 ± .075	.444 ± .092
5	.200 ± .095	.028 ± .115
6	.126 ± .097	.206 ± .100
7	.395 ± .074	.394 ± .097
8	.047 ± .099	.134 ± .113
Total	.410 ± .083	.419 ± .095
Average	.284	.312
Scholarship	.587 ± .063	.536 ± .081
Faculty judgments	.687 ± .058	.665 ± .072
Average of all	.346	.360

The range of the differences for the men is from 2 to 18, four being between 2 and 5. This makes an average difference for the men of 6 points. The range of the differences in favor of the women is from 3 to 23; two of the differences are 3, two 5, three between 6 and 9, one 10 and one 23. The average difference in favor of the women is 8.61. Of the 28 correlations, exclusive of the averages, 21 are sufficiently high to be of some significance. The values of greatest significance are those obtained when correlation is made with scholarship and faculty judgments.

In Table IV. the relationship between men and women's judgments of women and the several criteria are considered. The same criteria are used here as were employed in Table III, and the values are grouped in the same manner as in the preceding table.

By observing the data of this table it will be noted that in all 14 cases of comparison the women have higher values. The differences in favor of the women range from 15 to 46, with an average of .322. All of these differences are large enough to be significant. The average of the three correlations obtained when Thurstone's Test was employed shows a difference of 35 points in favor of the women. In regard to the average of the nine r's of Army Alpha, there is a difference of 30 on the side of the women. When all the correlation values are averaged the women obtain an advantage of .259.

In the column of the woman's judgments, all of the values are of some significance; 4 are between .266 and .372; 3 between .401 and .467; 3 between .545 and .597; 4 are between 60 and 70. Ten of the 14 values are sufficiently high to be quite significant. The average of the

TABLE IV

Correlation of Men's and Women's Judgments of Women with Various Criteria

	Men of women	Women of women
Thurstone A	.245 ± .110	.467 ± .081
B	.265 ± .109	.639 ± .061
A + B	.201 ± .112	.660 ± .058
Average	.233	.588
Army Alpha 1	.116 ± .113	.300 ± .095
2	.130 ± .114	.372 ± .091
3	.073 ± .115	.445 ± .084
4	.147 ± .112	.545 ± .073
5	.054 ± .116	.401 ± .088
6	.114 ± .112	.266 ± .097
7	.014 ± .117	.283 ± .096
8	.231 ± .081	.597 ± .067
Total	.218 ± .104	.597 ± .067
Average	.121	.422
Scholarship	.280 ± .106	.704 ± .051
Faculty judgments	.281 ± .117	.619 ± .069
Average of all	.162	.421

14 r's is .421. None of the 14 correlation values obtained for the men's judgments of women are of any significance. The highest value is only .281 while the lowest is .014. The average of all 14 values is .162. In no instance is the r three times the size of the P. E.

With the foregoing data as the basis, the following conclusions are justified:

1. No significant difference appears in the judgments of the two groups in terms of the central tendency.

2. Each group shows some partiality to the opposite sex in estimating its intelligence; that is, the men give evidence of placing a slightly higher value on the intelligence of women than they do that of men. The women appear to do the same thing in regard to the men. This partiality is not striking.

3. The type of intelligence that this group of people rated should probably be termed scholastic intelligence. Three of the four correlation values in Tables III. and IV. having to do with scholarship are sufficiently high to be significant. Scholarship is not the important factor in determining men's judgments of women. The only instance where higher values are found is when the faculty ratings were used as a criterion for correlation purposes. In another study the correlation between faculty judgments of intelligence and scholarship was found to be .760.

4. When the intelligence of men is estimated, the two groups manifested about equal ability. If there is any difference at all, it is in favor of the women. However, the difference is not sufficiently large to be of any significance.

5. The women evidenced a decided superiority in judging the intelligence of women; practically all the correlation values were high enough to be of significance.

6. The men's ratings of the women were practically worthless. In no instance was a significant correlation found.

The practical outcome of this study is that when men are to be judged by a rating scale, either men or women could be used as judges. However, when women are to be rated it would appear to be wiser to employ women as judges.

TACTUAL INTERPRETATION OF ORAL SPEECH

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In a paper read before the American Psychological Association a year and more ago I stated that a subject in our laboratory at Northwestern University had learned to recognize seven spoken words when he had no criteria to go by excepting the vibrations of the speaker's vocal apparatus conducted through an air column in a tube 14 feet long to the palm of the subject's hand. In May, 1923, I added a footnote to the paper when proof was being corrected for the Journal of Abnormal Phychology and Social Psychology, saying that up to that time 34 words had been learned, together with a great number of sentences made up of those words in various combinations. In fact he was able to get the sense of any such sentence. Furthermore, he had learned to distinguish high and low tones provided there was a difference of an octave at least between them. This result was obtained in the course of 78 periods, one a day. Actual practice never occupied more than 35 minutes at a sitting.

The subject in this case was a normal hearing young man, a sophomore in the University. The situation was so arranged that he could not hear. The speaking tube I have referred to extended through two walls and the intervening room. At the subject's end it terminated in a double pine box, the outside dimensions of which are 2 by 2 by 2½ feet approximately. The space between the outer and the inner wall, five inches deep, is packed with cotton waste. At the front end of the box is an aperture surrounded by a rubber collar.

The subject thrusts his hand through the aperture and holds his palm closely over the end of the tube. In this position the rubber collar grips the forearm and the whole apparatus is, for our purposes, sound proof. Additional precautions against hearing were introduced as follows:—First, the experimenter muffled his face in a feather cushion and spoke through a narrow aperture in it into a funnel upon his end of the tube. Second, the subject plugged his ears with soft putty and cotton batting, covered his ears with a heavy bandage, and kept an electric motor humming at his side. Even without these precautions it was impossible for any one of about twenty-five students and for several disinterested visitors who are competent critics of experimental work to hear what was going on.

Visual stimuli were employed as aids whenever a new word was being added to the tactual vocabulary. When the subject saw the word "Ray", for example, displayed upon a card, he knew that the next tactual impressions upon his palm would be such as arise from speaking that word into the tube. The visual tactual connection was repeated as often as necessary to establish the association, and new words were added as rapidly as possible.

At the end of the academic year the subject had attained an accuracy of from 88% to 95% in the recognition of 200 word impressions. (Each word in the vocabulary repeated several times.)

Up to this time practice had been only with the right hand. On the last day of April, which was the last day of practice, the left hand was employed as the right one had been used theretofore, and recognition proved to be quite as accurate as with the other hand. This result suggests that we are not dealing here with an absolute increase in sensitivity but with a control of attention directed toward small differences in tactual stimulation. On the same day we made another crucial test at the suggestion of Professor McDougall. A list of eight monosyllabic words was prepared upon no one of which the subject had practised. He recognized six of the eight. This indicates, I believe, that the vowel sounds in these words had become isolated in the course of the development of the vocabulary of 34 words, even though no specific attempt had been made in that direction.

Four months after the last test in April, 1923, after a summer of no practice, the subject was tested again by the method with which he had become familiar. On this day he recognized 71% of the 200 tactual stimuli: a loss of 30.5% on the basis of his maximum record in April. The stimuli and method employed in this test were those that were in use on the last day of practice in April.

The query has been raised in some quarters whether the subject in these experiments has not the advantage of bone conduction. I think not, for the following reasons:

(1) The tactual stimuli are so slight that it is inconceivable that they can escape being absorbed by the cushions of flesh in the palm and in cartilage in the joints intervening between the palm and the brain center.

(2) The subject persistently denies that his experience is auditory. This he could not do if bone conduction were a fact.

(3) If bone conduction were involved the subject would not be compelled to learn the meaning of the impression more than you have to learn the meaning of the impressions you receive when the receiver of your telephone is held against your chest. But there has been learning and it was a tedious process.

I am indebted to Mr. George Crane, Assistant in our department, for indispensable aid in conducting this experiment, and to his brother, John Crane, for having given his time as a subject without academic credit.

In view of our success with the speaking tube it occurred to us to substitute for it an acousticon device such as is used for the aid of the partially deaf. It is well known that if one holds the ear piece of such a device in the hand, one can sense its vibration occasioned by the speaker's voice, against the transmitter at a distance. The question is: "Can a subject learn to interpret these vibrations against the skin in a situation in which hearing is out of the question?"

Through the generosity of the Dictograph Products Corporation of New York City, we were provided at the close of the last academic year, and repeatedly since, with the necessary apparatus.

It was our expectation to begin experimentation with the present year, following essentially the same method as that which proved successful last year, but with two modifications:

(1) Stimulation should be applied not to the palm, but directly to the tip of a finger resting lightly against the diaphragm of the receiver.

(2) Instead of employing isolated words as stimuli to be later framed into sentences, we would begin with sentences forthwith and later arrive at isolated words and their phonetic elements. We should thus parallel an approved method of teaching reading.

On October 29, the subject who succeeded with the speaking tube last year was tried out, without previous drill upon the acousticon. He recognized 58 out of 100 impressions, the stimuli being selected from among those with which he had become familiar last year.

The experimenter and the subject in work with the acousticon are separated by from 30 to 60 feet. The receiver lies within the sound-proof box, and the subject's hand, grasping it, is enclosed as in the earlier experiments. The additional precautions against hearing, already described, are employed in this case also.

In preliminary experiments in which the writer was subject, four short sentences were used as stimuli:

Jack did like teacher.

Henry did not begin.

He did like work.

Say, did Jack accept?

No well-defined principles led to the choice of these sentences. Many others would have served as well. They contain a considerable variety of vowel values. It was our expectation that, after considerable practice, these vowel values would begin to emerge in the tactual sense.

Work began with the fourth week in October. The tip of the index finger of the subject's left hand was held lightly against the diaphragm of the receiver. Practice was had four days each week, extending over from 45 to 90 minutes daily. Owing to limitations due to other engagements on the part of experimenter and subject, it was impossible to distribute the time in an ideal manner, as is required by the law of distribution of time in the chapter on learning.

At each sitting, for purposes of drill, the experimenter pronounced the four sentences into the transmitter in an order known to the subject, ten times in succession. The same sentences were then pronounced in orders not known to the subject during the remainder of the day's period of experiments. Notes were compared after each reading of the four sentences.

After two weeks—eight sessions—the subject had attained an average accuracy of approximately 70% on the four sentences, each of which was presented 50 times. The fourth sentence he recognized in 86% of cases. It began to be apparent to the subject, however, that up to this time his criteria of judgment were tempo, emphasis, number of syllables in a sentence—not the quality of the stimulations. We therefore framed new sentences, using the old words, to test the question whether any more intrinsic quality of the words was beginning. The result was disappointing. Previous practice had given the subject no noticeable advantage in learning the new word groupings.

The subject then began holding the receiver with the aperture disclosing the diaphragm toward the palm. In this case the vibration of the diaphragm is conducted through a cushion of air to the palm and the tactual area stimulated is less restricted than in the earlier practice. By this method, in six sittings the subject attained a confident mastery of the four original sentences and the new ones. These trials carried us up to the end of the first week in the present month.

Up to that time we had drawn the conclusion that success in the interpretation of tactual stimuli arising from oral speech will depend upon the stimulation of a fairly wide area or pattern of tactual organs.

On December 10, we began practice upon the long vowel sounds and continued through the 11th and 12th. We spent approximately one hour on each of these days at drill alone. The order of presentation was always known to the subject, and in the course of every period each vowel was presented 30 times, or 90 times during the three days. Our method of procedure from the 13th to the 19th, inclusive, was as follows:

(1) The experimenter recited the vowels five times in a known order.

(2) He recited 15 series of unknown order, 10 in each series (each vowel occurring twice), the subject writing

down what vowel each impression seemed to him to represent.

(3) The subject and experimenter checked up and the experimenter repeated the series for drill.

(4) After this a new unknown series was presented. Beginning with the 20th each vowel in the series of 10 was pronounced three times instead of once. Otherwise the method remained the same as before. This modification of procedure is apparently producing good results.

Experience up-to-date satisfies me that it is possible to learn to interpret oral speech by tactual impressions.

I have not yet made a learning curve for each vowel. **I** is most easily learned with **A** and **O** close seconds. **E** and **U** are easily confused. As nearly as I can describe the criteria they are as follows:

A is a long, heavy, steady impression.

E is long and steady, but not so heavy as **A**.

I gives two impressions. The first is quick and sharp. The second is prolonged, rather heavy and smooth.

O has a roll about it that may be mistaken for two distinct impressions such as **I** affords.

U is short, light, and smooth.

A SERIES OF STUDIES ON THE RELATIVE VALUE OF PSYCHOLOGICAL TESTS AND TEACHERS' JUDGMENTS AS A BASIS FOR MEASURING PUPIL MENTAL ABILITY

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INTRODUCTION

No single factor in education in recent years has been so widely heralded as the panacea for so many of our educational ills as psychological and standardized tests and measurements, and perhaps no single factor ever came into widely accepted use in public education with quite the same degree of apparent justification for dependability and validity. The very origin and development of these tests seemed to be a guarantee that they would do all that even the most enthusiastic of their proponents claimed for them. Arising as they did under scientific auspices, further developed according to the best of scientific educational procedure, it seemed that there was little else to do but accept them as a part of regular school practice and make the best possible use of the results.

Many school systems throughout the country have adopted the use of some of the now over two hundred and seventy different varieties of tests in their classrooms, and some school systems have gone even so far as to use them exclusively as a basis for classifying, grading and promoting individual school children and judging the quality of the teaching and the effectiveness of the school supervision. This practice presents a problem of which it is the purpose of this study to attempt to find at least a partial solution. The problem involved is concerned with the reliability of the average teacher's judgment of the mental ability of his pupils, as compared with the use of standardized tests for the same purpose. It is not accepted as a proven thesis, as far as this paper is concerned, that "Intelligence" should be the sole basis for classifying, grading or promoting pupils, though it seems so to be used in many school systems. It is assumed that intelligence plays a very important role among the factors that should determine the classifying, grading and promoting of pupils, and that in order to place pupils in the school system where they will probably make the best progress of which they are capable, it is necesary to know, among other things, all that it is possible to know about their intelligence.

We recognize that traditionally the teachers' judgment, often expressed in very vague terms, was the only basis used in classifying, grading and promoting pupils. That these judgments were often mistaken will probably be first admitted by the teachers themselves. There are many reasons why teachers' judgments are not infallible. In the first place, they are personal and individual judgments, the validity of which must vary according to the ability of the teachers to judge. In the second place, the judgments of the teachers are being applied to the most difficult and complex of all phenomena, i.e., mental capacities, whose nature is so complex that the most searching study must be made of each pupil before one can be reasonably sure of one's judgment. In the third place, teachers' judgments of pupils' mental capacities are, by the very nature of their situation, largely determined by the accomplishment of the pupils in school studies, limiting the judgment, therefore, to a special type of activity in a special environment. Accomplishment in any field is a resultant of many factors, such as interest, capacity, industry, health, etc. To say that mental ability, therefore, is measured by accomplishment in school work is true only in part. In the fourth place, it is inconsistent to measure children of differing degrees of maturity on the same basis, yet this is the common practice, chronological age seldom being taken into consideration. A ninety per cent achievement in a school subject by a child ten years of age means a mental capacity greater than the same degree of achievement by a thirteen year old child, yet it is the usual procedure among schools to apply a standard of achievement to a class regardless of the age of the children in it. An examination of the grading and promotion plans of public school systems will indicate that this method is almost universally followed.

Economy of time, provision for individual differences, and other equally important considerations make it imperative that there shall soon be developed a reliable and ready means of measuring mental ability. There are at the present time two leading methods employed in different school systems for this purpose, viz., teachers' judgments and psychological tests, some using one exclusively, some using the other exclusively and some using both in varying degrees. It is the purpose of this paper to indicate the results of several different types of attempts to determine whether or not, under differing conditions, the two methods will produce the same or similar or different results. At this time, it cannot be said with sufficient assurance whether the intelligence tests or standardized subject tests or phychological tests or the teachers' judgment is the most reliable. Where the tests and the teachers' judgment agree we feel reasonably certain of our results; where they differ it remains a question as to which is correct.

A STUDY OF THE RESULTS OF AN ATTEMPT BY TEACHERS TO SEGREGATE PUPILS ON THE BASIS OF MENTAL ABILITY IN THREE GROUPS: ACCELERATED, NORMAL, AND RETARDED, AND THE RESULTS OF A SEGREGATION OF THE SCORES MADE BY THE SAME PUPILS ON THE OTIS TEST EXPRESSED IN INTELLIGENCE QUOTIENT EQUIVALENTS.

When the Winchester, Va., Public schools were reopened for the fall term in September, 1919, the teachers were asked to group the pupils in sections or classes as far as possible on the basis of mental ability, grouping the brighter pupils together, the average pupils together and the slower pupils together, whenever there were enough pupils to make three or more divisions. Allowing for the limited time given in preparation for this reorganization and the fact that the re-distribution was further complicated by a change from the old 7-4 plan to a 6-3-3 plan, we still find a considerable lack of agreement between the judgments of teachers as to pupil mental ability, and pupil mental ability as measured by the Otis Intelligence Tests.

Tables 1, 2, 3, 4, 5, 6, 7 and 8 indicate the distribution of chronological ages, mental ages and total scores in the Otis Intelligence Tests, and the equivalents in Intelligence Quotients in grades seven to nine inclusive after the pupils had been distributed into groups according to mental ability as determined by the teachers' judgment. (In this connection account must be taken of the fact that about twenty pupils, or approximately 6% of the total number of pupils, could not be placed as recommended by the teachers because of program complications.)

This was done only in grades seven, eight and nine.

Table 1 consists of a group of pupils that were considered bright or accelerated by the teachers who judged them. The Otis test shows a range of mental ability in this group from I. Q. 33 to I. Q. 130 with a median of I. Q. 103. Seven pupils, or sixteen per cent of the group, have an I. Q. below 80 while only thirteen pupils, or thirty-three per cent of the total, are clearly in the accelerated class as measured on an I. Q. basis only. The other Tables show equally striking differences between Intelligence as measured by the teachers' judgment and as measured by the Otis Test. The summary shown in Table 8 presents further evidence of a lack of conformity between the results of these two methods of measurement, e.g., in the normal group ninth grade we find a range in I. Q. including 157, which is higher than any I. Q. in any of the accelerated groups. In the seventh grade accelerated group we have an I. Q. of 33 which is clearly a feeble-minded score. Aside from individual discrepancies in scores, which may be regarded as exceptions or may be explained by circumstances not revealed by the test, we find the median of the only retarded group greater than the medians of two of the three normal groups and almost equal to the median of the third normal group.

It must be considered at this point that the seventh and ninth grade normal groups contain all the slow or retarded pupils in those grades, not enough in number, however, to make the difference indicated in the distribution as determined by the judgment of the teacher. As a result of this study, it appeared that the correlation between these two measures of mental ability was very low. After these results were brought to the attention of the teachers, it appeared that the teachers' judgments were mistaken in about as many instances as it was demonstrated that, because of other personal qualities such as perseverance, concentration, industry, "the will to do", etc., or a lack of these and similar qualities, a pupil was better able to work with a group above or below his mental ability. After a redistribution of the pupils considering *both* the teachers' judgments and the intelligence tests, we found that about ten per cent of the pupils of an accelerated group would be composed of pupils below the I. Q. limits for the group, but able to do the work of the group because of personal qualities not measured by the intelligence test but observed by the teacher. In normal groups twenty per cent were below the I. Q. limits of the group for the same reason, and ten per cent were above for reasons of indifference, laziness, over-confidence and similar qualities. In the retarded groups two per cent were found whose I. Q. would indicate that they belonged to the accelerated group and twenty-five per cent to the normal group. As far as this study is conclusive, then, it appears that these measures of ability cannot safely be used separately but that they can be used together with a reasonable degree of assurance.

A STUDY OF THE SCORES MADE BY A SPECIAL GROUP OF FIRST GRADE PUPILS ON THE DEARBORN GROUP INTELLIGENCE TESTS, THE SPECIAL GROUP OF PUPILS HAVING BEEN SELECTED BY THEIR TEACHERS AS AVERAGE CHILDREN OR BELONGING TO THE MIDDLE FIFTH OF THEIR RESPECTIVE CLASSES IN MENTAL ABILITY.

In further preparation for the reorganization of the Winchester; Va., schools on a basis that would provide for accelerated normal and retarded children, group intelligence tests were given to all pupils in grades one to eight. The total number of tests given was seven, no pupil receiving less than three different group intelligence tests. For convenience they are designated here as G-1, G-2, G-3, G-4, G-5, G-6, G-7. Of these G-1, G-2, G-3 were tests which, with some changes and additions, now constitute Series I of the Dearborn Group Tests of Intelligence.[1] G-4, G-5, and G-6 included parts of several standard psychological tests, several tests now a part of Series II of the Dearborn Group Tests of Intelligence,[1] and certain other psychological tests developed in the Harvard Psychological Laboratory. G-7 was one of the Alpha Tests of the Army Psychological Examination. All of these tests were standardized and graduated according to the plan indicated below, wherein are chosen the grades in which each test was given.

Grade	Tests given						
1	G-1	G-2	G-3				
2	G-1	G-2	G-3				
3	G-1	G-2	G-3	G-4			
4	G-1	G-2	G-3	G-4	G-5		
5				G-4	G-5	G-6	
6				G-4	G-5	G-6	G-7
7					G-5	G-6	G-7
8					G-5	G-6	G-7

Each pupil was given three or more different intelligence tests, to avoid, as far as possible, the contingency that a chance failure or success in any one test might misrepresent the pupil's true capacity. Such a contingency was further avoided by the fact that in most cases each test was given on a different day, that the dangers of an "off day" might be lessened. To avoid the difficulties usually encountered when pupils of widely differing degrees of maturity and of widely differing degrees of education are tested by the same materials, different tests were given to pupils of different grades, but those tests so overlap that comparison and correlation are possible throughout with known relations between the different tests.

As a basis for obtaining some data on the possible correlation between a teacher's judgment of mental ability and the results of these tests, the teachers in grade one were asked to make a list of all their pupils whom they would designate as of average mentality, i. e., falling in the middle fifth of their classes. When these lists were received a comparison was made with the list con-

[1] These tests are now published by the J. B. Lippincott Company, Philadelphia.

taining the names and scores on tests G-1 and G-2 from the testing program described above of these same first grade pupils. Table 9 indicates the results of this comparison. It is to be read as follows: Twelve pupils, or 26.7% of the total number of first grade pupils, who were judged by their teachers to belong to the middle fifth of their classes, or in other words who were judged by their teachers to be of average mentality, received scores on test G-1 indicating that they belonged to the lowest fifth of the class. In test G-2 there were eight pupils, or 17.8 per cent, who were judged to be average by the teachers, who were measured by the test as in the lowest fifth. In the middle fifth where we might expect a high percentage of agreement, if there was a high degree of correlation between these methods of measurement, we find a low percentage, 17.8 and 28.8. In other words, as far as this experiment goes, it appears that those pupils, who are judged by the teacher to be of average mentality, have about an equal chance of making a score on these intelligence tests that would place them in any fifth of the class.

As between these two methods of determining mental ability, there is no correlation in this case. Evidently the teachers were not measuring the same thing that the test was supposed to have measured, or, if either method is an adequate measure of mental ability, it cannot be said with confidence that it functioned in this attempt. There are a number of factors that would easily explain the inadequacy of either the test or the teacher in this case. The tests were new tests and not fully developed, they were given to first grade children, the teachers had had these children only two months, the school system in which the test was made was entering upon a period of reorganization, and the teachers, though experienced, were not well trained. Any one of these factors would be sufficient to discount the results, unless they were under control (which they were not) or were verified by other similar experiments and studies.

A STUDY OF THE DISTRIBUTION OF INTELLIGENCE QUOTIENTS OF A GROUP OF PUPILS AS DETERMINED BY A TRAINED EXAMINER WORKING WITH THE BINET-SIMON TEST (STANFORD REVISION) AND THE JUDGMENTS OF THE TEACHERS OF THE SAME PUPILS IN ALLOCATING THEM ON A BASIS OF MENTAL ABILITY TO A QUINTILE IN THEIR RESPECTIVE CLASSES.

In a further attempt to study the relative merit of the judgments of teachers as a basis for measuring pupil mental ability, an experiment was organized in which an effort was made to protect the validity of the results by every possible precaution that our experience, up to this time, would suggest. The results of this study are tabulated in Table 10. These ratings were prepared by teachers who were asked to indicate in which fifth of their respective classes they would place certain pupils who had previously been tested individually by a trained examiner with the Binet-Simon (Stanford Revision) Scale. The teachers, not being informed of the scores made by the pupils tested, were asked in which fifth of the class from "E", the lowest, to "A", the highest, these pupils would be classified in "intelligence".

The distribution of the ratings indicate a considerable discrepancy between the judgment of the teacher and the results of the tests. For example, eleven pupils were shown by the Stanford-Binet Intelligence Tests to have an I.Q. between 61 and 65, a rating that would indicate probable feeble-mindedness or a near moron condition. Three of these pupils were rated by a teacher in the lowest fifth of their classes, three were rated in the next to the lowest fifth, three in the middle fifth, one in next to the highest fifth and one in the highest fifth. Similarly, of twenty pupils whose scores in the Binet Tests indicated a status of slow-mindedness (I.Q. 81 to 85), two were rated as belonging to the lowest fifth of the class, four in the next lowest fifth, seven in the middle fifth, five in next to the highest fifth and two in the highest fifth, i.e., more than one-third of the pupils who, according to the Binet Tests, were rated as "slow", were rated by the teacher as "above the average".

Equally lacking in correlation is the case of the group of seventeen in all, whose I.Q.'s fell between 96 and 105, i.e., the normal group. Only three of these were rated by teachers as belonging to the middle fifth of their classes, five were rated as belonging to either the lowest or next to the lowest fifth of the class, and nine were placed in either the highest or next to the highest fifth of the class. In the case of two pupils who made a very high score that fell between 126-130 in the Binet Test, one was rated as belonging to the highest fifth of his class and the other was rated as belonging to the lowest fifth of his class.

The lack of correlation in the instances noted above between the judgments of teachers and the Stanford Revision of the Binet-Simon Test for intelligence indicate that in this instance, at least, doubt may be reasonably expressed on the reliability of either the results of the tests or the judgments of the teachers.

A STUDY OF TEACHERS' JUDGMENTS AFFECTING ALL THE PUPILS FROM GRADES ONE TO TWELVE INCLUSIVE, EXPRESSED IN TERMS OF INDUSTRY, SCHOLARSHIP AND INTELLIGENCE, AND THE DISTRIBUTION OF THE PUPILS IN TERMS OF INTELLIGENCE TESTS EXPRESSED IN INTELLIGENCE QUOTIENTS.

Our study so far seems to indicate that there is little or no correlation between the judgments of teachers and intelligence tests, when applied to pupil mental ability. Since either one or the other or both must be justified, and since it appears that in the process of judging so far a number of teachers have asked to have "mental ability" defined, it was decided to extend the study and organize it so as to direct the attention of teachers to intelligence as differentiated from other qualities often confused with it in the attempt to form a judgment. In this study the Intelligence Quotients were obtained in the first and second grades by the Stanford-Binet Tests; in the other grades, three to twelve inclusive, they were computed from the results obtained by giving the Otis Intelligence Tests in grades seven to twelve and the Dearborn Tests in grades three to six. The teachers' attention was directed to "intelligence" in such a manner as to differentiate it from "industry" and "scholarship".

In preparation for this attempt to compare the judgments of teachers in determining intelligence with the results obtained from Intelligence Tests, written instructions were distributed to each teacher as follows:

November, 1921.

DIRECTIONS TO TEACHERS

Follow these directions exactly:

1. In the place indicated write the first and last names of each pupil being tested.
2. Under "Age" give the exact present age in years and months, as 8-3.
3. School Grade. Write 1, 2, 3, 4, etc., showing present school grade of pupil. Indicate grade exactly, including group, e. g., 1A, 2B, 4C, etc.
4. Years in school. Write 3, 4, 5, etc., to indicate the exact length of the time pupil has been in school, from the time he first entered school to the end of the school year June, 1921. Indicate in years only, not years and months.
5. Ratings by Teachers. These ratings are to be made on a five point scale, as follows:
   - A means superior, about the score of the best 5 per cent of children of that race* and age in public schools.
   - B means high average, above the average, but not as good as A. About 20 per cent of the children make this score.
   - C means average, the score of the middle 50 per cent of that race and age in the public schools.
   - D low average, means below the best 75 per cent of school children of that race and age, i. e., below the middle 50 per cent, but not as poor as the lowest 5 per cent.
   - E means inferior, about the score of the poorest 5 per cent of the children of that race and age in the public schools.

QUALITIES

a. *Scholarship.* In rating a pupil in scholarship, think about how well he does in his school studies. If he is average, mark him C. If he is good as the best 5 per cent of children you have known in the public schools, mark him A. If he is better than the poorest 75 per cent of the public school children you know, but not as good as the best 5 per cent, mark him B. If he is poorer than the best 75 per cent you have known, i. e., poorer than the middle 50 per cent, but not as poor as the poorest 5 per cent, mark him D. If he is as poor as the poorest 5 per cent of children in the public schools, mark him E. Proceed similarly with every other child on the list. Compare him with school children generally, not only with those in his own group.

b. *Intelligence.* Intelligence is not the same as scholarship. In scoring pupils for intelligence, think of the skill with which they are able to meet new situations, both in school and out. It is not always true that the most intelligent pupil makes the highest marks in school, nor that the pupil with the highest marks in

* Colored children were in separate schools.

school subjects is the most intelligent child. An intelligent child may earn high school marks if he is industrious, if he is physically well, if he is regular in attendance and if all other school conditions are favorable. If these conditions do not maintain he may still be intelligent and not earn high marks. Proceed in estimating the intelligence by the same method as used in estimating scholarship, scoring each pupil A, B, C, D, or E as indicated.

c. *Industry.* In rating a pupil for industry, consider his ability to apply himself to his school work, both in school and out, to learn his lessons and to do other set tasks, as far as this may be known to you. Proceed as in the case of scholarship and intelligence and score each pupil A, B, C, D, or E as indicated.

The form (Appendix A) was supplied to each teacher with the copy of the directions. Where there were different ratings for the factors of "Intelligence", "industry" and "scholarship", as actually appeared in sixty-three per cent of the cases, it was evident that in the mind of the teacher there was a difference between these elements that are often considered under one head as a basis for promoting or for estimating pupil mental ability.

In order that the teachers might not be influenced by giving too definite consideration to any one of the three qualities to be rated, the purpose of this expression of judgment was not made known to them. With these precautions it is reasonable to assume that we have as accurate an expression of the ability of these particular teachers to judge the intelligence of their pupils as it is possible to get. It is also to be observed, in connection with this effort to determine the relation between these methods of measuring pupil mental ability, that most of the teachers have now had two years' experience with the use of intelligence tests and an organized effort to judge pupil mental ability in connection with the tests. It is also to be observed that the pupils being judged in this study were allocated in groups known as accelerated, normal and retarded, which fact would have its effect as a general guide to the teachers in making their estimates and would in turn be modified by the fact that a pupil in the first fifth of a retarded group would in all probability not be judged as in the first fifth of an accelerated group. In making our comparisons this latter fact has been provided for by segregating the reports of the estimates of the teachers by groups as the pupils actually appeared in the classrooms. Tables 11, 12 and 13 reveal the results of this attempt on the part of the teachers to estimate or judge the mentality of their pupils allocated in groups according to mental ability, the mental ability groups having already been determined by a combination of other teachers' judgments and an intelligence test.

Table 11 should be read as follows: In all the accelerated classes (11 in number) there were two pupils whose I. Q. ranged from 60-69 who were judged by their teachers to be equal in intelligence to the middle fifth of their classes (both these pupils were judged in the highest fifth in ''industry'' and ''scholarship''). Of all the pupils in the accelerated classes, there were fourteen pupils whose I. Q. ranged from 70 to 79. One of these was judged by his teacher to be of an intelligence equal to the lowest fifth of his class, three as belonging to the next to the lowest fifth, five as belonging in the average fifth, two next to the highest fifth and three in the highest fifth. The three judged to be in the highest fifth were also judged to be in the highest fifth in ''industry'', the two in next to the highest fifth were also judged to be in the highest fifth in ''industry'' and ''scholarship''. It is also significant to note, on the other hand, that of the two pupils whose I. Q.'s are over 149, one was judged by the teacher as in next to the highest fifth in ''scholarship'' and in the average group in ''industry''; the other was judged to be in the first fifth in ''scholarship'', the first fifth in ''industry'', but was given a mark of ''A—'' in ''Intelligence''. (No provision had been made for an ''A—'' rating; it was the teacher's method of drawing attention to the fact that this pupil's intelligence was of a quality inferior to his ''industry'' and ''scholarship''.)

In Table 12 a similar explanation is found in the detailed reports of the unusual ratings shown in the Table; for example, the one pupil whose I. Q. is given as within the range of 50-59 and was judged by his teacher to be in the average fifth of his class in ''scholarship'' and in the highest fifth of his class in ''industry''. Of the ten pupils, whose I. Q.'s were within the range of 120-129, seven were judged to be in the next to the lowest fifth in "industry", and three in the lowest fifth. All ten were judged to be in next to the highest fifth in "scholarship".

An analysis of Table 13 with the detailed reports of the teachers shows similar explanations for nearly all of the exceptional ratings varying in degree from only slight explanations to full explanations. For example, the one pupil, whose I. Q. is given as within the range of 120-129 and who was judged by his teacher to be in the average fifth of his class in "intelligence" and in next to the upper fifth in "industry" and in the average fifth in "scholarship", is either an anomaly, or a teacher has made a mistake in judgment, or he does not have the I. Q. indicated by the test. A number of instances, equal to eleven per cent of the total number similar to this one, have been found. They represent roughly the extent of the failure of the combined use of the teachers' judgments and intelligence tests in allocating pupils. These pupils are either misplaced or have been properly placed because of circumstances not revealed by the elements discussed in this study.

Our previous attempts to determine the relation between the use of intelligence tests as a method for measuring "intelligence" and the value of a teacher's judgment for this purpose indicated that there was only a slight correlation between the two methods. The number of individual variations in the two methods did not justify the statement that there was a close or even a fair correlation between them. The attempt just described, however, shows that there is a very close correlation between the two methods, when "intelligence" has been differentiated from other factors, such as "scholarship" and "industry". In our previous studies we were comparing the results of a measurement of intelligence only, with a measurement of intelligence plus industry, scholarship and other personal factors. We were comparing methods of measurements that could not be compared because they did not measure the same things. Our latest effort, however, indicates that the teacher's judgment and the intelligence test are comparable when applied to the same factors and that they do correlate to a high degree.

Tables 14, 15, 16, 17 and 18 indicate the distribution of all the pupils in the school, allocated on the basis of mental ability as determined by the intelligence tests and mental ability plus other significant factors as determined by the teachers' judgments. It is noted that there is a group of pupils, between the I. Q. range of 60 to 120, some of whom are in the retarded group, some in the normal group and some in the accelerated group. In a strict segregation into groups on an I. Q. basis alone, this would not happen, but where the judgment of the teacher is used as a partial basis for segregation the result is an overlapping of the groups as far as the I. Q. is concerned, due to the fact that the teacher observes certain facts about the pupils that the intelligence test does not reveal, and these facts are significant enough to make it wise to place some pupils in groups above their I. Q. rating and some below.

As far as intelligence is concerned, some pupils who might do well in an accelerated group apparently do only well enough to hold a place in a retarded group and conversely some, who, as far as intelligence is concerned, might be in the retarded group, are able (because of other personal qualities) to hold a place in an accelerated group. It seems obvious then, that while the intelligence test is reliable as an approximate measure of the mentality of groups of pupils, the teacher's judgment is indispensable to a more detailed and exact study of the group and of the individuals within the group. In other words, the results of the tests must be interpreted in the light of the teacher's judgment and not be held for the measurement of factors which they were not intended to measure.

CONCLUSIONS

1. Intelligence Tests should not be held responsible for testing anything but that for which they have been designed to test.

2. In judging intelligence only, care must be taken to differentiate it from other qualities.

3. The results of intelligence are, as far as scholarship is concerned, very much the same as the results of industry.

4. It is possible for a pupil with a high degree of intelligence and a low degree of industry to be outclassed by a pupil of a low or average degree of intelligence and a high degree of industry.

5. Teachers' judgments are essential to a proper interpretation of tests for determining the intelligence of their pupils where an attempt is made to segregate pupils on an ability basis.

6. Generally teachers' judgments and the results of intelligence tests do not correlate. This is true because generally a teacher's judgment of intelligence includes some other factors.

7. As a supplement to the judgments of teachers in the process of promoting and allocating pupils, intelligence tests intelligently given and interpreted are of very great value. To a school system where an attempt is made to allocate pupils on a basis of mental ability, they are indispensable.

TABLE I

GRADE 7A

Distribution of chronological ages, mental ages, total scores (Otis Intelligence Test) and Intelligence Quotient Equivalents. Selected on basis of teachers' judgment as bright or accelerated pupils.

Pupil's name	Chron. age	Mental age	Test score	Intelligence quotient
A	15-11	5-3	7	33
B	15-3	9-2	54	64
C	13-1	9-3	55	71
D	13-8	10-9	73	79
E	13-7	10-9	73	79
F	12-0	11-1	77	92
G	13-2	11-2	78	85
H	12-6	11-3	79	90
I	13-1	11-4	80	87
J	12-3	11-4	80	92
K	15-3	11-4	80	74
L	12-6	11-7	83	92
M	15-0	11-9	85	72
N	14-1	12-5	93	88
O	13-9	12-9	97	93
P	14-8	12-9	97	87
Q	14-5	12-10	98	91
R	13-1	12-11	99	98
S	12-4	13-0	100	105
T	12-7	13-2	102	104
U	11-7	13-2	102	123
V	13-2	13-3	103	100
W	15-7	13-3	103	100
X	13-6	13-3	103	106
Y	12-8	13-7	107	107
Z	11-11	13-8	108	115
a	12-1	13-8	108	113
b	12-10	13-10	110	108
c	12-2	14-2	114	116
d	13-1	14-3	115	109
e	12-3	14-7	119	119
f	14-2	14-8	120	104
g	13-0	14-8	120	113
h	12-4	14-9	121	119
i	14-2	14-10	132	105
j	13-0	15-0	124	111
k	13-4	15-0	124	113
l	12-2	15-1	125	124
m	14-8	15-2	126	97
n	13-7	15-2	126	112
o	12-9	16-3	139	128
p	14-2	17-4	152	122
Minimum	11-7	5-3	7	33
Median	13-1	13-3	103	103
Maximum	15-11	17-4	152	130

TABLE 2

GRADE 7B

Distribution of chronological ages, mental ages, total scores (Otis Intelligence Test) and intelligence quotient equivalents. Selected on basis of teachers' judgment as average or normal pupils.

Pupil's name	Chron. age	Mental age	Test score	Intelligence quotient
A	16-2	8-1	41	50
B	13-6	8-4	44	62
C	13-6	9-0	52	67
D	16-7	9-0	52	54
E	12-8	9-11	63	78
F	13-8	10-0	64	73
G	12-4	10-0	64	83
H	12-11	10-2	66	79
I	13-6	10-5	69	77
J	15-0	10-6	70	70
K	14-0	10-8	72	76
L	13-11	10-11	75	78
M	16-5	11-3	79	71
N	13-7	11-3	79	83
O	13-11	11-3	79	81
P	12-3	11-6	82	94
Q	14-6	11-8	84	80
R	12-4	12-1	89	98
S	16-5	12-1	89	68
T	14-3	12-5	93	87
U	16-3	12-5	93	76
V	12-11	12-6	94	97
W	12-8	12-7	95	99
X	13-9	12-7	95	91
Y	15-2	12-9	97	84
Z	12-5	12-11	99	104
a	14-1	12-11	99	92
b	15-3	13-2	102	92
c	13-0	13-3	103	102
d	15-5	13-3	103	86
e	15-10	13-4	104	84
f	14-3	13-4	104	94
g	13-11	13-5	105	96
h	15-10	13-5	105	88
i	15-0	13-5	105	89
j	13-0	14-2	114	109
k	13-9	14-4	116	104
Minimum	12-3	8-1	41	50
Median	13-11	12-1	89	84
Maximum	16-7	14-4	116	109

TABLE 3

GRADE 8A

Distribution of chronological ages, mental ages, total scores (Otis Intelligence Test) and intelligence quotient equivalents. Selected on basis of teachers' judgment as bright or accelerated pupils.

Pupil's name	Chron. age	Mental age	Test score	Intelligence quotient
A	14-0	10-10	74	77
B	16-6	11-5	81	64
C	14-3	11-10	86	77
D	13-6	12-3	91	91
E	13-8	12-7	95	92
F	14-3	13-0	100	91
G	14-3	13-1	101	92
H	14-4	13-8	108	95
I	14-11	13-8	108	92
J	13-8	14-0	112	102
K	14-7	14-0	112	97
L	13-0	14-3	115	110
M	14-0	14-4	116	102
N	13-9	14-5	117	105
O	13-1	14-9	121	113
P	13-8	14-9	121	108
Q	14-1	14-11	123	105
R	13-9	15-2	126	110
S	11-5	15-5	129	135
T	13-7	15-7	131	115
U	14-6	15-7	131	107
V	13-9	15-9	133	115
W	14-11	15-11	135	107
X	15-1	16-1	137	107
Y	12-5	16-1	137	130
Z	12-9	16-1	137	126
a	14-9	16-2	138	110
b	14-4	16-4	140	114
c	14-9	16-5	141	111
d	14-6	17-0	148	117
e	12-10	17-1	149	133
f	14-2	17-6	154	124
g	15-7	17-7	155	112
h	14-10	17-11	159	121
Minimum	11-5	10-10	74	64
Median	14-2	15-2	126	107
Maximum	16-6	17-11	159	135

TABLE 4

GRADE 8B.

Distribution of chronological ages, mental ages, total scores (Otis Intelligence Test) and intelligence quotient equivalents. Selected on basis of teachers' judgment as average or normal pupils.

Pupil's name	Chron. age	Mental age	Test score	Intelligence quotient
A	17-9	9-7	71	59
B	19-2	9-7	71	55
C	16-5	11-3	79	68
D	15-2	11-9	85	78
E	15-2	11-10	86	78
F	14-6	12-5	94	96
G	13-1	12-6	94	96
H	14-4	12-8	96	89
I	14-6	12-8	96	88
J	15-2	12-10	98	84
K	17-11	13-4	104	78
L	15-11	13-4	104	89
M	12-8	13-6	106	106
N	14-10	13-7	107	91
O	13-5	13-8	108	102
P	15-1	13-8	108	90
Q	14-3	13-10	110	97
R	13-8	13-11	111	102
S	14-10	14-5	117	97
T	13-8	14-8	120	107
U	15-11	15-0	124	94
V	18-0	15-7	131	87
W	15-5	15-8	132	102
X	13-7	15-9	133	115
Y	11-9	15-10	134	134
Z	13-7	16-0	136	111
a	16-2	16-2	138	100
b	14-8	17-6	154	120
c	13-7	17-6	154	129
d	15-5	17-11	159	116
e	12-7	18-7	167	148
Minimum	11-9	9-7	71	55
Median	14-10	13-8	108	96
Maximum	19-2	18-7	167	148

TABLE 5

GRADE 8C

Distribution of chronological ages, mental ages, total scores (Otis Intelligence Test) and intelligence quotient equivalents. Selected on basis of teachers' judgment as slow or retarded pupils.

Pupil's name	Chron. age	Mental age	Test score	Intelligence quotient
A	17-8	8-4	44	47
B	16-7	9-4	56	51
C	16-6	9-6	58	58
D	16-2	9-11	63	61
E	15-1	10-9	73	71
F	18-9	11-0	76	54
G	16-6	11-4	80	63
H	13-8	11-6	82	77
I	17-6	11-7	83	61
J	14-9	12-4	92	84
K	14-7	12-6	94	86
L	16-9	12-7	95	75
M	16-4	12-8	96	78
N	16-4	12-10	98	79
O	14-11	12-10	98	88
P	15-2	12-11	99	85
Q	14-4	13-2	102	92
R	15-4	13-5	105	87
S	16-9	13-6	106	81
T	14-4	13-11	111	97
U	14-6	14-1	113	97
V	12-1	14-4	116	117
W	15-8	14-5	117	94
X	13-2	14-6	118	110
Y	13-6	14.8	120	109
Z	13-9	14-8	120	107
a	15-8	14-8	120	94
b	15-6	14-10	122	96
c	17-5	15-1	125	87
d	16-3	15-2	126	93
e	14-3	15-2	126	107
f	15-5	15-7	131	101
g	16-0	16-0	136	100
h	13-4	16-0	136	120
i	14-8	16-7	143	113
j	16-1	16-8	144	103
k	15-0	16-8	144	112
l	13-11	17-9	157	128
m	13-5	18-0	160	134
Minimum	12-1	8-4	44	47
Median	15-4	13-11	111	91
Maximum	18-9	18-0	160	134

TABLE 6

GRADE 9

Showing the distribution of chronological ages, mental ages, total scores (Otis Test) and intelligence quotient equivalents of all pupils in grade 9, (1920). These pupils are selected on the basis of a combination of the results in Otis intelligence tests and the teachers' judgment as the lower half of grade 7 (1918) to go on with Junior High 8th grade work, the upper half to be known as grade 9, effecting the change from the 7-4 plan to the 6-3-3 plan. For distribution in upper half of grade 7, (1918) see table 7, being grade 10 (1920).

Pupil's name	Chron. age	Mental age	Test score	Intelligence quotient
A	16-9	10-4	66	61
B	16-7	11-8	74	72
C	17-6	11-10	86	67
D	14-2	11-11	87	84
E	15-11	12-0	88	75
F	17-3	12-9	97	74
G	15-5	13-1	101	85
H	17-5	13-3	103	76
I	16-0	13-3	103	83
J	15-11	13-3	103	83
K	14-3	13-4	104	94
L	15-7	13-6	106	87
M	14-1	13-6	106	96
N	17-11	13-7	107	76
O	16-6	13-9	109	83
P	14-10	13-9	109	93
Q	16-4	13-11	111	85
R	17-5	14-2	114	81
S	13-10	14-2	114	102
T	15-9	14-3	115	91
U	14-8	14-5	117	98
V	14-1	14-5	117	102
W	16-2	14-7	119	90
X	18-6	14-7	119	79
Y	15-4	14-9	121	96
Z	16-5	14-10	122	91
a	15-11	14-10	122	93
b	17-5	14-11	123	85
c	18-11	15-0	124	79
d	13-7	15-1	125	111
e	15-4	15-2	126	99
f	16-3	15-2	126	94
g	16-10	15-3	127	91
h	16-4	15-7	131	95
i	17-6	15-8	132	90
j	14-9	15-9	133	107
k	17-5	16-8	144	96
l	12-2	19-1	173	157
Minimum	12-2	10-4	66	61
Median	16-1	14-3	115	90
Maximum	18-11	19-1	173	157

TABLE 7

GRADE 10

Showing distribution of chronological ages, mental ages, total scores (Otis Test) and intelligence quotient equivalents of all pupils in grade 10, being same pupils as were selected as upper half of grade 7 (1918) to go on with high school work to be known as grade 9 (1919), grade 10 (1920) etc.

Pupil's name	Chron. age	Mental age	Test score	Intelligence quotient
A	19-6	12-3	91	63
B	15-2	13-1	101	86
C	16-7	13-3	103	76
D	16-5	13-9	109	88
E	17-11	14-6	118	81
F	13-1	15-0	124	115
G	17-2	15-3	127	84
H	16-5	15-3	127	92
I	16-2	15-3	127	94
J	13-11	15-3	127	115
K	15-3	15-3	127	100
L	16-0	15-4	128	96
M	14-9	15-6	130	105
N	18-4	15-8	132	85
O	15-0	15-9	133	105
P	15-5	15-10	134	102
Q	16-0	16-0	136	100
R	16-10	16-0	136	95
S	14-10	16-1	137	108
T	17-4	16-2	138	93
U	15-4	16-2	138	105
V	15-11	16-3	139	102
W	15-1	16-3	139	107
X	15-1	16-3	139	107
Y	13-7	16-5	141	121
Z	18-8	16-8	144	89
a	14-7	16-9	145	115
b	18-10	16-11	147	90
c	13-7	17-5	153	128
d	15-2	17-5	153	115
e	15-1	17-5	153	115
f	13-8	17-6	154	129
g	16-2	17-7	155	109
h	15-3	17-10	158	117
i	17-2	18-0	160	105
j	14-10	18-1	161	121
k	16-8	18-2	162	109
l	16-2	18-2	162	112
m	13-4	18-3	163	137
n	14-4	18-6	166	129
o	14-10	19-7	179	131
p	15-11	20-5	189	128
Minimum	13-1	12-3	91	63
Median	15-5	16-3	139	105
Maximum	19-6	20-5	189	137

TABLE 8

Grade	Accelerated			Normal			Retarded		
7	Minimum	I. Q.	33	Minimum	I. Q.	50	No group		
	Maximum	I. Q.	130	Maximum	I. Q.	109			
	Median	I. Q.	103	Median	I. Q.	84			
8	Minimum	I. Q.	64	Minimum	I. Q.	55	Minimum	I. Q.	47
	Maximum	I. Q.	135	Maximum	I. Q.	148	Maximum	I. Q.	134
	Median	I. Q.	107	Median	I. Q.	96	Median	I. Q.	91
9	Minimum	I. Q.	63	Minimum	I. Q.	61	No group		
	Maximum	I. Q.	137	Maximum	I. Q.	157			
	Median	I. Q.	105	Median	I. Q.	90			

Summary of tables 1, 2, 3, 4, 5, 6, 7, showing minimum, maximum, and median intelligence quotients of pupils selected by teachers as belonging to either accelerated, normal or retarded groups.

TABLE 9

Showing the scores on * Test G-1 and on Test G-2 received by first grade pupils who were judged by the teachers to be of average intelligence—receiving grade C by teachers.

	Numbers whose scores indicated intelligence that of					
	Lowest fifth *	2d fifth	Middle fifth	4th fifth	Highest fifth	Total
Test G-1 (numbers).......	12	9	9	9	7	45
Test G-2 (numbers).......	8	6	13	8	10	45
Test G-1 (per-cent).......	26.7	20.0	17.8	20.0	15.5	100.0
Test G-2 (per-cent).......	17.8	13.3	28.9	17.8	22.2	100.0

* Series I Dearborn Group Tests of Intelligence.

* TABLE 10

Showing the correlation between (a) the intelligence of pupils as measured by the Stanford-Binet Intelligence Tests, given in terms of the Intelligence Quotient (I. Q.) and (b) the teachers' judgments concerning the pupils' intelligence, (given from E lowest to A highest). 130 cases.

Read as follows:

Of pupils having intelligence quotients between .50 and .55, two were judged by teachers to be in the lowest fifth of their classes, in intelligence. Of pupils having intelligence quotients between .56 and .60 one was judged by the teacher to belong in the lowest fifth of the class and one was judged by the teacher to belong in the next to the highest fifth. Of eleven pupils who had intelligence quotients between .61 and .65 three were judged to belong to the lowest fifth, three to belong to the next to the lowest fifth, three were judged to belong to the

* Educational and Psychological Tests in the Public Schools of Winchester, Va., University of Virginia Record Vol. 6, No. 6, January, 1922.

middle fifth, one was judged to belong to the next to the highest fifth, and one was judged to belong to the highest fifth.

Intelligence quotient	Teachers' judgments E	D	C	B	A	Total
50–55	2	..	..	..	..	2
56–60	1	..	..	1	..	2
61–65	3	3	3	1	1	11
66–70	1	5	2	..	..	8
71–75	2	7	3	1	..	13
76–80	3	4	4	..	..	11
81–85	2	4	7	5	2	20
86–90	1	5	3	3	..	12
91–95	1	4	2	1	1	9
96–100	1	3	2	5	2	13
101–105	..	1	1	1	1	4
106–110	..	2	1	2	1	6
111–115	1	..	1	2	3	7
116–120	..	..	..	2	1	3
121–125	..	..	..	..	2	2
126–130	1	..	..	..	1	2
131–135	..	..	..	2	1	3
136–140	..	..	..	..	..	...
141–145	..	..	..	..	..	...
146–150	..	..	..	..	1	1
151–155	..	..	..	1	..	1
Totals	19	38	29	27	17	130

TABLE 11

A Comparison of an Allocation of ACCELERATED Pupils According to I. Q.'s and According to Teachers' Judgments

I. Q.	Number of pupils in Lowest fifth of class	Next lowest fifth of class	Middle fifth of class	Next highest fifth of class	Highest fifth of class	Total
Below 50	0	0	0	0	0	0
50–59	0	0	0	0	0	0
60–69	0	0	2	0	0	2
70–79	1	3	5	2	3	14
80–89	0	7	20	15	4	46
90–99	0	5	27	31	14	77
100–109	0	2	36	54	13	105
110–119	1	4	30	34	21	90
120–129	0	0	5	24	14	43
130–139	0	0	3	6	10	19
140–149	0	0	0	2	4	6
Over 149	0	0	0	0	2	0
Totals	2	21	128	168	85	404

TABLE 12

A Comparison of an Allocation of NORMAL Pupils According to I. Q.'s and According to Teachers' Judgments

I. Q.	Number of pupils in					Total
	Lowest fifth of class	Next lowest fifth of class	Middle fifth of class	Next highest fifth of class	Highest fifth of class	
Below 50	0	0	0	0	0	0
50–59	0	0	1	0	0	1
60–69	0	6	6	2	0	14
70–79	1	11	22	7	0	41
80–89	1	18	55	25	0	99
90–99	2	14	60	26	3	105
100–109	0	8	36	21	3	68
110–119	0	3	10	9	3	25
120–129	0	0	2	5	3	10
130–139	0	0	0	0	0	0
140–149	0	0	0	0	0	0
Over 149	0	0	0	0	0	0
Totals	4	60	192	95	12	363

TABLE 13

A Comparison of an Allocation of RETARDED Pupils According to I. Q.'s and According to Teachers' Judgments

I. Q.	Number of pupils in					Total
	Lowest fifth of class	Next lowest fifth of class	Middle fifth of class	Next highest fifth of class	Highest fifth of class	
Below 50	3	2	5	4	0	14
50–59	3	12	5	2	0	22
60–69	4	13	7	3	0	27
70–79	9	35	32	4	0	80
80–89	3	41	38	2	0	84
90–99	0	15	17	10	0	42
100–109	0	6	15	2	0	23
110–119	0	0	3	2	0	5
120–129	0	0	1	0	0	1
130–139	0	0	0	0	0	0
140–149	0	0	0	0	0	0
Over 149	0	0	0	0	0	0
Totals	22	124	123	29	0	298

TEACHER'S ESTIMATE—PUPIL ABILITIES
November, 1921

Last Name, First Name	Age	Grade	Years in school	Scholar-ship	Intelli-gence	Indus-try

IS EDUCATIONAL RESEARCH YIELDING APPROPRIATE DIVIDENDS?

WALTER S. MONROE, UNIVERSITY OF ILLINOIS

It may perhaps appear suggestive of heresy to announce a title which raises the question of the value of educational research, but the experience of several years devoted largely to this field and my contacts with other investigators have convinced me that this is a question of vital importance. About ten years ago there began to be established in colleges and universities explicit organizations for the avowed purpose of conducting educational research. Several of these research organizations now enjoy liberal appropriations for this work. Somewhat similar research departments have been established in a number of public school systems. At the present time the number of such organizations in existence is probably one hundred. In addition there are a large number of workers who are carrying on educational research as personal projects. The Commonwealth Fund, General Educational Board, and other educational foundations are making generous donations to both individuals and research bureaus. The total annual expenditure for educational research is unknown, but undoubtedly it amounts to several hundred thousands of dollars.

The amount of educational research is also indicated by the large number of published reports. In the advance sheets of the biennial survey of education for 1920-22, a summary of certain phases of educational research for that period includes bibliographies totaling 518 titles. School surveys and mental tests are not included. Furthermore, it is announced that only the principal contributions are given in these bibliographies. Beginning in 1917, the Bureau of Educational Research at the University of Illinois has compiled a list of masters' and doctors' theses in Education. Although the compilations are not complete, as all the institutions have not reported their titles, 410 doctors' and 1896 masters' theses have been listed during a period of six years. All doctorial dissertations are expected to be significant contributions to our knowledge about education. Many masters' theses make minor contributions.

What are the net results of all this activity? What additions have been made to our knowledge of education? What has been the effect of educational research upon school practice? Are we developing a group of competent and reliable research workers? Is the work being done increasing in quality as well as in amount? What has been the effect of educational research upon the attitude of teachers and of others not engaged in carrying on investigations? It would be presumptious for me to attempt a final answer to these questions, but a number of facts which have seemed significant and perhaps indicative of a general trend have recently come to my observation. Some of these facts I shall pass on to you with the hope that I may stimulate you to think about some vital questions. In the time at my disposal, I propose to cite illustrations of four sources of waste in educational research.

In a doctorial dissertation recently accepted and published by one of our foremost graduate departments in education, the investigator set for herself the problem of making an inventory of the content of the minds of children of six and seven years of mental age. Obviously the first step in dealing with this problem was to locate a representative group of children whose mental ages fell in the interval from six years and no months to seven years and eleven months. This was done by administering the Stanford Revision of the Binet Test to certain groups of children. Later they were given also the Herring Revision of the Binet Test. The average of the two measures was used as the criterion of mental age, although the results of the second test do not appear to have been used in determining what children should be chosen for the investigation. For reasons which are not made clear in the report, the investigator later administered four group intelligence tests and eleven specialized individual tests, and calculated from the scores thus obtained a number of coefficients of correlation and regression coefficients.

A careful reading of the monograph fails to reveal any use which was made of the additional data secured from these tests or of the derived measures which were calculated from the resulting scores. Two tables of coefficients of correlation are presented with the statement that the relations and inter-relations shown are "food for thought," but the report contains little or no evidence that the investigator made any effort to masticate or digest this "food." In fact, it is difficult for the reader to conceive how these correlations might have contributed to the study of the problem under consideration. One gets the impression that the giving of the tests and the subsequent calculations are for ornamentation rather than for any useful purpose. If one may be permitted to read between the lines, he might say that the investigator or her advisers believed that an acceptable doctorial dissertation must contain some coefficients of correlation and statistical formulae, and that in this case these features were added somewhat as an afterthought in order to meet these requirements. At least the reader cannot escape the conviction that the returns upon a certain portion of the investment in this investigation yielded only very meager returns if any at all.

It is not always possible for an investigator to estimate correctly in advance the value of all data collected, and of the calculations which he may make. There will necessarily be some scrapping of material in pioneer work, but this published report has been described as illustrative of a source of waste in educational research which unfortunately is more prevalent than seems to be justified. A careful definition of the problem and a strict adherence to the limitations of this definition will result in a mental reduction in the amount of useless data collected and tabulated.

The writer of a recent article gave a tabulation of the intelligence quotients derived from a group intelligence test. Several of the I. Q.'s were so low and others were so high as to suggest the presence of errors in the scores from which they were calculated. In the original article no mention had been made of this possibility, but a few months later a criticism was published in which the point was made that the investigator should have considered these limitations in preparing his report of the study. In a reply the author of the original article criticised his critic. Among other things he said, "Nor can there be any question about the reliability of gathering the data. The tests were given by two experienced examiners and scored by trained scorers under supervision."

This statement expresses what appears to be a prevalent attitude toward the measures yielded by standardized educational tests. If the tests were administered by experienced examiners and if there is reason to believe that no errors were made in marking the test papers, then the scores may be considered accurate measures of the traits or abilities which the tests were designed to measure. If specifically interrogated, most test users would probably admit that our present standardized tests are imperfect, but a large number disregard possible limitations when they are using these instruments of educational research. Variable errors are always present in test scores and constant errors are frequently introduced even when the tests have been carefully administered. Critical studies of standardized tests have demonstrated that the possibility of errors in test scores is sufficiently great to make the investigator assume the responsibility for proving that his data are accurate when there is any reason for suspicion. Failure to do this means that the investigator is building upon a suspicious foundation which may result in the collapse of his conclusions. The conclusions reached by educational research cannot be more dependable than the weakest step in the study.

In view of the frequent failure of investigators to be critical of their data, it is then not inappropriate to raise again the question, "Are we receiving adequate dividends for the time and money which is being invested in educational research in the United States?"

There are literally hundreds of persons putting time and money in educational research, but with few exceptions they are working independently and with little reference to what other workers have already done. If one examines the voluminous literature in the field, he will find relatively few attempts to summarize and organize previous contributions. As a result there are several sources of waste. Most of the educational research which has been done is fragmentary. The studies have been based upon too few cases, or have included only minor aspects of the problem, or have not been carried on long enough to lead to dependable conclusions. Because it is fragmentary much of this work will naturally be lost unless steps are taken to conserve it.

Cooperation has been urged as a means of coordinating and unifying educational research. Workers within certain areas have formed associations and provided facilities for exchanging information in regard to the problems which they are studying or which they expect to study sometime in the future. In this way they believe that duplication of effort can be avoided, or at least minimized, and that when two or more persons are engaged in studying the same problem or related problems, cooperation is mutually advantageous. Some leaders have taken the initiative in organizing those interested in a particular field into a cooperative group and have claimed that such pooling of abilities and resources will result in superior work.

In certain types of studies, cooperation in the form of assistance is necessary and in other cases it has doubtless been beneficial, but it will not correct certain wasteful tendencies. This can be accomplished only by changes in the attitude and interests of those engaged in educational research. Instead of emphasizing "original" research they must develop an interest in studying, in summarizing and in organizing the published reports of the work of others. In my experience with graduate students, I have found them much more eager to attempt an "original" study than to inquire into what has already been done. Recently I inquired of the departments offering graduate work in education concerning the types of theses which they urged students to undertake, or which they found most satisfactory. "Summaries of other investigations," were reported as being among the least satisfactory types of theses. On the other hand, the types most frequently mentioned as being encouraged, or considered most satisfactory, included original investigations, surveys of a school system, or causal investigations. The popularity of such studies appears to be due to the ease with which they may be made; and the unpopularity of a summary of the work of others is due in part to the fact that such work is difficult and when well done requires a higher degree of ability. One of my correspondents made this illuminating statement, "According to present-day standards anything with tables and statistics seems to be most satisfactory. It is questionable, however, whether they really mean very much in most cases."

The prevailing attitude is reflected also in the preference for studies involving the use of a questionnaire, or of standardized tests rather than for those based upon data to be found in records or published sources. In far too many cases this preference is indicative of mental laziness. It is easy to ask questions for other people to answer. It is also easy to administer a standardized test. No particular ability or acquaintance with the field of education is required to do either of these things. Frequently I have received a number of questionnaires calling for information which was available in reasonably accessible published sources. These questionnaires have come not merely from graduate students who might have been unacquainted with the field, but in some cases from men who were acknowledged leaders and who have been identified with educational research for many years.

I do not wish to be understood as condemning the questionnaire as an instrument of research. Its use is inevitable for certain types of studies and there will always be occasions when a questionnaire will be appropriate, but I am citing the misuse of it as evidence of an undesirable attitude on the part of what I fear is a large number of persons. They seem to be most interested in doing something that will attract attention because of some special feature or of its newness rather than in making comprehensive and permanent contributions to our knowledge of education. Until there is a changed attitude with reference to the purpose and ideals of education research, and I am convinced that the responsibility for this change rests with those of us who are college teachers of education, most of our research will be fragmentary with resulting waste. As long as present conditions prevail we should ask ourselves, "Is educational research paying appropriate dividends upon its investment?"

When the proposal was first made that mooted questions relative to school practice could be answered by scientific methods, there were many unbelievers. For years the conservatives far outnumbered the progressives, but gradually the skeptics have been converted to the belief that educational experimentation is possible. Today these same people are among those who are accepting the fragmentary and imperfect findings of educational research as comprehensive and final. It is not at all unusual for a person who avows a belief in educational research to make dogmatic endorsements of the results of studies which meet few if any of the requirements of scientific procedure. For example, a teacher in a certain city school system recently asserted that the teachers of that system had solved the problem of constructing a curriculum in history. It was obvious that this teacher believed the work was finished and, because methods called scientific had been used, nothing more was to be said in the matter. This is not an isolated case, but unfortunately it is typical of the attitude of many toward educational research.

As I talk with superintendents and others, including university professors, who have not had intimate experience with educational research, I am surprised and distressed by their childlike faith in the conclusions based upon very imperfect studies. It appears that in our effort to convert those who hesitated to believe in educational research as a means of answering questions that we have overdone the matter. The possibilities of educational research have been advertised, and like all good advertisers we have extolled the good features and have failed to mention the limitations, or if mentioned we have suggested that they could easily be overcome. The result of our selling campaign begins to be apparent. In general, educational research may be said to be sold to the public and to the greater majority of teachers and administrators, but educational research itself is failing to deliver the goods. There is being engendered a dogmatism which will exert a deadening influence upon our efforts to study educational problems scientifically. Again we may appropriately ask ourselves the question, "Is educational research yielding appropriate dividends upon its investment?"

This recital of waste in educational research might be greatly extended, but perhaps enough has been said to demonstrate that the title of my paper represents a very real question. There are those who are watching educational research to see what we make of it. Some day they will say, "What have you given in return for the generous investment which has been made in your work? Exactly what have you discovered about education?" They will expect an answer, not in terms of possibilities but of findings which may be considered as conclusive. They will not be satisfied with results that are merely fragmentary. When that day comes we shall need to be able to show that educational research has yielded and will continue to yield adequate dividends upon the investment. At the present time we may point with pride to certain notable achievements, and there is rapidly accumulating a commanding body of scientific information about education, but a few notable achievements will not be accepted as sufficient evidence that the present confidence and support of educational research should be continued. In closing, I command to your earnest consideration the question with which I started. A thoughtful reading of even a small portion of the published results of educational research will furnish much "food for thought."

PAPERS ON HIGH SCHOOL SCIENCE

THE ORGANIZATION OF A SCIENCE CLUB

Raymond Lussenhop, Bowen High School, Chicago

The remarkable success of the Bowen Bird Boosters cannot be accounted for by the location of Bowen High School in the great Calumet district, where the students are accustomed to see smoke stacks instead of trees. To find the reasons for success, then, we must inspect the organization, the activities, and the policies of this science club.

Science teaches us accuracy, conciseness, and clearness. Why should its clubs not follow this trend? The purposes of this club are very plainly defined in the constitution, which states: "The objects for which this club are formed are: (1) to study birds; (2) to protect the birds; (3) to attract birds around our school, in our parks, and about our homes; (4) to subscribe for current bird literature and to support the Audubon Society both financially and with our influence".

"The officers of the club shall consist of a president, a vice-president, a secretary, and a treasurer." By an unwritten law, the president and the treasurer are always boys; the vice-president and the secretary are always girls. These officers are elected every spring. They must be members of the Zoology classes of that year and must be sophomores. The officers cannot be re-elected. This prevents a small group from getting and keeping control, a deadly mistake in any organization.

The membership is limited to those students who have taken or are taking bird study in the Zoology classes. At present the membership is 275. At the end of each year, all old members are dropped unless they retain their membership by the payment of their dues. For the first year the dues are 35 cents; for each year after the first, Juniors, 10 cents; Seniors, 5 cents. Seniors and Juniors taking Zoology are eligible for membership but not for holding office. Faculty members may be admitted to membership only on the recommendation of a student member of the club. The discussion and the vote on this prospective member must be held in secret, no member of the faculty remaining in the room while the students discuss or vote on such a motion. Faculty membership is only honorary, as the voting privilege is withheld. We have 13 at present.

Of course, the most important activities of such clubs are their meetings. During the fall term, the Bowen Bird Boosters hold their meetings once a month; during the spring term, once every two weeks. The programs for these meetings are always posted a week in advance and are centered around a certain topic. For instance, a program will be centered around pigeons, or bird pests and their control; our game birds; migration, etc. At least two musical numbers are rendered but such numbers are always kept from being the most prominent part of the program. Every student taking part in the program must be a member of the club. This rule is inflexible.

Regular meetings are never allowed to become social gatherings; but an annual picnic held once every spring in some forest preserve, which can be reached by truck, is especially for fun. Our largest social affair, a fine program and dance, was given on our tenth anniversary. Even at this affair, attended by about 400 members, many belonging 10 years back, the program was entirely a student affair. The constitution does permit prominent men who are interested in birds to appear on programs, such as game wardens, museum workers, etc., men who are able to give interesting talks.

The policy kept in mind concerning programs is : (1) a program should never fail. If the program is made a farce, if the dignity of the occasion is forgotten for one moment, the program is a failure. It may amuse, it may even instruct, but its negative result is very serious, for each time a program falls through more students will lose interest and the club loyalty will lag; (2) all students scheduled for appearance must be present at the meeting and no excuses excepting those of sickness are accepted. In 10 years we have had but two failures to report; (3) to give real information. In order to obtain the best results, all reports are prepared under the guidance of the faculty adviser. Students in the first two years of high school have not, as a rule, had much training in outlining material. The faculty adviser sees that each student understands clearly his subject and that he knows which points are most important. In this way, the students gain confidence and can appear before the club with poise and dignity.

Another activity which deals directly with bird study is that of the bird identification lists. Three records are kept, the individual, the class, and the club. The individual record is kept by the student, on which he records all the birds he identifies on his bird hikes, or that he sees on his way to school. Spaces on these lists must be filled out as to the date, the bird's name, whether single or in flocks, place where seen, and what the bird is doing. The faculty adviser checks these lists from time to time, and corrects any mistakes. The class list is posted on a bulletin board, and if a student has identified ten birds, a red star is placed after his name; if 25, a silver star; if 50, a gold; if 100, a blue bird. This arouses enthusiasm in each class. On the third record which is furnished by the Illinois Audubon Society, the bird names are already printed with blank spaces in which the name and date of the first observer may be written. This arouses the keenest competition. These lists are of the most practical value in making the students familiar with our more common birds. For this work, the Reed bird guides are indispensable.

After careful analysis and consultation with some of our student members, I have come to the conclusion that the keystone of success of such a club does not rest so much in the organization or activities but in the wisdom of the relation of the faculty adviser and the faculty members to the students. In the first contact that students have with our club adviser the policy is clearly shown. When the incoming members begin their election campaign, no hints or suggestions are thrown out about who would make good officers, so that the students feel almost forced to elect the adviser's choice. Such a choice is left entirely to the students. Moreover, the faculty adviser promises to work cheerfully with their choice no matter if she does not approve entirely of the student put into the position. No requirement in the way of scholarship is demanded; just good, all-around fellows the students admire. And in the ten years, not a set of officers has failed. The students know who is who, and no year is going to see its officers disgrace the Bowen Bird Boosters. It is an honor to be elected to office, and every fellow is determined to do his best if given that honor by fellow students.

The merits of the many forms of student government are still under discussion. It is plainly a fact, however, that when students are told that a club is theirs and theirs alone, they want that club to be the students' in fact and not only in theory. The wise faculty adviser must always remember that she is an adviser and not a president of that club. The officers should be confident of the teacher's ability and support. They should regard her as a friend when in office and as a teacher in the class room, relations which are very different. When high school students want their student organizations to be managed by students, many teachers seem to misunderstand. Students do not want the faculty advisers to sit back and say, "All right, if you want to run your own organization we will have nothing to do with your affairs." Students simply mean that they want cooperation on both sides. The faculty adviser should look after affairs as to preparation and advice and the students should carry such affairs out in their own ways and methods. Teach principles, and let the students apply them.

If science teachers really wish to humanize and make science work more practical, what better means could be found than a science club? But it takes time; in the case of the Bowen Bird Boosters it has taken ten years to build up a set of policies and principles making cooperation secure. If the faculty advisers wish to manage the business, if they wish to appear on programs, and if they desire to be conspicuous for their work, they cannot make students believe it is a students' club. The adviser's praise must be the club's growth in strength and influence. If the adviser disregards personal prejudices and treats students as equals in the same club, and if the club is founded and run on principles of student democracy, success is bound to result.

Not a great deal of business is necessary in such an organization, but that which is, must be handled in a business-like way. Our secretary's book contains the record of every meeting and event for the entire ten years. The treasurer's book and the accounts for the same are audited twice a year by the president and the faculty adviser. These are open at any time for the inspection of the members. Develop some traditions to bind the successive years together. We have a standard pin; each year the club subscribes for the magazine "Bird Lore" for the next year; each year the club leaves a present for the laboratory. The ten years have built up a bird-bath fund of $75.00. This bath will be cast this summer and placed in our school yard.

HOW CAN WE HUMANIZE THE GENERAL SCIENCE COURSE?

Superintendent M. P. Mitchell, Hampshire Township High School

Upon first attacking this subject one might be tempted to say that such a course does not need to be humanized; that all science, especially General Science which perhaps at best scratches only the surfaces of the special sciences, is in itself a humanized subject. Without doubt those science teachers present feel in regard to this subject that personally the subject is all of that to them. We have, however, to look at our classes to find some who have not found this subject to mean the same to them as we may have hoped. To me, the question confronting the teachers of this course is not so much the one of "Making the General Science Course Humanized" as it is of "Keeping the Course Humanized". There is no other subject in the Curriculum of the High School which should appeal more to the human curiosity and inquisitiveness than the General Science course.

The problem of keeping the course humanized or vitalized seems to be two-fold in nature. The first task of the teacher is to use only those methods of teaching which will appeal to the adolescent child before him. An analysis of my own teaching together with a recent survey of several schools clearly indicate that the most interest on the part of pupils is aroused through the laboratory work. This, then, should play an important part in the teaching program. The laboratory work may be administered in a number of different ways. In my first class in General Science I believe that I performed fully ninety per cent of the experiments for the class, permitting them to look on. Such a procedure did not satisfy the class or prove to be good teaching. I have completely changed my methods since that first teaching. I prefer to have my class perform as many individual experiments as time and other conditions permit. Next to this I prefer to have the class working in groups sufficiently small, so that every member of the group has an active part in the performance of the experiment.

Certainly the results obtained are more accurate when I personally carry on the experiments, but such results mean less to the members of the class. I much prefer the use of simple home-made apparatus to the elaborate and often expensive apparatus used in the more advanced science courses.

Too much emphasis cannot be laid upon class excursions or field trips. In addition to stimulating interest and providing a change in the regular routine of class work, such trips take the student to the right place to study science, that is, where nature has provided it. The class room with its artificiality does not often furnish the most suitable environment for teaching. True, most of the time must be spent there, but every opportunity should be taken to conduct the class work elsewhere.

In the class room itself much may be done to vitalize this subject. A regular routine question and answer method three times a week in the recitation room has been responsible for the waning of interest and enthusiasm on the part of the pupils. A little variety in the program not only appeals to the rather restless adolescent boy or girl but also gives to the careful teacher the key to the interest of the members of the class. The work may be varied in a number of ways. Special reports are always well liked. These subjects may be definitely assigned or left for personal selection by members of the class. Lectures or talks by the instructor or other people of the community may be used occasionally to advantage.

I believe that I have found nothing that appeals more to the child taking the science course than a definite personal problem for him to work out. The possibilities of such problems are unlimited in almost any community. Some may be wholly individual problems and others general or community problems: e. g.—

1. How much oxygen should be supplied to the class room per hour?

2. How much fertilizer will be needed to take the place of 1,000 bushels of corn sold *off* a farm?

3. What would be a good economical diet for a boy or girl of your age?

A few magazines are practically indispensable to the General Science course. I doubt if I would consider teaching another General Science class without the magazines listed below.

1. Popular Science Monthly.
2. Nature Magazine.
3. Hygiea.

In addition to these publications there are numerous exhibits prepared by various commercial companies, also pamphlets, circulars and bulletins. Perhaps the best supplementary material is to be found when conditions permit the use of a motion picture projector. Visual education has come to stay and when it is impossible to take the class to the subject under study, a very satisfactory substitute may be made by bringing films and slides to the class. The large number of companies producing educational films makes it a relatively easy matter to secure suitable films at small expense.

A feature of the work that I have found to be worth while during the present year is a Science Scrap Book. For this the children are asked to cut clippings, pictures, various kinds of specimens, etc., classify same and put in a book which they may keep. This encourages them to read, to observe carefully and in general ties up the science course with their daily life.

A Science Club presents many possibilities for humanizing the work in General Science. I regret to report that I have never seen my way clear to organize such a club as the time seemed well taken up with supervision, athletics, etc. The arguments however are all in favor of such a club providing the proper supervision and help can be given.

If this course is to be successfully humanized, the second task of the teacher is to eliminate undesirable elements. In addition to the elimination of the formal question and answer type of recitation, two other changes may be profitably made. Too often the beginning science course is made a one text book course. While there are several very good text books on this subject, and permit me to say that I personally consider our friend, Mr. Hessler's book to be the best on the market, yet the science work will mean more to the class when several reference books are regularly used. It is not enough for a child to see a statement in one text book and accept the same for gospel truth without getting the opinions of several authorities upon the same topic. The more reference material used the more the course will mean to the class.

Without question the one feature of the science work most disliked by all the class is the note book work in connection with the laboratory experiments. Why should we as teachers demand so much from these beginning science students? Is it a natural condition to report in written form every important change or incident noted in Nature? Why then subject the child to the mental torture of this routine work? In several cases I find that the note book work must be done outside the regular laboratory. Heavy note book work soon becomes a drag upon the students with the result that all of the science work becomes distasteful, and enrollment in other science courses discouraged because of this one disagreeable factor. Of course some note book work should be given, but ample time should be provided in the laboratory period for such work. Only the most important experiments should be written up. There seems to be no good reason why the note book work could not be incorporated as a part of the English work. Apparently Freshmen in High School should be able to apply as much of their instruction in paragraphing, punctuation, vocabulary, etc., in the laboratory note book as in short stories, which usually accompanies the work in English.

What, then, are to be the aims of the General Science course? It might be inferred that the student is to be amused, his curiosity aroused and then be left to wonder why he has taken this particular course. One of my early science instructors made the statement that science seeks to know the "Hows" and "Whys" of nature. I believe this is not sufficient in itself. There are two other very important factors to be considered in successful teaching of science. They are, first "Where" and second, "How does this affect my life?" This last phase is perhaps the most important, and should not only serve to arouse permanent interest in the various fields of science, but should also encourage individual thinking on the part of every boy and girl enrolled in this subject.

HOW CAN WE HUMANIZE HIGH SCHOOL SCIENCE?

CLARENCE BONNELL, HARRISBURG TOWNSHIP HIGH SCHOOL

BIOLOGY

Biology in many of our high schools has more or less the reputation of being one of the useless subjects. The popular characterization of the biology instructor with his eye-glasses, miscroscope, and butterfly net is often the counterpart of what parents and practical people in general think of a biologist. He is often considered a heretic religiously, especially in these days of fundamentalism and Bryanism. The writer has been the subject of prayers and warnings from the pulpit of a devout Southern Baptist pastor in a nearby village, from which some of his pupils have come; and a good Methodist brother in the home city has warned his Sunday school class against ever taking this damnable course in high school.

But for the fact that biology has gotten a "toe hold" in our high school course during twenty years of tactful handling of delicate questions, it would possibly be omitted now. I am glad to say that the classes are crowded and some have to be turned away each year. We think this is because the subject matter is made to connect so closely with the very life activities of those who take it, that they pass the word along to others the next year, for the course is an optional one.

Except for those who have actually had the course, or learn of it from their friends, it is considered a fad,—an impractical thing with no useful qualities such as are always associated with commercial courses, the manual and domestic arts, mathematics, physics, chemistry, or even dead languages, literature, or history. This mental attitude has resulted in turning biological subjects toward so called practical ends, such as agriculture and domestic science, so that true biology courses which give an organized account of the life processes of plants and animals have been quietly and gradually dropped from many high schools.

Such an attitude of opposition and indifference results largely from the sort of biology teaching had in the past. Too many high school biology instructors are too much skilled in mysterious terminology and too little versed in the common every-day facts of life that are daily crowding about them and their students. Those whose tendencies have been toward the every-day manifestations of the life within and about them have been drawn to the more popular economic applications of biological knowledge and so are teachers of agriculture or domestic science. Thus it has become that the cartoonist's sketch of the bald headed, impractical anatomist peering through his microscope at the mangled remains of an unfortunate insect is not altogether without foundation in fact. Some of us are trying our dead level best to live down the imputation, but witness the yearly crop of high school annuals, or "take offs" in the class day exercises!

A few years ago, while at a meeting of the Illinois Academy of Science, I slipped away to a botany class in the high school in the same city. They were having laboratory work under a well trained lady from one of the largest universities. The subject was mush-rooms, and the material was in cans. It had been bought in Chicago. The instructions were in a manual. No conversation was permitted between pupils. I called the attention of the teacher to the fact that a fine collection of life size wax models of Illinois mushrooms was on display at the Academy meeting a few blocks away and that the students would be welcome either during school hours or after. None came. Was this a *human* way to act? Were these boys and girls permitted to react naturally toward mushrooms?

Biology may become the "livest" subject in school. This is possible if every recitation and every laboratory exercise is promptly and naturally connected up with the every day experiences of the child. I may mention but a few of these means of connecting formal instruction with the every day environment.

We collect material continually. Some organized collecting is done at certain appropriate seasons of the year. But every day is also a collecting day, and seldom a day passes that some specimen of plant or animal is not brought in. It is understood that more credit is given those who thus interest themselves. Whatever the subject in hand, time is always taken to discuss the new specimen in class. If it is a snake, the question of its possibly being a poisonous one may arise. A dozen other points may be suggested. If it is a snake egg or frog's eggs, the method of propagation or the whole life history may be gone into. It takes skill acquired by experience to prevent such every day discussions from crowding out regular assignments. Nothing is so common or so strange that it will not excite interest. Last week, the music instructor found a mouse that had dropped into her empty metal waste basket and had later given birth to a family of four. These were promptly delivered to the biology room. Two days after, a litter of young rats was brought from home by one of the girls. Then it was that we discovered that eight out of about one hundred twenty students in four classes had not known till that day that rats are not grown up mice. Daily connection of farm, garden, household activities, and the student's own bodily activities with formal instruction continually brings up unexpected and startling ignorance of common live things about us. So, students and teachers do not grow stale over the subject.

A frank desire to know and to correct misunderstood situations is engendered. We find that we are taking a delight in ferreting out unfounded beliefs. It is surprising how many of them come to light. There is much of the superstition and mis-information which has been handed down from our forefathers and which still clings to us. We cover up superstition with scientific facts.

The making of a scrap book of biological clippings from current periodicals is one of our greatest aids in making everyone feel that biology is a living subject made up of things that are happening right now. Only five such clippings are required each month. The child is required to quote from his text or from a specified reference list of texts, something relating to the clipping. This is recorded in the scrap book, together with an original comment by the student. And here comes the rub. It is so hard to be original.

One illustration must serve to show further what I mean by devices to humanize this subject. About January 1st, a rabid dog bit a child in each of two families in our community, and a man and his wife and a child in another family. The first two families took their children to Chicago for the Pasteur treatment. The third family went some distance to a mad-stone which has local fame and is said to have been taken from the heart of a white deer. This stone is said to have been handed down to its present owner for several generations.

The local paper gave all these particulars and the article began to appear in our scrap books. Although we had not reached the topic "rabies" in our course, a full discussion was had in class. Soon after, the career of Pasteur was brought in as a laboratory day lecture. It was made clear that the family that had gone to the mad-stone was running a great risk. Last week the woman developed hydrophobia and died a horrible death. After the details came out in the paper, the matter came up in class and was further gone over. These young people have had one lesson at least that has gone home. This is humanizing biology.

HOW CAN WE HUMANIZE PHYSICS?

W. H. P. Huber, Elgin High School, Elgin

This paper has been prepared at the request of the Chairman of this section. The subject assumes that Physics as taught today is a dry, formal, and systematized subject which does not lend itself to the life needs and interest of the student. The charge may be partly true. If so it should merit the attention of every teacher interested in the welfare of the human race, so that it may be returned to its rightful sphere of influence and usefulness.

Probably the most important factor in humanizing Physics will be found in the teacher. First, he must have a good knowledge of the content of the subject and its relative value. More important still, he must be able to impart it to the student in such a simple way that it will be easy to understand. He must also be filled with enthusiasm for the work so that everyone in the class will be inspired to put forth his best effort. The view point and limitations of every individual in the class must be known.

Let us turn for a moment to the modern business men and industrial leaders; they no longer do things the way they did a decade ago. Old buildings are torn down. New and elaborate structures are erected. Old machinery is discarded; new and improved is installed. The latest and most efficient methods are sought and used. In teaching Physics the prudence of the business man and industrial leader should be followed. Traditional and devitalizing material should be eliminated. Formal methods may be changed. Highly specialized material frequently occurs in many of our text books. In most cases it will be better to omit the greater part. It is better adapted to students of an engineering school than to the average high school boy and girl. If used to any great extent it will confuse the mind and develop a lack of interest causing the course to become unpopular in the school.

Another important need today in nearly all secondary science is to secure a text-book with real scientific knowledge and stimulating material which functions in every day life. The language must be simple and easy to comprehend. How often we hear the expression, "I do not understand a single thing in that paragraph," yet when the paragraph is explained the idea is simple and clear.

When subjects are studied in which formulas occur, concrete examples must be used and the real relation discovered before the algebraic statement is made. All laws should be developed by the same process. When the chapter on any subject is finished, summaries should be made, as they help the student to focus the mind on the points of importance. In new subject or advance assignments, all new words of importance should be pointed out or written on the board. If the student is required to complete a regular dictionary of these words and their definitions, he will more likely fix their meaning in his memory.

Special reports and themes furnish an excellent opportunity to introduce new and interesting material not found in the regular text. As a rule these should be brief and definite. Longer papers will nearly always be more profitable to the student if the teacher gives an outline and names references for wider reading. The reason for giving the outline is the elimination of irrelevant matter that might otherwise be used. The note book may also be used with profit to keep articles of special interest on the things studied in connection with those used in the text. The writer required each member of the class to make a collection of 25 different things involving the use of electricity. Comments were made on each thing and the electrical principle stated.

Field trips bring the classes into direct contact with the applied principles studied in the class or those to be studied. In nearly every case these prove to be more valuable than the more formal exercise of the laboratory. During the present semester the writer has taken his classes on three different field trips to study various phases of electricity.

In trying to get away from the more formal methods, one laboratory exercise in each class was devoted to the practical study of labor and time saving lamp socket devices. The Superintendent and three employees of the

Electric Light Company were present to conduct the exercise. The production and transmission of the current over high voltage wires was first considered by the Superintendent. After stating the reason for high voltage transmission it was explained how it was again stepped down and distributed to the various places for consumption. The limits of the lamp socket and use of fuses were next considered. Several different appliances were used and explained. The merits of each were considered. The amount of current consumed was determined by use of the voltmeter and ammeter. The cost per hour for each devise was found. The electrical driven brush and the straight type vacuum cleaner were compared. The advantages and disadvantages of each were pointed out to the class. The same was done with the vacuum and rotary washing machine.

One laboratory exercise has also been devoted to the study of ways in which alternating current can be changed to direct current. This exercise was taken up because a large number of storage batteries are used on radio outfits. Eight different types of rectifiers were secured and examined. The motor generator was studied and it was pointed out that it could be made by using an ordinary motor and an old generator from some discarded automobile. One boy later reported a good outfit with no cost except the time in a machine shop required to make a pully for the generator. Others made transformers and bought a tungar bulb at a considerable saving. Some made the more simple and less costly nodon valve rectifier. We devoted about a week to the subject of radio. Seven boys built neutrodyne sets and several built simpler sets.

Color and light in home decorating offers another interesting project for both the boys and girls. It is just as important as to study pitch quality and harmony in sound. How many of us know how to use complimentary colors? Where to use intensity of color and how much? How sunlight and artificial light cause the color to change, and why? What is meant by warm and cool colors and where to use them? How color and the size of a room are related? What color and shade of drapes to use on a window, and why?

Similar projects which will appeal to the student can be found on almost every subject studied in Physics.

HOW CAN WE HUMANIZE HIGH SCHOOL CHEMISTRY?

ALBAN FIEDLER, EAST HIGH SCHOOL, AURORA

Professor Louis Sherman Davis says, "Interest in a science is proportional to the immediate bearing which its subject matter has upon the life of the student. Hence the matter and process with which chemistry deals should touch the life of the student as closely as possible." It would seem necessary, then, that the subject be kept in close contact with everyday life and that the work be made as practical as possible. With the great number of practical applications today, the danger is apt to be too great a digression into highly attractive subject matter which will interfere with the systematic teaching of the principles involved. The object of this paper is to summarize briefly a few devices which have been used successfully by the writer to teach the principle and fact with reference to their application.

Smith[1] says, "When a generalization has been stated it will find immediate application." He gives us several examples of application. The law of conservation of matter is illustrated by the raising of the same crop on the same piece of land year after year. In the absence of the law of definite proportion we could not regulate the heating of our houses because the rate of combustion would not depend upon the supply of oxygen. Similar illustrations of almost all the generalizations of chemistry may be found.

Visits to factories and industrial plants often furnish an opportunity to point out to the pupil an application of a principle or fact noted in the class room. By means of these visits he should be made to realize that chemical knowledge is practical and to see that there is a definite relation between the test tubes of the laboratory and the vats of the factory. To be really profitable, such excursions must be made with a definite plan covering the things to be seen. Many questions will be suggested by what has been seen. So the first recitation after an excursion should be devoted to answering these and to assigning further study based on these observations. The

[1] Smith & Hall, pp. 129, 130.

excursion may take the place of a laboratory exercise.

Obviously, it will be impossible to bring a great many industrial processes before the pupils except by means of moving pictures. Miller[2] says, "The film has far-reaching potential usefulness in the study of chemical processes and manufacturing." Plant processes can be thrown on the screen anywhere. The class discussions of the pictures should bring out the important points. To quote Miller again regarding the use of films, "The point to be safeguarded is to see to it that it is used as a means in clarifying or economizing the pupils' productive thinking. If the pupil is transformed from the spectator to the participant the evils of the film disappear."

Collections of chemicals and specimens are very helpful for illustrating the applications of chemistry to industry. A pupil's interest in the process involved in the manufacture of common glass, for example, is intensified considerably when he sees specimens of the raw materials, the mixture and the finished articles. Smith[3] says, in regard to connecting things that are natively interesting with other things which are not so, "It is one of the best means of lending interest to facts that might otherwise seem dry." Charts such as the Coal Tar Products Tree can be used to good advantage. Specimens and charts may often be obtained from the manufacturer for the asking.

Aside from the reference works of a more or less technical nature, books like those of Slossons[4] and Duncan[5] can be put to good use. They present the romantic aspects of chemistry and are highly interesting to the average student. If the principles taught in chemistry seem dry, why not develop the pupil's interest by placing books of this type in his hands? In a great many cases the generalizations underlying the descriptive matter in books of this type can be brought home more easily and made to seem less dry to the student. In a number of instances I have used to advantage advertising literature

[2] Directing Study, p. 53.
[3] Smith & Hall, p. 141.
[4] Slosson's "Creative Chemistry."
[5] Duncan's .'Chemistry of Commerce" and "Some Chemical Problems of Today."

describing the process of manufacturing, properties, and uses of various commercial articles. Our bulletin board is usually pretty well loaded with newspaper and magazine clippings brought in by the pupils. "The Science News-Letter" is a reliable source of material covering the latest development in chemistry as well as in other sciences. Material of the sort mentioned above may be assigned as topics and the presentation of these topics may be followed by a discussion of the principles involved.

Experiments should furnish data and information to be used in recitation. The best results will be obtained when the pupil is seeking an answer because he is interested in doing so. As an illustration take the "Determination of the concentration of a solution by titration". When done according to the directions given in most laboratory manuals the results are discouraging and the pupil loses interest. Let the object of the experiment be stated as "What is the most economical brand of household ammonia to purchase?" and have the pupils bring samples from home. From the standpoint of the pupil there is an entirely different problem—one in which he is vitally interested. Whenever time permits, the pupils should be encouraged to bring in materials to test in various ways, and the results should be reported to the class. In connection with tests for food adulterations, etc., the results cover a wider range if each pupil brings samples to be tested from home.

"The practice of topping out a course in chemistry with a large unit of work, either on the individual or the co-operation basis, is suggested."[6] Some weeks before the close of a year's course, the pupils may be given a choice of problems such as wood-products, soils, photography, etc., and the laboratory periods given over to experimental work on these problems. The pupils may be required to make a report each week to the teacher showing the progress made. A pupil usually finds it necessary to understand the generalizations of chemistry and to apply these in the development of his project. The results may be exhibited to the public at the close of the

[6] Miller "Directed Study" pp. 164, 165.

year. There is an incentive to work because the pupil has chosen a problem which appeals to him. The earnestness and enthusiasm shown is gratifying.

Much might be written on the use of any of the above devices. There is no claim for anything original. But if this rambling paper has brought back to the mind of anyone here something which may be of use, it will have accomplished its purpose.

MAKING SCIENCE TEACHING MORE EFFECTIVE IN RELATION TO LIFE

H. A. HOLLISTER, UNIVERSITY OF ILLINOIS

The chief life contacts of science may be classed under *health, morals* and *industry.* The question before us therefore is: What constitutes effective teaching in relation to these three great divisions of life interests?

Speaking of super power, or what is more commonly called giant power, Gov. Pinchot of Pennsylvania says: "Giant power is a term coined to suggest the realization of far reaching social objectives through a vaulting engineering technique. It means giving to every producer of current an opportunity to add to the common stock and to every user an opportunity to draw therefrom, but it also means the education of the public, to the point where it can intelligently and fully cooperate with public and private enterprise in these objectives."

R. F. Schardt of the Commonwealth Edison, quoting Pinchot, goes on to say: "This is constructive recognition of the biological factor in civilization, a restatement that engineering objectives are affected by the human stock. The technical progress of civilization cannot be indefinitely continued, nor even the present status maintained, unless some attention is paid to improving the personnel which man the machine."

This brings to the fore the problem of health as really underlying the whole fabric of human existence, especially as our social order advances to higher levels of attainment in all those things which characterize modern civilization as ever advancing.

The first and most fundamental call, therefore, which human life makes on science is the instilling into the minds of youth the value of life at its best and the means of preserving it and projecting it on to coming generations with increasing rather than diminishing virility, and with adaptability to every changing social and physcal condition. This means the training in knowledge and practice of the laws of health of body and mind; of how to conserve, rather than to waste, one's physical resources and mental inheritance; of how to care for the propagation of the race so as to eliminate inherent weakness, both physical and mental; of how, in other words, to produce and preserve a super man, in the true sense, to deal with super power for human weal.

The moral element enters here, for morals and health are closely related at many points. But in all our teaching let us emphasize the *doing* of the things that need to be done rather than the *don'ts* with their vicious suggestiveness and their appeal to the daring of youth. The common, everyday conditions of living seem here to demand a new stating in terms of what biology has taught us. This applies to both the moral and the health aspects of our problem.

It seems needless to enumerate here all the elements which center around this particular phase of science teaching. They are well known to us all. What we should strive for is to give to our pupils a consciousness of real objectives to be attained if they are to live their lives to the greatest advantage for themselves and for posterity. Where we have been failing in this particular is in not making any clear and definite use of what science has already taught us. To quote from the same source as above: "Hardly a trace of this scientific knowledge has been applied, positively or negatively, to the betterment of the human stock. How long a scientific civilization, making ever increasing demands upon the ability of the people, can be maintained under such conditions is becoming a pressing issue."

That is another way of saying that it is the mission of the school, as far as the teaching of science is concerned, not only to instruct youth in the principles of biology and physics, but to introduce them, as far as possible, to the practical applications of these principles in the home, in the community, in business and in industry. And the more nearly such scientific attitudes become habitual the more successful will be our teaching. Sanderson of Oundel had the right idea when he set out to teach his boys science by attacking the problems of daily life in his school community. As a result, and also as an acid test of the sanity of his method, when the world war came on, his boys thus trained were able at once to assume tasks of grave responsibility in applying science to the many hurried readjustments that the modern conditions of warfare into which the British nation was plunged demanded.

The principle is no less true under peace conditions. How urgent are the needs of many readjustments of the rank and file of our citizenry in these days of radical innovations in all the fundamental aspects of living! And how true it is that in our haste for material development we have forgotten the corresponding need of applying the latest word in science to the conservation and improvement of the human biological factor. We see this in the risk to lives that comes along with the invention of complex machines. This is notably true of the automobile now in common use, and yet a large percentage of the users know little of the mechanism they undertake to direct in the midst of ever increasing traffic. For the driver who takes the trouble to know and master his car, and to consider the risks, the danger is always from the "other fellow." Thus both in education and in the moral sense of responsibility for others our biological advancement is far behind the demands of this age of the application of physics and chemistry in doing the world's work.

We need a different literature of science, one that may be broadcasted with the hope that all who listen in may comprehend. We need more of such material as Slosson's "Creative Chemistry," of Hunter's "Civic Biology," in order that the masses, through our schools, may learn the language of science as applied to living. We need more teachers of science like Miss Smallwood and Miss Loomis of Chicago, Miss Huffman of Woodstock, and Clarence Bonnell of Harrisburg,—teachers who make science a living thing that vibrates throughout all that is important and vital in our social and civic life.

As has been suggested, we have been stressing too much the material benefits of science as applied to commerce and industry to the serious neglect of its application to the biological wellbeing of our people. It is not enough to assign text-book lessons and perform a few experiments in the laboratory in order to "pass" and earn a "credit." We need to teach the language of science so that our youth may be able to read intelligently and also with interest the results of research as they apply to the great fundamental interests of life. The vast expenditures of the national government and of institutions in conducting experiments and research are still failing of accomplishment with the majority of those who should profit by their published results because they are unable to read the literature of science with understanding and appreciation. As one illustration, note the premium that men still put upon the services of the chef who can most skillfully concoct the dishes that, because of their delectable qualities that tickle men's palates, lead to a stuffing and gormandizing that end in premature death or incompetency. On the other hand, men listen, how grudgingly, to the trained dietician who seeks to enlighten them on the relation of food elements to normal bodily functioning and consequent health.

We hear much these days about conflicts between religion and science. This because we, as science teachers, have failed to compare the eternal verities of science with the fundamental teachings of religion. Yet what more important relationship to life than this does science hold for us as individuals and as a Christian nation?

I can do no better than to quote here from an article by Professor T. E. Savage in the March number of "The Open Court." Professor Savage is a Geologist of no mean ability and his word may well command our attention. He says:

"If God's presence permeates nature in such an intimate way, we should expect to find nature's laws teaching the same moral lessons as the Bible, and working along lines parallel with it in bringing about righteousness in the earth. In a very large way this is true. The Bible says, 'Prove all things, hold fast to that which is good.' Science has accepted this rule as one of its fundamental principles. The Bible says, 'The Wages of sin is death.' Science repeats the same warning and shows us how nature works to bring about this result. When a man indulges in evil practices and persistently transgresses the laws of health, his physical vigor and power of resistance are lessened thereby, and he falls an early victim to disease. Nature detects even those who appear to be sound, but are rotten at the core. The Bible says, 'The iniquities of the fathers are visited upon the children to the third and fourth generations.' Science shows clearly the truth of this statement. Where parents are dissolute and victims of sinful habits, the children also possess weakened constitutions as well as sinful tendencies, either as a result of inheritance, or of early environment and neglect. Where for only a few generations parents are persistently vicious the stock grows weakened, idiotic, and eventually becomes extinct. Persistent sinfulness is stamped out in a few years by natural selection acting through heredity. In the language of science the sinner is out of harmony with his environment, and if he and his posterity will not or can not change, natural selection will as surely cut off his race as in the case of any other animal not in adjustment with its environment. This is 'the power not of ourselves that makes for righteousness.' Happily, in a similar way the higher qualities of character developed by the parents are also impressed upon the children by early education and example. The Bible says, 'The righteous shall inherit the earth,' and science assures us that righteousness or right living makes for health and length of life."

Surely in this grossly materialistic age we may well stress such ideals in our teaching of the fundamentals of science to those who are the hope of the future.

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 scientific 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. Each national member, except life members of the Academy, shall pay an admission fee of one dollar and an annual assessment of five dollars.

Local Members shall be those who are members of the local Academy only. Each local 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. 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, and who have not paid as much as $20.00 in fees to the Academy.

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 1st 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. The other above officers 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 2nd 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.

They 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, 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 all 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 Publication.

All members shall receive gratis the current issues 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 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.

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.

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Note—The names of charter members are starred; names in black-faced type indicate membership in the American Association for the Advancement of Science.

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