TRANSACTIONS

OF THE

Illinois Academy of Science

TENTH ANNUAL MEETING

Knox College, Galesburg, Ill.
February 23-24, 1917

VOLUME X

1917

Published By The State

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Edited By
J. L. PRICER
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Secretary, J. L. PRICER, NORMAL UNIVERSITY, NORMAL.

Treasurer, T. L. HANKINSON, STATE NORMAL SCHOOL, CHARLESTON.

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DR. V. E. SHELFORD, University of Illinois.
MR. H. S. PEPOON, Lake View High School, Chicago.
DR. GEO. D. FULLER, University of Chicago.
DR. A. G. VESTAL, State Normal School, Charleston.
DR. FRANK C. GATES, Carthage College.

Committee on Conservation of Wild Life

R. E. WAGER, State Normal School, DeKalb, Chairman.
H. C. COWLES, University of Chicago.
H. S. PEPOON, Lake View High School, Chicago.
FRANK SMITH, University of Illinois.

PAST OFFICERS OF THE ACADEMY

1908

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

1909

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

1910

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

1911

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.

1912

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

1913

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

1914

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

1915

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

1916

President William Trelease, University of Illinois, Urbana.
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.

Minutes of the Tenth Annual Meeting

Knox College, Galesburg, Illinois, February 23-24, 1917

The meeting was called to order in Beecher Chapel, Knox College, at 2 p.m. on Friday by President William Trelease. President Thomas McClelland of Knox College delivered an address of welcome, in a very happy manner, extending the freedom of the college and of the city to the members of the Academy. President Trelease responded by a unique address, setting forth in a very novel but fitting manner the general attitude of men of science toward the problems of society.

The minutes of the ninth annual meeting, as published in Volume IX of the Academy Transactions, were read by the Secretary. Reports were made by the Secretary, the Treasurer, the Librarian, and by the committee on Conservation of Wild Life. These reports appear further along in the volume.

An auditing committee, consisting of Thomas L. Hankinson, Chas. T. Knipp, and J. C. Hessler, was appointed by the President, and on motion, the Treasurer's report was referred to this committee.

A. R. Crook, chairman of the membership committee reported a list of 26 candidates for membership in the Academy and recommended their election. On motion, the Secretary was instructed to cast the ballot and the candidates were declared elected. Other candidates were elected to membership at the business session on Saturday. A list of the members elected at the meeting appears further along in the volume.

President Trelease next appointed the following committees:

Committee on Nominations: W. A. Noyes, S. G. Winter, R. E. Wager, F. D. Barber, and J. H. Ferriss.

Committee on Resolutions: Isabel S. Smith, F. L. Stevens, A. R. Crook, and F. W. DeWolf.

A proposed amendment to the constitution, which had been duly presented to the members was unanimously adopted as follows: Article III was amended (1) by striking out the words "corresponding members" and "honorary members" from the first paragraph, and by inserting the word "and" before the words "life members," and, (2) by striking out paragraphs 4 and 6, relating to corresponding members and honorary members.

On motion, the Council of the Academy was instructed to prepare a codification of the Constitution and By-Laws of the Academy so as to make them harmonize with the various amendments, resolutions and practices adopted by the Academy at different times, and to report the same to the members in time for action at the next annual meeting.

On motion, the Treasurer was instructed to invite fifty or more members to pay dues sufficient to make them life members. This measure was prompted by the need of funds to enable the Academy to catch up with the publication of its transactions. On August 20, 1917, twelve members had responded to this call.

On motion, the President and Council were instructed to reorganize the committee of Secondary School Science, and to consider with the committee the recommendation made by the Secretary in his report that some kind of "junior membership" be planned for students in high schools and colleges, and if such a plan can be worked out, to report at the next annual meeting.

Following this business session, a session was held at which a number of papers of a general nature were presented. All of these papers are printed in this volume under the head of "General Papers."

TENTH ANNIVERSARY SESSION

At 6 o'clock on Friday evening, about 150 members and friends of the Academy assembled at the Galesburg Club for dinner and for an elaborate program of addresses by delegates from other academies of science and from scientific organizations within the State. This program was planned and arranged entirely by President Trelease and much credit is due him for its eminent success. The program was arranged in honor of the tenth anniversary of the founding of the Academy.

The dining room was beautifully decorated in patriotic colors in honor of George Washington.

Dr. Trelease acted as chairman and toastmaster and opened the meeting by calling on President J. M. Tilden of Lombard College, who delivered the address of welcome.

Professor William E. Nipher of Washington University, St. Louis, Mo., representing the American Philosophical Society and the Academy of Science of St. Louis, was the next speaker. Professor Nipher referred to his early education in which he had made a general survey of all the fields of knowledge, finding, much to his disappointment, too much strife and conflict in the fields of human affairs and of animals and plants. He said that he finally discovered the field of atoms and molecules in which all is peace and harmony and decided to devote his life to their study. Next, the speaker discussed in a very concrete way, the energy involved in the creation of the earth and ended suddenly by saying that he didn't any longer believe that the Creator did it in seven days.

Dr. W. A. Noyes of the University of Illinois, who spoke as the representative of the National Academy of Sciences in the absence of Dr. V. C. Vaughn, of the University of Michigan, told of the plan of organization of the National Academy and of the valuable services which it rendered to the government in times of both war and peace.

Professor J. E. Wells of Beloit College extended the greetings of the Connecticut Academy of Arts and Sciences of which he is a member and delivered an eloquent address on the purpose and meaning of such organizations.

Dean C. H. Eigenmann of the University of Indiana, who, on account of illness, was unable to be present to represent the Indiana Academy of Science, sent an interesting eight page telegram in which he described a dream which he had recently had. According to the telegram, he dreamed that he and his neighbor, Billy Sunday, had died, and traveled together to the realms beyond this pale. His credentials admitted him to the realms of Satan, which by special permission Mr. Sunday was allowed to enter temporarily. Here they found all the prominent scientists of the Middle West having a glorious time trying all sorts of experiments to which the high temperature of the place was suitable, and they had so improved the place that Sunday longed for permission to remain.

The Iowa Academy of Science was represented by Professor H. S. Conard, of Grinnell College, who complimented the Illinois Academy for its extensiveness and the large number of branches of science that it included. He spoke especially of the work of the Committee on Ecological Survey and wished it the greatest of success.

Professor E. H. S. Bailey of Lawrence College brought greetings from the Kansas Academy of Science, one of the oldest state academies in the country. He said that the Kansas Academy had celebrated its 49th anniversary in January and was in a prosperous condition.

Professor W. H. Hobbs of the University of Michigan represented the Michigan Academy of Science and spoke on the purposes of academies of science. He said that one of the main purposes of such organizations was the dissemination of accurate knowledge.

In the absence of Professor J. M. Coulter of the University of Chicago, Dr. H. S. Pepoon of the Lake View High School, Chicago, spoke of the work of the Chicago Academy of Science. He told of the work of the Academy in exhibiting stuffed birds and other animals against a scenic back ground representing their natural habitats.

Dr. C. W. East, District Health Officer of the State Board of Health, represented that institution in the absence of the Secretary, Dr. C. St. Claire Drake. Dr. East said that today, people trust themselves too much to the care of health authorities instead of sharing with them the fundamental knowledge. He made the point that the efforts of health authorities to improve health conditions depend very largely on a general increase in knowledge on the part of the people of the fundamentals of health.

Director F. W. DeWolf of the State Geological Survey, spoke briefly of his work and of the changes in the grouping of the scientific workers likely to be brought about through legislation then being discussed at Springfield. In closing, he paid a fine compliment to Dr. T. C. Chamberlin, the eminent geologist of the Academy, and Dr. Chamberlin, on being called for by the President, responded by calling attention to the multiplication of scientific societies, bureaus, etc., in Illinois. He also took a text from the first address of the evening, made by Dr. Nipher, and added some significant comments. He raised the question as to whether there had always been peace and harmony among the atoms and molecules of matter, or whether they may not have reached this state through a process of evolution similar to that evolution through which more complex forms of matter are passing now.

Dr. Chamberlin was honored by being elected the first president of the Academy and it was exceedingly fitting that he could be present at this tenth anniversary meeting and deliver the principal address of the meeting, as he did on the morning following this banquet session.

Dr. A. R. Crook, Curator of the State Museum, spoke briefly of the relations of the institution over which he presides, to the Academy, and in closing paid a beautiful tribute to Dr. S. A. Forbes, who was elected the second president of the Academy, and whom the members of the Academy also delight to honor along with Dr. Chamberlin. The following sentences are quoted directly from the remarks of Dr. Crook: "You know his unique history—a soldier in the civil war at eighteen, a captain at twenty; for forty years an investigator in cryptogamic botany and zoology, especially as this science concerns itself with the relation of mammals, birds, fishes and insects to plant life and agriculture; the author of thousands of pages of scientific publications which have added to the agricultural wealth of the State, and even more remarkably to the intellectual wealth.

"The Academy is under lasting obligations to him and to no one are we more indebted, and of no one are we more proud, than of this soldier, scholar, teacher, author, and highly revered gentleman, Professor Stephen A. Forbes." Dr. Forbes was compelled to be absent from this meeting, the first one that he had missed since the organization of the Academy. His absence, however was caused by the fact that his services were more urgently needed in looking after the interests of science before the State legislature.

Mr. E. B. Vliet of the University of Illinois, next spoke as a representative of the Chemical Club of the University, of which he is an undergraduate member. His remarks served to add variety to the program, by giving a little glimpse of the enthusiasm of the younger members of the Academy and workers in science.

The Illinois Water Survey was represented by its director, Dr. Edward Bartow, who, realizing the lateness of the hour and the possible weariness of the audience, spoke in more or less of a humorous vein.

Professor F. L. Stevens of the University of Illinois, closed the program of addresses with an account of the work of the Bacteriological Club of the University.

At about 10:30 o'clock, President Trelease again took the floor and stated that the Constitution of the Academy required that each year the President of the organization should prepare an address, but that there was no authority in the Constitution which could compel the people to listen to it. Consequently he handed his manuscript to the Secretary for publication in the Transactions and the meeting was adjourned.

Letters were received from the American Academy of Arts and Sciences, the Ohio Academy of Science, and the California Academy of Sciences, all regretting their inability to send a representative to the meeting.

SYMPOSIUM OF PUBLIC HEALTH

On Saturday morning at 9 o'clock, was held a general session consisting of a Symposium of Public Health Problems. The speakers on this program were selected and the program arranged by Dr. J. H. Beard, Health Officer of the University of Illinois, and much credit is due him for his untiring efforts to make the program a success as well as for the excellent paper with which he opened the symposium.

Dr. Hermon M. Adler, Professor of Psychiatry, Harvard University, and director of the Cook County Survey, was to have spoken on the subject of Mental Hygiene, a Public Health Problem, but was prevented from being present by illness. All the other papers of the symposium appear in the volume. This session was largely attended by the citizens of Galesburg.

At 11 o'clock, a special lecture, complimentary to the people of Galesburg, was delivered by Dr. T. C. Chamberlin, on the subject: Earth Genesis. Further along in the volume is printed a paper which Dr. Chamberlin prepared for another occasion, but which contains essentially what he said in this lecture. The lecture was illustrated by lantern slides and was largely attended and greatly appreciated by the people of the city.

At twelve o'clock following Dr. Chamberlin's lecture, the faculties of Knox College and Lombard College served a complimentary luncheon to the members of the Academy at the Galesburg Club.

Following the luncheon, the Academy met in four sections, at 1:30 o'clock, for the presentation of papers. The papers presented in these section meetings are printed in this volume with the exception of a few that have been published elsewhere.

At 4 o'clock, the Academy again assembled in general session for the election of officers and the transaction of other business. The first item of business at this session was the reading of a telegram from Dr. W. S. Bayley, chairman of the legislation committee, stating that the Academy appropriation bill before the legislature was in danger of failure and needed the support of the members.

On motion, the Secretary was instructed to prepare and send telegrams to the governor and to the chairmen of the two appropriation committees of the legislature, urging the importance of our request for financial aid from the State, and all members were urged to write letters to those officials. It is a great pleasure to record the fact that in response to these requests and the earnest efforts of the legislation committee, an appropriation bill was finally passed and signed by Governor Lowden, providing a thousand dollars a year for the biennium, for the publication and distribution of the Transactions of the Academy. This is all the more remarkable when it is realized that the nation was just entering the great world war, and the State government was pursuing a policy of the strictest economy. The Academy and the cause of science generally are under lasting obligation to Governor Lowden, to Hon. E. J. Smejkal, who included the Academy item in his general appropriation bill, and to all other members of the legislature who supported the measure in the unprecedented time of stress.

The above paragraph was written and in type before it was discovered that Governor Lowden had really vetoed the Academy item in the general appropriation bill. The gratitude expressed and felt, having been a reality to us for about six months, we have decided to allow the paragraph to stand, as an expression of the gratitude we shall feel, when our worth to the State has been finally recognized and acknowledged in a sure and substantial way.

The nomination committee, consisting of W. A. Noyes, S. G. Winter, R. E. Wager, F. D. Barber, and J. H. Ferriss, proposed the following officers for the ensuing year:

President—J. H. Hessler, Decatur.

Vice-President—J. H. Ferriss, Joliet.

Secretary—J. L. Pricer, Normal.

Treasurer—T. L. Hankinson, Charleston.

Member of the Publication Committee—Geo. D. Fuller, Chicago.

Membership Committee—C. H. Smith, Chicago; Stuart Weller, Chicago; C. W. Finley, Macomb; C. E. Spicer, Joliet; W. S. Bayley, Urbana.

On motion, the Secretary was instructed to cast the ballot and the nominees were declared elected.

The report of the Committee on Resolutions was presented and adopted as follows:

The Illinois Academy of Science just bringing to a close its 10th annual meeting in the attractive city of Galesburg, desires to express its appreciation of the hospitality which has been extended during its two days stay here.

That this has been one of the most successful meetings in the history of the Academy is due partly to the fine character of the papers presented, and especially to Prof. Chamberlin's report of his epoch making work on Earth Genesis; partly to the presence of the distinguished delegates from other States, and organizations; partly to the abundant and wise labors of our officers; and also in large measure to the cordial reception of the Academy by Knox College, Lombard College, the city schools, and the Galesburg Club, as expressed by their presidents, faculties and officers.

To them, to the local committees, to the newspapers and to all who have added to the pleasure and profit of our meeting here, we hereby express our most hearty appreciation and thanks.

RESOLUTIONS ON THE DEATH OF PROF. T. J. BURRILL

Whereas: In the providence of our Great Ruler during the past year, our respected and beloved member and associate, Thomas Jonathan Burrill, has been removed from us.

Be It Resolved: That this Academy express its appreciation of the long years he has devoted to science as investigator, teacher and as executive; and that it acknowledge in particular the indebtedness of the world to him for his fundamental contribution to bacteriology as related to plant disease.

We the more deeply deplore his loss to the University, to the Academy, to all who knew him and to the scientific world, because of his thoughtfulness of others, his generosity and fine Christian character.

Be It Further Resolved: That this expression of his worth and of our loss be spread upon the minutes of the Academy and that a copy of this resolution be sent to his bereaved family.

ISABEL S. SMITH.
F. L. STEVENS.
F. W. DEWOLF.
A. R. CROOK, Chairman.
Committee on Resolutions.

February 24, 1917.

The following resolution on the death of E. J. Hill was presented by Dr. H. S. Pepoon and was unanimously adopted by the Academy.

To the officers and members of the Illinois Academy of Science:

Whereas: Professor E. J. Hill, of Englewood, city of Chicago, and an old and faithful member of the Academy, has been removed from our midst by death, thus losing for us an active member and an enthusiastic supporter and loyal friend;

And Whereas: Professor Hill was by common opinion and consent the leading botanical authority of the Chicago district, having won for himself by arduous labor in field and study, a most reputable place among the ranks of the working botanists of the United States, giving practically his whole life to investigation and collection, and having published papers on many difficult problems in plant taxonomy and distribution;

And Whereas: His work was eminently a labor amidst us in our own chosen field of Illinois, a very large proportion of his field work being carried out in the State, to the great enhancement of the botanical knowledge of our area;

Be It Therefore Resolved: That the Illinois Academy of Science at Galesburg convened, takes this public opportunity to express to all men, and in a special manner to his family, our appreciation of the work of our colleague in his chosen field, our feeling of personal loss at his passing from us, and our sympathy and consolation to those in the family life and the greater public he has left behind to mourn his absence.

No further business appearing, President Trelease called on the newly elected president for a few remarks, after which the tenth annual meeting of the Illinois Academy of Science was declared adjourned.

J. L. Pricer, Secretary.

MEMBERS ELECTED AT THE GALEBURG MEETING

Adams, Wm. J., A.M., 238 Holton St., Galesburg. (Biological Science.)
Baumeister, George F., B.S., Aledo. (Biology and Chemistry.)
Bawer, G. S., M.D., Galesburg. (Medicine.)
Blackwelder, Eliot, Ph.D., University of Illinois. (Geology and Geography)
Blake, Anna M., S.B., 308 Mason St., Normal. (Botany and Physiology.)
Butcher, B. H., A.B., Canton. (Science Education.)
Clark, H. Walton, A.M., U. S. Biological Station, Fairport, Iowa. (Botany and Zoology.)
Clute, W. N., Joliet, (Botany.)
Covington, E. Gray, M.D., 410 E. Market St., Bloomington. (Medicine.)
Finley, J. Orton, Oneida. (Agriculture.)
Foberg, J. Albert, B.S., 4031 N. Avers Ave., Chicago. (Mathematics.)
Harris, Charles L., Macomb. (Archeology.)
Hartin, Fred., B. E., Rantoul. (Biology.)
House, Edward O., Ph.D., 317 S. 8th St., Monmouth. (Chemistry.)
Husted, Ward W., B.S., 256 S. Cedar St., Galesburg. (Chemistry.)
Jelliff, Fred R., A.B., Galesburg. (Geology.)
Kisler, L. P., Roanoke.
Lambert, Earl L., B.S., Carthage. (Botany and Zoology.)
Lightbody, Ernest R., B.E., Weldon. (Biology.)
MacInnes, F. Jean, B.S., 614 Michigan Ave., Urbana. (Plant Pathology.)
Millspaugh, Chas. F., M.D., Field Museum, Chicago. (Botany.)
Musselman, T. E., M.A., Quincy. (Ornithology.)
Neifert, Ira E., M.S., 806 E Knox St, Galesburg (Chemistry)
Nelson, C. Z., 534 Hawkingor Ave., Galesburg. (Botany.)
North, E. M., B.A., Galesburg. (Geology, Astronomy & Pedagogy.)
Phipps, Charles Frank, M.S., State Normal School, DeKalb. (Physics and Chemistry.)
Ray, Ward L., A.M., Aledo. (Chemistry).
Ridgway, Robert, M.S., 1030 S. Morgan St., Route 7, Olney. (Ornithology)
Sayers, Frank E., B.S., M.D., 123 North St., Normal. (Public Health.)
Smith, Sylvia, B.E., Evanston. (Biology.)
Sperry, Holland R., Galesburg. (Biology.)
Spicer, C. E., Joliet. (Chemistry.)
Walsh, John, 282 W. Berrien St., Galesburg. (Water Supply.)
Warrum, Jesse J., A.B., Macomb. (Chemistry.)
Willard, Alice, M.A., 704 N. Cherry St., Galesburg.
Wilson, Eva M., M.D., Manhattan. (Medicine.)
Winter, S. G., A.M., Galesburg, Lombard College. (Biology.)
Wirdlinger, Sidney, Ph.D., Galesburg. (Chemistry.)
Woods, F.C., Galesburg. (Physics.)

The following two members were elected by the Council at a meeting held in Urbana, April 7, 1917.

Baker, W. J., Galesburg. (Chemistry.)
Longden, A. C., Ph.D., Galesburg. (Physics.)

Reports of Officers and Committees

REPORT OF THE SECRETARY

A meeting of the Council was held at the LaSalle Hotel in Chicago on July 8, 1916, all members being present with the exception of the Treasurer, Dr. H. S. Pepoon.

At this meeting, Galesburg was selected as the place in which to hold the present meeting, and the general plan of the program, as it has been finally arranged was decided on.

The matter of publication of back volumes of transactions was considered, and finally left in the hands of the Publication Committee, with instructions to publish as many volumes as the funds available would pay for. On finding that the treasury contained about $400.00, and that about $200.00 of 1916 dues could be collected, the Publication Committee decided to publish Volumes VII and VIII, and a contract for the printing of the same was let to the Miller Printing Co., of Bloomington for editions of 1000 copies of each of the two volumes. Volume VII consists of 120 pages and cost $237.77, and Volume VIII consists of 160 pages and cost $276.28.

Copies of each of the two volumes have been sent to each of the 364 members whose names are listed in the volumes, with the exception of eleven whose addresss are not known, and five who are now deceased. At the request of the Legislation Committee, forty copies, twenty of each volume, were sent to the chairman of the appropriations committee of the State legislature. The remaining copies of the two volumes have been sent to the Librarian, Dr. A. R. Crook, of the State Museum at Springfield.

In addition to a rather extensive correspondence in connection with the publication and distribution of the two volumes of Transactions, nine hundred announcements of this meeting were mailed to members and to a selected list of physicians and high school and college teachers. Along with the announcements sent to non-members a printed circular setting forth the aims and purposes of the Academy and the conditions of membership was enclosed. 425 copies of the final program of this meeting were mailed to members and prospective members.

RECOMMENDATIONS

It is obvious that prompt and regular publications of Transactions is vital to the life and welfare of the Academy. Realizing this fact, the secretary took it upon himself to enclose with the announcement of this meeting, a printed slip, making the suggestion that fifty or more members, pay up dues now, sufficient to make them life members. The Constitution provides that life members shall be such as have paid $20.00 as dues. A few have responded to this call already. I should like to join these and urge others to do the same. Money raised in this way will be needed even if we do succeed in securing financial aid from the State, and a strenuous membership campaign can easily replace the life members with new active members who will pay dues annually.

It seems desirable that the Constitution and By-Laws of the Academy should be modified to make them include the provisions of certain resolutions and practices that have been, at different times, adopted by the Academy. I would therefore suggest that the Council be instructed to prepare such a codification and present it to the members in time for action at the next annual meeting.

The Committee on Secondary School Science needs to be reorganized, for all the members but one have either resigned or removed from the State. I regard a committee of this kind of vital importance to the Academy. It seems that we have made almost no progress in our endeavors to form some kind of workable relations with the high schools of the State and yet I believe that we should persist until something is accomplished in this line. I believe that we should have some sort of junior membership to which high school students, and possibly college students might be eligible. Many high schools and colleges support science clubs of one kind or another, and I believe that it might be possible to affiliate these clubs with the Academy through a junior membership.

I believe that the Academy should continue to form other working committees like the committee of Ecological Survey. Why not a committee of Public Health? Why should not the symposium part of the program usually initiate some new line of work that could be carried forward by a committee?

J. L. Pricer, Secretary.

REPORT OF THE TREASURER

RECEIPTS

February 23, 1917.

Feb. 20, 1916, balance in bank	$307.79
Feb. 21, 1916, dues collected	320.50
Feb. 23, 1917, from sale of Transactions	5.25
Feb. 23, 1917, from interest	1.52
Total receipts	$635.06

DISBURSEMENTS

Stationery, stamps, and printing for Secretary and Treasurer	80.05
Exchange on foreign checks	4.15
Printing Vol. VII, 1000 copies	237.77
Printing Vol. VIII, 1000 copies	276.28
Total disbursements	$598.25
February 23, balance in bank	33.81
Cash on hand	3.00
	$635.06

The Treasurer begs leave to say further that he has been engaged for some time in clearing the books of all those names that investigation has proved to be actual "dead timber." In so doing, however, he has discovered a goodly number who, from wrong address, removal, or other cause, have not responded to the former notices of the Treasurer, but who, on a presentation of their present status, are paying up back dues, and are again in good standing. There are doubtless more in like position that can be returned to our ranks by proper correspondence.

He would therefore emphasize the necessity of not carrying out the literal letter of the Constitution until by verification of all addresses, due notice, and letter of resignation in hand, the delinquent has shown his fixed intention of leaving the Academy.

There are at the present date 73 members in good standing who have been notified twice within the last four months of dues unpaid, who have as yet not responded. 180 members have paid 1916 dues, from which it would appear that we have approximately 260 members in good standing.

H. S. Pepoon, Treasurer.

REPORT OF THE LIBRARIAN

In accordance with instructions given at the Fifth Annual meeting of the Academy as recorded on page 19, Volume V of Transactions, the Curator of the State Museum has been acting as custodian of the surplus volumes of the Academy Transactions and of the books and pamphlets received from other Academies of Science, educational institutions and individual workers in exchange for our publications sent out.

The plan adopted for exchanges has been to charge all parties 75c for unbound and $1.00 for bound copies of all volumes, except Volumes IV and V, which were published by the State at no expense to the Academy. Our Treasurer has the record of the volumes so disposed of.

Volumes IV and V have been sent without charge to persons requesting them.

When libraries or other institutions have offered valuable publications in exchange they have been supplied with all volumes without charge.

The policy of your Librarian in general is to in every way promote the financial welfare of the Academy.

There now remains in stock the following copies of the various volumes:

Vol. I., unbound, 166; bound, 9.
Vol. II., unbound, 629, bound, 6.
Vol. III., unbound, 641, bound, 20.
Vol. IV., unbound, 438.
Vol. V., unbound, 626; bound, 71.
Vol. VI., unbound 252.

Vol. VII., unbound, 600.

Vol. VIII., unbound, 600.

One hundred and two pamphlets and ten bound volumes, a total of one hundred and twelve publications have been received. All have been stamped with the Academy stamp and card catalogued. The list may be published if desired.

A. R. Crook, Librarian.

REPORT OF THE COMMITTEE ON THE CONSERVATION OF WILD LIFE

Your committee, together with thoughtful people everywhere, views with apprehension the rapid approach of the time when shall be gone forever, those conditions under which may exist the flora and fauna characteristic of the primeval conditions of our state. That this time is not far distant is evident unless vigorous efforts are immediately made to check its advance. On all sides is the destruction of bird life by ignorant foreigners, to whom hunting licenses are unlawfully issued. Otherwise good citizens are also surely reducing, year by year, the numbers of our most beneficial birds, such as the quail and prairie chicken, while the constant clamor ot the sportsman for longer open seasons on the objects of his desire, indicates that his horizon is bounded by his own selfish interests rather than the rights of the future. Destruction of rare and beautiful plants goes on apace. Everywhere one finds that plants a few years ago abounding in considerable numbers are now totally obliterated—and the places thereof shall know them no more. The greed for land and dividends is draining our swamps wherein nest many species of birds, and abound numberless kinds of plants. Interesting and beautiful bits of woodland are sacrificed also to the ever-increasing appetite for more cultivable land, and if such woodlands be not destroyed, the constant pasturage leads eventually to the same end since the herbaceous plants are blotted out, no coppice develops, and the maturing of the trees leaves nothing to take their places when gone.

Beholding these things, it is their desire to place the Academy on record as thoroughly in sympathy with the efforts made by various organizations in this and other states, to arouse public opinion to an appreciation of the value of wild life, as well as to preserve the same. We suggest in this connection a resolution commending the efforts now making for the preservation of the Dune Region in our neighboring state.

There are known to be considerable tracts of land of little or no agricultural value within the boundaries of the state of Illinois, some of which are adapted excellently to the purposes of bird reservations, while others, some of which have greater prospective values, retain remnants of the primitive prairie flora, while others still are of practically no value as agricultural or mineral lands, but exhibit remarkable associations of plant life, equally interesting geological and geographical formations, while serving no doubt, as the breeding grounds for not a few species of animal life. These tracts, scattered as they are over the state, ought, it is the belief of your committee, eventually to be acquired and set aside by the people of the state, as public parks, or wild life reservations.

Desirable as is the procedure just suggested, its culmination depends so entirely upon a public opinion in harmony with the idea, that the committee believes it inadvisable to recommend the immediate inauguration of steps leading directly to that end. As an end ultimately to be attained, it believes, however, the Academy should definitely state its purpose.

The recommendations of the committee concern themselves, therefore, with steps looking toward the evolution of a public opinion favorable to the purposes stated. That this must be the mode of attaining them, all will agree. It must be a campaign of education. The recommendations are:

1. The acquisition by the State University of a certain tract of land known as The Cottonwoods, which may serve it as an example of wild life preservation as well as a source of materials for teaching purposes.

2. The setting apart of a suitable area of land by the same institution on which may be developed by planting of trees and shrubs, conditions suitable for nesting sites of wild birds, as well as for the attraction of the same for teaching purposes.

Such also will serve as an example and give weight to the idea through its support by the state supported institution of learning.

3. The encouragement of high schools, societies, or other institutions, in gaining control over tracts of land for the purpose of preserving the wild life native or breeding thereon, such control to be either by lease or agreement.

4. The accumulation of data bearing on the location and nature of tracts suitable to the purposes above named.

5. And, finally, the editing and publishing of a booklet in which shall be set forth definite principles of wild life protection, as well as appeals to the public thought in order to bring about the same. This publication, it is believed, should be profusely illustrated in order that it shall appeal to old and young alike. It should be distributed to the teachers of biology in all high schools, and find its place in all public libraries. Were it possible, every school in the state should be supplied with it. Its distribution outside of the state should be made at a nominal cost above that of publication, and such sale would assist materially in defraying the cost of its production. This element in its recommendations, the committee feels to be most fundamental to the ultimate purpose before set forth.

R. E. Wager.
H. C. Cowles.
H. S. Pepoon.
Frank Smith.
Committee.

REPORT OF THE COMMITTEE ON AN ECOLOGICAL SURVEY

To the Illinois Academy of Science:

The most comprehensive and important work of the past year in the field of the ecology of the State is that on the prairie remnants of Illinois, by Homer C. Sampson; the work of the State Laboratory of Natural History on the northeastern lakes of Illinois and on the Fox River draining them; and that of the State Entomologist's office on certain families of insects.

Dr. Frank C. Gates, of Carthage College, a recent accession to our committee, is making preliminary lists of the plants and birds of Hancock county, working out their associations and successions as a basis for future studies.

Dr. Arthur G. Vestal, who has also returned to Illinois during the past year, has begun studies of the historic relations between prairie and forest vegetation in the Charleston region; and Mr. T. L. Hankinson, of Charleston, has been making collections of amphibians and reptiles in that region, while students under his direction have been doing some good work on the spiders, galls, and certain groups of insects of the same area. He has increased his local collections, which now run to more than 14,000 numbers, and some of his students have been helping to organize the data of these collections since September, 1915.

Facilities for ecological work have been notably improved by the completion and equipment of a new vivarium at the University of Illinois, in which Dr. V. E. Shelford, of our committee, is working upon both aquatic and entomological problems. During the past year he has completed a series of experiments on the effect of wastes from gas-works upon fishes, and has shown that essentially all compounds found in these wastes are poisonous, and that they can not be eliminated from contaminated water by any possible treatment. Their introduction into streams should consequently be prohibited. He also made a series of preliminary experiments on the effects of weather upon insects, and concludes that moisture and light, as well as temperature, have much to do with the seasonal abundance of certain insect pests.

Mr. H. E. Chenoweth, working under Dr. Shelford's supervision, has made experiments on the reactions of the white-footed wood-mouse to atmospheric conditions, showing an avoidance of the winds, dry air, and high temperature characteristic of prairies; and two other students, Messrs. Hamilton and Heimberger, studying the reactions of earthworms and underground insects, have shown that temperature, moisture, the kind of soil, and the carbon dioxide and ammonia content of the air in the soil, have important effects on the distribution of these animals. Mr. Powers has shown that the oxygen requirement of various species of crawfishes is in accord with the percentages of that gas present in their usual environments; and Miss Jewell has proven that the red chironomous larvae and tubificid worms commonly found in water contaminated with sewage, may live for long periods without oxygen in acid water, but not in water with an alkaline reaction.

Mr. Sampson began in the summer of 1915, to study the associations of prairie plants occurring in the relic tracts of virgin prairie in Illinois. This work was done under the immediate direction of Dr. Cowles and Dr. Fuller of the University of Chicago, but was financed by the Natural History Survey. The locations of the areas studied were obtained by correspondence with county surveyors throughout the State. Among the tracts found to be sufficiently undisturbed to warrant study were flood-plains and sand prairies along the Mississippi River at Hanover and between Ebner and Savanna, sand prairies in the valley of Green River, in Bureau and Henry counties, morainic sloughs near Lacon and Camp Grove, in Marshall county, numerous prairies on the old bed of Lake Chicago in the outskirts of the city, and a few small areas in Jasper and Clay counties in southern Illinois. Old fence rows and railroad right-of-ways were also examined after the survey had advanced far enough to indicate their limitations as normal prairie relics. The data thus far accumulated seem to warrant the following tentative conclusions:

1. The virgin prairies of Illinois exhibit definite associations of prairie plants. These associations are related in a definite way to definite types of topography and soil conditions which range all the way from such pioneer habitats as clay,

sand, and swamps, to the well-drained soil of the upland prairies.

2. The development of the physiography of these pioneer habitats is followed by dynamic successions of the plant associations. The associations in these successions differ in each particular case according to the initial habitat, but in all cases they ultimately lead to this climax prairie.

3. *Andropogon furcatus* is the most abundant grass of this climax prairie, and usually occupies more than 80 per cent of the total area of the association which it represents. This fact suggests that *Andropogon furcatus* is the climax grass of the Illinois prairies.

4. In their order from pioneer to climax, the most important associations of the hydrarch successions are *Scirpus fluviatilis, Carex vesicaria, Spartina Michauxiana, Calamagrostis canadensis, Panicum virgatum*, and *Andropogon furcatus*. The most important associations of the xerarch succession on sand are *Panicum pseudopubescens, Andropogon scoparius*, and *Andropogon furcatus*.

5. During long-continued grazing, the *Andropogon* and *Panicum virgatum* associations are displaced by a sod of bluegrass (*Poa pratensis*). Each of the other associations is likewise displaced by more or less definite types of pasture plants.

6. Owing to the numerous diverse types of disturbance by man, the associations of prairie plants on railroad right-of-ways are unnatural, and in certain respects do not agree with those found in undisturbed virgin areas.

Relic patches of these virgin associations on these right-of-ways are, however, still abundant enough to give a general picture of the original prairies. Data collected from this point of view show that most of the prairie area of old glacial regions of the State had reached the Andropogon furcatus stage before the coming of the plowman, while much of the prairie area of the Wisconsin glaciation was dominated by *Spartina Michauxiana, Calamagrostis canadensis*, or *Panicum virgatum*, according to the development of the drainage conditions. This conclusion is further substantiated by the word of the older inhabitants who saw these prairies in all their original grandeur.

7. In a general way the trend of the associations on the black soil and clay prairies follows the changes in the moisture content of the soil as the physiography of the regions develop. In the sand prairies transpiration, stability of the soil, and probably nutrition, are also factors of prime importance.

8. The data also support the theory that many of the black soil prairies of Illinois originated from glacial lakes and swamps, and have existed as prairies since glacial times.

The work of the Natural History Survey on the lakes of the Fox River district in Illinois has been under the immediate charge of Mr. R. E. Richardson, biologist of the State Laboratory staff. In these operations, we have returned to an area in which the survey did considerable work more than thirty years ago, and have consequently the means of comparing present and former conditions. Twelve collecting stations were selected last spring, one on Fox River at Algonquin, where the field headquarters were established, three on Pistakee Lake, and the others on Fox, Nippersink, Cedar, Deep, Sand, Long, Crystal, and Zurich lakes. The stations were each visited ten times between June 6 and November 29, for thoroughgoing collections from the open water, the bottom, and the shores, a single round of all the stations usually requiring from five to eight days. These collecting stations were chosen to give as wide a variety as possible of contrasting conditions and environments; and the product of the work is enabling us to make some interesting and important comparisons between the biota of our lakes and that of our rivers, especially with respect to the plankton; between that of the Illinois and of the Fox; and that of the several lakes, each fairly typical of its special class. The yearly history of the life of a lake, and the transformations which it undergoes as the season progresses, are also proving most interesting, especially as each of the different kinds of lakes seems to have its more or less peculiar seasonal regimen. It is too soon to generalize from the product of our studies, even in a preliminary way, but the field opened up by these beginnings is a very promising and inviting one.

In the course of the year's work of the State Entomologist's office, two important papers have been published which contain a considerable amount of ecological data—one by Dr. Philip Garman, on the Zygoptera, or damsel-flies, of Illinois, and the other by J. R. Malloch, on the immature stages of Diptera. Another paper, mainly ecological, published within the year is a general survey of the May-beetles of Illinois, based on a collection of nearly 115,000 specimens, obtained during six years' field work in forty-two Illinois counties. I should perhaps include in this list a study of the chinch-bug outbreak of 1910-1915, printed this year, in which an effort is made to correlate the origin of this uprising, and the course of its events, with peculiarities of weather, soil, crops, and other ecological influences. Especially elaborate studies have also been made on the life history of the codling moth as related to conditions of temperature, humidity, movements of the air, etc., and a first paper on this subject was printed in the last report of the State Entomologist of Illinois. Indeed, the time has now come when all serious studies of economic problems in entomology must include a careful mustering and analysis of ecological factors, the practical importance of which is now commonly acknowledged by students of applied entomology.

Respectfully submitted,

STEPHEN A. FORBES, Chairman.

Addresses

PRESIDENT'S ADDRESS

PRODUCER, DISTRIBUTOR, CONSUMER

Wm. Trelease, University of Illinois

This meeting marks the tenth anniversary of the organization of the Illinois Academy of Science. Lacking none of the features which have made the earlier meetings interesting and profitable to the members in attendance, and helpful and stimulating to the hospitable citizens of the community in which it is held, it enjoys the peculiar good fortune of counting among its participants a number of distinguished scholars who honor us by their presence as representatives of other and older bodies of men working together in other places for purposes very similar to our own if not identical with them. How they see and are meeting the problems and difficulties of organization for collective effort, we shall hear from their own lips and to our benefit. Perhaps, even, they may tell us directly how we can escape some of the pitfalls that they see us headed for, and that they have had to climb out of themselves.

Concurrently with our meeting, a prominent feature of which is the symposium on public health that Dr. Beard has so successfully planned, there is being held a gathering of physicians representative of several counties of the State. If a double program has been arranged for the two meetings, it is because time was not adequate for making one program better serve the purpose of the meetings as a whole. It was hoped some months ago that at this time an organization might be effected of the collegiate mathematicians of the State, thus bringing to our meeting place active interest in a field of science that is lacking to our programs though its exponents are to be found among our members. That this organization could not be arranged for in connection with this meeting, does not preclude the possibility and hope that our later meetings may be enriched by such an affiliation.

Among the delegates to this meeting are representatives of several activities of the commonwealth lying in our field—sanitation, sewerage, and pure water, inquiry into the biological and mineral resources of the State, and the exposition of these in an educational museum which, properly supported and developed, cannot fail to be of great public utility.

At the last meeting of the Academy, Professor Wager brought to our notice the crying need of taking steps—too long neglected—for preserving for our own use and for the use of those who are to follow us, some of the gifts of Nature to a State which is too rich in other endowments to have appraised its prairie and forest, bluff and watercourse, bird and wild flower, at their true value as inalienable from coming generations. A possible national dune park, State reserves, and limited tracts owned or controlled by such organizations as the Chicago Chapter of the Wild Flower Preservation Society, are among the fruits of well directed effort in this direction. Thus far the Academy has been able to give encouragement and approval only: other States have active organizations for the purpose. Is it too much to hope that Illinois will do likewise, and to believe that in conjunction with the Academy of Science a conservation association will work most effectively?

I see in the continuation and enlargement of such affiliations, one of the great possibilities open to us. That less close and general contact among our members may be possible as their numbers at a meeting increase and the program of necessity breaks into sections that meet concurrently, is an evil necessarily attending growth and affiliation: but this is of far less consequence than the good resulting from such organization. The plainest lesson of biology is that success and effectiveness lie in the partition of activity between structurally adequate units; and the aggregation of these into correlated organs and bodies and associations, sharing through specialization the common labor, and unifying it through co-operation.

When the Council made preliminary plans for this meeting, a wish was expressed to disprove any belief that might be shaping itself that a successful meeting is to be looked for only when it is held at the Capital or in one of the university centers. Notwithstanding inherent transportation difficulties, you have justified the belief of your officers that a gathering of this kind may be held with profit wherever the spirit of scholarship exists. The Academy is indebted to the colleges of Galesburg for this demonstration: and I have no hesitancy in saying that, action and reaction being equal, the debt is being repaid in local helpfulness. The Academy has met already in normal schools; the prediction is safe that in holding future meetings under such auspices, the Academy will further its natural functions, growing in efficiency through every helpful effort. We are invited to hold an early meeting at Joliet. If the invitation is accepted, the meeting can be made one of the best in our history: for Joliet is not only an enterprising industrial city, but one which makes provision for home instruction not only up to the customary school limits, but half way through the college curriculum.

Changing standards of value and their bearing on the various strata of society have received so much discussion of late that we have all become familiar with the fact that a community consists of producers, distributors, and consumers. Every one of us falls into the last-named of these three classes, though he may figure also in either or both of the others and perhaps primarily in one of them. The primitive nomadic and agrarian simplicity of producing everything material that one needed has long since passed except for barbarous peoples or under temporary pioneer conditions, and even then, though life might be sustained on one's own productivity, it has enlisted trade for its amplification. Today consumer and producer are coming to a general agreement that increased cost to the former does not yield generally an inordinate profit to the latter, but that the middle man absorbs the larger part of the difference between cost of production and retail price; and if just in the analysis, they recognize that in the main this is a reasonable reward for bringing into our lives material and intellectual opportunities that nothing but commerce could afford, or for giving us an open market.

A somewhat similar analysis of our educational system shows that, as in commerce, three classes exist—producers, distributors and users of knowledge—we call them discoverers, teachers, and pupils, unless we coin for them more high-sounding names under the impression that we increase their importance or dignity by this. It is within our memory, and some of us have enjoyed personal association with men who passed through the experience, that men have worked literally and in the best sense of the word as amateurs in broadening the field of scholarship and founding new sciences and new industries now well established as not only valuable, but essential, while making their own subsistence through practicing some vocation or profession already established in the social system. Today the same groping for new things is going on in every one of these newer sciences and industries. Inherited wealth, the production in remunerative quantities of marketable goods or ideas, or leisure for following a predisposition while earning a living, have been the foundation of these advances: they constitute today the support on which most progress rests; but this is being strengthened and broadened by special provision for enabling the exceptional man to use better or to the best, the talent that marks him as exceptional—in originality, intelligent interest and industry.

Through these conditions it has come about that our largest social system, the most essential and best organized after government itself—that of education—has afforded to teachers, indirectly, opportunity for expansion in the field of scholarship and discovery, while invention and the application of discoveries have been promoted directly in proportion to their money-earning worth. Profitable invention and popular authorship are not taught in the schools; in rare cases they may not rest on scholarship as measured by the common standards; but they nevertheless mark exceptional, often unique, talent, and their reward, larger than that of the scholar, is admittedly just and merited.

A body like the Illinois Academy of Science is essentially a body of teachers: teachers in the primary schools, teachers in the secondary schools, teachers in the colleges, teachers in the universities. It is organized to promote stimulating personal intercourse and the interchange of ideas and information; and, in a lesser degree, to give opportunity for bettering methods, avoiding wasteful duplication of effort, and effective co-operation for achievement of the greatest possible collective results. Its membership consists largely—too exclusively, as I feel—of teachers, but every teacher within its geographic field owes it to himself and to every other teacher to be actively interested in such an organization.

As a nation we are coming to feel that national life can be assured only through that most elemental sort of ability that we call preparedness for self defence, and that this means due participation by every able-bodied man. The great nations that are now at war quickly came to a realization that for them national life depends on adequate industrial organization, and they have effected this. One does not need to lay his ear to the ground to hear the sound of approaching educational organization to the same end, and among these sounds the word "research" is heard very significantly.

Even though we be spared participation in the horrors of the great cataclysm that is rending the world, we shall find it a changed world for the rest of our lives. Everyone is familiar with the expressions "natural selection" and "survival of the fittest," as applied to organic evolution. They are as aptly applied to social evolution; and Bailey's epigram, "the survival of the unlike," points their instant meaning with accentuated emphasis when unlike world conditions are shaping themselves with such rapidity as they are now doing. If the middle-aged teacher of today hopes to grow old in the harness, he must not only see but fall in with the procession. If the young teacher hopes for preferment, he may best look for it through getting well to the forefront, as he can and should if he use the vigor of youth and endurance that is in him.

When we are asked for an elementary teacher in any branch of science, now, we hear the question, "Can he teach agriculture?" A few years ago it was "nature study" that was called for. Vexed by undigested *ologies* and disjointed *isms,* the secondary schools are now trying out "general science." The wants are identical in essence: nature study has been proved, agriculture is having its day of trial, and general science is through the door and may be the favorite panacea tomorrow. Practical, intelligent contact with the world they live in is what we ask for our children. If nature study has been faked, if agriculture be defined too exclusively, if general science prove too vague, a new word will be heard; but it will be merely another effort to secure for the cry a comprehension that the other calls have not brought.

Is it the fault of our children that they do not get what we did not get ourselves, and now ask for them: what they grow up to demand for their children because they were denied it themselves? We see unmistakable signs that the teachers of little children are addressed in this demand. Do they lack what is wanted? If so, they will assuredly give place to those who have it, in the new shaping of affairs: for to the school we are turning with increasingly intelligent insistance that it shall nourish and stimulate interest, afford adequate discipline for the performance of subsequent tasks, and pass the child on with so large a stock as may be of useful information.

Ability to meet this requirement in the schools is echoed up successively from kindergarten to grammar school, to secondary school, to college, and to university; and the tendency is growing to demand that a teacher in any class shall have benefited from a more advanced field than that in which he is to practice. To the colleges fall the opportunity and duty of building onto the foundation of the school a superstructure of ambition, and of correlation and application of a broadened and deepened knowledge. To me the task of a university seems to be to equip this superstructure with a love of productive scholarship, practice in its methods, and a wisdom that differs in kind as well as in degree from the information and knowledge of school and college. And beyond the university with set requirements for winning its academic approval, lies life: life without set requirement and of unbounded opportunity, or life with its possibilities cramped by need of winning the staff on which it rests.

If doctors or masters go from the university without being capable teachers or public servants or investigators, who is to blame? Some say that the blame lies with these men who come with sufficient preparation for no adequate plan for the life for which they are supposed to be getting the last help that others can give them, and in whom the interest of childhood has never been warmed into the ambition of adolescence. Those who say this, see a remedy in quick and complete elimination of the weaklings, so that their own time, the money of trustful patrons or commonwealths, and the productive power of expert teachers may not be wasted.

If college graduates pass into the secondary schools without fitness for their duty as teachers, who is to blame? Some say that the fault is theirs; some, that it lay in the college which received them with faulty preparation and confined them to narrow and narrowing scholastic paths, or else permitted them to wander to little purpose through the whole field of human knowledge, or even allowed athletic or social ambition to take the place of scholarly aspiration.

If graduates of high schools and normal schools who become teachers in the primary school cannot answer those very simple but very perplexing questions that are characteristic of little children, are they likely to offer to their pupils a choice of secondary or artificial interests better fitted to serve as the web of an education than those they repress? If they themselves do not know the common things of nature, of agriculture, or of world science at large, and so fail to make good, who is to blame? Is it that their teachers in the secondary schools failed because their own teachers in the college failed, because in turn these did not get from the university what it owed them? We are disposed to pass the blame along or to lay it on faulty materials out of which even a good workman cannot make anything capable of standing inspection. Do we bring it to rest somewhere on ourselves? If so, the remedy ought to be applied right there. Do we distribute it equally or partially? If so, the average ought to be raised by removing the weakness.

Teachers cannot place the trouble indefinitely with the human materials that go through the workshop. Men and women are not born into the world equal in talent, physical vigor and environment. We are coming to recognize the obligation of society to make the best possible out of every human stick, and we may be going even beyond the dictates of wisdom in what we do for the deformed and the defective. If a child is incapable of marching with the other children, we put him into a grade or a school where his gait is that of the others instead of holding back a normal class, or dragging him hopelessly along at its pace.

There are some who contend, and with emphasis, that if a student is not able or willing to sustain a rather high grade of scholarly progress in college, he should not be permitted to direct public or private benefaction to himself from some one more capable or more worthy. And not a few people think that the benefits of university student life should be restricted to those who demonstrate from the start or by very marked improvement, that these are being assimilated. A more careful sifting of materials and selection of workmen is coming with the changing conditions. If I read the signs correctly, this selection is going to eliminate from the work shop those who are not good teachers: but it is going to pass the straight and the crooked sticks through different shops instead of casting some aside.

What are the ideals sought in a teacher? They appear to be an undying interest followed by ambition and culminating in a good workman's love of his handiwork, in some field of knowledge, reinforced by adequate knowledge and wisdom and equipped with scholarly habits and a capacity to share with others what he has and in such a way as to vivify in them his own interest, knowledge, and productive talent, without himself losing in either.

So far as I know, there is only one way of achieving this—intimate personal contact with the truth; and that is all but synonymous with sustained contact with the scholarly progress of the world and with the underlying materials of such progress. Does a man go into teaching without realizing this? In my judgment he mistakes his vocation. Does he enter the profession unequipped for it? If so he faces predestined failure. Does he think to lead a care-free life of respectable indolence? He should remember that his opportunity is desired by equally able men of higher ideals.

In school and college few men, and they the exceptionally constituted, find time or opportunity for scholarly production beyond their grade; but if they see this door closed to them, it is because they have not lifted the latch rather than that nothing original has been left for them to do with limited opportunity. The university nevertheless is the real workshop of our day and generation: it has found means of lightening the burden of service so that time and energy remain for research beyond the set task of teaching, and it offers appliances and materials adequate to such work of the more advanced kind. By a process of natural selection misfit investigators who cannot or will not teach and teachers who cannot or will not produce are eliminating themselves from its dual chairs.

When I accepted a call to the University of Illinois, something less than four years ago, I found reason to congratulate myself that I was entering an institution which generally pays its younger men a fair salary for twenty hours' service a week —half the daylight time, exclusive of Saturdays and Sundays —leaving them free to carry half the normal amount of graduate study if they wish to work for a higher degree: which eases up on the amount of class room service after they have earned the Doctor's degree and passed into higher grades of appointment; and which makes due allowance for the petty but engrossing duties of department administration.

To me, this was an indication that the great establishment of which Illinois has so much reason to be proud, has passed from the stage in which justification of expenditure has to be made on the basis of either clock-time or semester-student-hours spent in teaching, and that beyond this essentially half of one's time through the college year, and a bonus of a quarter of the year in form of an entirely free vacation, is placed at his disposal for delving into the specialty that represents to him the fascinating part of life—with due provision also for necessary recreation and desirable public service.

It has never seemed possible to me that a university man who sells his service as a teacher may be tempted to defraud the purchaser by trifling with his duty or evading its performance; or that any such man can bend himself to see any justification of such an act when freedom to do what he most wants to do is so liberally granted. The privilege of entering into the lives of a body of young people such as one finds on the campus has seemed to me in itself a sufficient reward for the time and effort needed to do the best in one's power for them in the class periods that the limited schedule makes possible: and the financial end of the contract has seemed to me a means of making possible the scholarly use of what is left free of the day and the week and the year.

So far, I have found very few people who are so misguided as to look to teaching as the means of acquiring fortune, or who are so self-complacent as to take the leisure it accords as a merited tribute to eminent scholarship: on the contrary, they realize that they have acquired eminence, if it be theirs, through scholarship, and they sustain both, if at all, through a directed industry that constitutes the chief pleasure of life for them.

It is really a misfortune that in the great universities only advanced and specialized students come into close relations with their most eminent teachers, and this is not infrequently a cause of complaint. I wonder if it has occurred to those who would claim the personal attention of a university's eminent scholars in the elementary class room that disillusionment would follow as soon as the stopping of intellectual growth had put the idols' scholarship in the past tense? I wonder if it has occurred to those who, as a general principle, would accept full time teaching by the clock—even effective teaching—as a university professor's duty, that every man who is satisfied to repeat without amplifying, eats bread that is craved by some other man as a necessity for acquisition of the knowledge that he himself retails? That is what it comes to.

I am presenting the point of view of a teacher. If I had to view the matter as an executive, I am not sure that I should not recognize that now and then a university teacher is successful beyond his colleagues in stimulating interest and enthusiasm in something worth while but in which his own productivity is nil. If so, I should recognize his worth; but if he enjoyed the privilege of a moderate teaching schedule and great unused opportunities for research, I might ask to be shown that he really stimulated an interest and enthusiasm that seemed foreign to the impulse of his own nature.

I know of no means so well suited as an organization like our own to bringing teachers and investigators together for mutual helpfulness. I know of no comparable opportunity for humanizing and vitalizing abstract discovery side by side with exhibition of the obscure little things that some few have eyes to see and through the seeing of which, once understanding how to look, every one of us may establish and maintain that touch with nature which is the mainspring of successful teaching in science, and which is also the germ of research —out of which, with favoring environment, productive scholarship grows in larger units. In our field, the successful middle man of necessity is also consumer and producer. This Academy is a market in which he may at once buy, sell, and negotiate, and at the same time learn.

The touchstone of success is efficiency. The measure of efficiency lies in achievement. Achievement nowadays rests on division of labor and specialization. Successful teachers are known by the successful specialists they train and through the additions they make to knowledge. Because these additions are published, publication becomes something of an index to one's productivity, qualitatively as well as quantitatively. It constitutes a sort of Who's Who in Activity, valuable as far as it goes, and characterizing the unsuccessful quite as well as the successful man; but its indications, as the years run on, are seen to be sometimes read through the fads and the tendencies of the day, and they may not always carry their face value. Nevertheless publication gives the most available data for judging productivity, and the day of oral transmission of knowledge has so far passed that it now constitutes the principal means of such transmission. Publication of the detailed results of investigation, of the human interest phases of such results, and of popularly comprehensible introductions to the sciences has become a duty of everyone who has that which may be shared with others through this channel.

What is true of the individual is true of the organization. To do its work effectively, our Academy must stimulate investigation through its meetings; and it must make public its acquisitions. It is greatly to your credit that this fact, recognized clearly from the first, has been applied in the issuance of annual volumes that contain much of interest to the general public and stimulating to the teacher, and much that future investigators must reckon on in their work. This has been done under great difficulties, and money has not been found for making publication either as full or as prompt as the merit of the Academy's papers demand. The prospect is now most hopeful that the commonwealth will meet a request for funds that will enable your officers to publish promptly and fully— if in modest form— what you contribute to science and its popularization through these meetings, and to distribute your Transactions broadcast through the State so that every investigator and every teacher may make free use of them. It is our solemn obligation to see that through publicity we make a record, collectively and individually, in which we and the State may take pride.

EARTH GENESIS

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(Special address, Complimentary to the People of Galesburg.)

To those who feel an interest in the evolution of the earth, it is of first moment to learn how the planet was born and what conditions controlled its growth. The other planets of our system no doubt had a birth of like nature and these, as well as the earth, bear traits that serve as signs of the family lineage. It is not clear that the sun was born at the same time, or in just the same way. There is no doubt that the sun and the planets are close akin, but this does not make it sure that they were participants in a common birth. We shall present evidence that the planets sprang from the sun, not at his birth, but later in the course of his history. The satellites might easily seem to be the offspring of the planets and this was the common view in the last century, but there are signs that planets and satellites had a common birth and that the satellites escaped being little planets only because their birth-places fell within the spheres of control of their larger sisters to whom they were forced to dance attendance as a first duty, and respond to the common call of the sun incidentally. If these relations are true, we may search the planets, planetoids and satellites for signs of the later family history, while we look to the sun for signs of their parentage and of the earlier history.

But are these real kinships? Let us look to the evidence.

If the planets were separated by centrifugal action from a nebula of which the sun is regarded as the residual mass —the view that was foremost during the last century—the planets should revolve in paths that lie in the plane of the sun's equator. But the plane of the earth's orbit is inclined 7° 15′ to it and the planes of the orbits of the other planets and planetoids diverge at other angles. These angles may not seem to imply a very wide departure from the theoretical requirement, but when the immensity of momenta of these bodies is considered the divergence is really serious.

But there are much more formidable difficulties. If the planets were separated from the parent nebula at successive stages by centrifugal action, the equatorial rotation of the nebula must have had successively the speeds of the separated parts. These speeds may indeed have been slightly altered subsequently by tidal and other actions, but Sir George Darwin has shown how trivial the tidal effects must have been at the most, and the others are negligible under this hypothesis. The velocity at the equator of the nebula must have increased from about 5.5 kilometers per second at the separation of Neptune to more than 45 kilometers per second at the separation of Mercury. Moreover its velocity must have continued to increase still further as the nebula shrank into the existing sun. As this further increase must have much exceeded that which had already taken place, it might well be supposed that material for other planets would have been separated, and this view was entertained in the last century and diligent search made for inner planets at times of solar eclipses; indeed eminent astronomers even announced the discovery of such planets, but the observations proved illusory. If the radius of the orbit of such a planet had been 1,612,900 kilometers its orbital velocity would have been 275 kilometers per second and the equatorial velocity of the nebula should have been the same at the time of its separation. To separate matter by centrifugal action at the equator of the present sun, the velocity should be 435 kilometers per second. The actual velocity is about 2 kilometers per second. This is a discrepancy so enormous as to seem fatal to the centrifugal theory.

Moreover this difficulty is supported by others not less formidable, though time will not permit us to consider them adequately. Suffice it to say that the values of the planetary momenta seem to be seriously at variance with the requirements of the centrifugal theory. Attention was directed to some of these troublesome features by Babinet a half century ago but he does not seem to have regarded them as fatal, but only as limiting conditions to which the theory must conform. Much later and quite independently Moulton carefully inquired ino the question whether the moments of momentum of the solar system were compatible with the centrifugal theory and found the discrepancies insurmountable. As his arguments rest upon the constancy of moments of momentum, a firmly established principle, they are scarcely less than rigorous.

A less technical argument may be appreciated by laymen, who may readily picture to themselves the solar nebula just before the matter of Jupiter and his satellites was separated from it according to this hypothesis. The mass of the Jovian matter was less than one-thousandth part of the mass of the nebula at that stage. A rough estimate may easily be made of the momentum that could be carried by this little outer rim of one-thousandth part compared with that carried by the remaining 999 parts. It is obvious from even a mere inspection that the moment of momentum of the thousandth part could only be some minor portion of the whole. But yet the Jovian system actually has more than nineteen times as much moment of momentum as all the inner bodies, including the sun, which were supposed to have been formed from the rest of the nebula. It seems incredible that the material for the Jovian system could have been separated in this way. A like inspection of other supposed centrifugal separations leads to analogous discrepancies, some of them proportionately more remarkable.

The cumulative force of the objections to the centrifugal hypothesis seems too grave to be escaped by any special pleading. This does not mean that centrifugal separation cannot give rise to planetary matter in any case, but merely that origin by such separation does not fit the requirements of our present planetary system.

The satellites also offer a silent protest against the pedigree assigned them by the centrifugal hypothesis. The orbital speeds of Phobos and the small bodies that form the inner ring of Saturn demur. They cannot consistently concur in the implications of the centrifugal pedigree. Particularly sharp is the dissent of three satellites recently found to revolve in directions not only contrary to the postulates of the hypothesis but opposite to their fellow satellites attending the same planets.

In the face of these serious difficulties—not to cite others —there seems to me no alternative but to abandon the hypothesis that our present planets and the sun were formed in close succession from a common nebula by centrifugal separation. Some other mode of origin must be found that better tallies with the significant facts of the system. Obviously it must also tally with the great events of cosmic evolution of which the origin of our little system was but a trivial part, however important to us. But before considering these more general relations, let us look to the terms of the hypothesis we offer to better fit the facts of the case.

It has been implied already that the genesis of our sun—and of course the genesis of stars in general—is not regarded as a part of our immediate task. The evolution of the sun is held to be an earlier event. The birth of the present planetary system is assigned to an intercurrent incident, a later episode in the sun's history. This is one of the distinctive features of the new hypothesis. This later genesis of the planets seems required because the rotational features of the sun and the revolutionary features of the planets are so out of accord as to imply origins under different conditions. This is equally implied by the discordant ratio of mass to momentum. The sun holds about 745 out of 746 parts of the total matter of the solar system, while it only carries about 2 per cent of its moment of momentum. These discordant features lead to the conviction that a new agency came in, after the original formation of the sun, and gave to a very small fraction of the solar matter—after it had been drawn out from the sun—a special endowment of momentum. This action is assigned to so simple an event as the passing of a star (or other massive body) near the sun, calling forth a very small fraction of his mass and endowing it richly with momentum from the visitor's own store. As there are a hundred million or more stars in the heavens moving in diverse directions and at varying rates, much like the molecules of a gas, many close approaches and some collisions may be regarded as inevitable, and so our appeal is made to an event of high probability. Let it be noted that no appeal is made just here to actual collisions of stars, but merely to approaches of such degrees that there must have been millions more of them than of actual collisions.

The mode of action of the passing star in calling forth a trivial fraction of the sun's substance and giving it high momentum in orbital form, rests upon an extension and adaptation of a principle enunciated long ago by Roche and confirmed by Maxwell and others. It was shown by Roche that if a secondary body were made to approach its primary, it would be torn asunder by the differential attraction of the primary body so soon as it reached a point 2.44 times the radius of the primary, provided both were homogeneous bodies of the same density, and provided cohesion, elasticity and all expansive agencies are neglected. The principle holds in other cases of close approach than the special one studied by Roche.

Now, if the Roche principle be extended to bodies affected by a strongly expansive and even explosive habit, as in the case of the sun, it is obvious that special effects must be predicated. The influence of the attraction of a passing star is of the differential kind made familiar by the tides. The differential pull of the passing star draws out the explosive body along the line joining it and the star, facilitating explosion along this line. At the same time it compresses the explosive body at right angles to this line, and so localizes and intensifies the explosive action. Thus the explosive body may be said to have become a Janus-faced piece of ordance belted and compressed about the middle, while it fires its projectiles toward and from the passing star. The projectiles shot toward the star are not only drawn toward it by its attraction during their flight, but are drawn *forward* by it in the direction of its own movement. The projectiles shot in the opposite direction suffer an opposite effect in pursuance of well known tidal laws. If the projectiles during their flight are sufficiently deviated by the passing star, they will assume elliptic, parabolic, or hyperbolic orbits instead of returning to the sun as they do in the absence of the deviating effects of the star.

If the forward pull of the passing star is relatively small, as is likely to be the case when the star is distant or small and the ejection from the sun is consequently short, the projectile will fall back to the sun, but it will carry back whatever momentum it gained from the forward pull of the passing star, and this will accelerate or retard the rotation of the sun according to the relative direction of the sun's rotation at the time. If the forward pull has a deviating effect greater than the radius of the sun, the projectile will fall into an elliptical orbit about the sun; the only exceptions being the cases in which the deviating effect is so great that it causes the projectile to pass into a parabolic or hyperbolic orbit and be lost, or else into a reversed elliptical orbit about the passing star and thus become a secondary to it. All these cases are possible, not only, but all these cases were actually encountered by Dr. Moulton in tracing out the courses of the projectiles in the first nine test cases which he followed mathematically to see the actual workings of this combination of agencies. In these cases he made no postulates relative to the mass, position, orbit or velocity of the passing star, or of the projectiles from the sun, that did not seem to lie within the probabilities of the case. In forty-eight cases later tried, he found the dispersing potency of the combination surprisingly effective, even when the passing star was not more massive than our sun, and its approach not usually as close as that of the earth to the sun, though that distance and half that distance were used in a few cases. The remarkable fact was revealed that gravitation, commonly supposed to be the supreme agency of celestial concentration, is really, under the conditions of swiftly approaching bodies of explosive habits, a very effective agency of dispersion.

It was further shown that the passing star may remain within an effective range of action for a period of twenty years in certain cases. The average period in the cases selected proved to be about five years.

During the effective period of influence a succession of explosive impulses must almost certainly take place, and these should give a stream of projectiles in the form of bunches or pulses of solar matter attended by diffusely scattered matter, the two elements constituting, by interpretation, the knots and haze so common in spiral nebulæ. These streams would of course issue on opposite sides of the sun and would curve in opposite directions, a distinctive feature also common in spiral nebulæ.

It is not difficult to see that these features would arise naturally, if not inevitably, under these conditions, but it taxes the imagination somewhat more severely to follow the composite action through the whole series of pulsations called forth successively by the disturbing star until it passes to an ineffective distance, but if done, it will appear that the arrangement of pulses at any instant takes the form of a spiral with two streams issuing opposite one another and consisting of knots and haze, the whole affected with much irregularity but retaining a general symmetry. From the nature of their origin, the streams lie nearly in the plane of the orbit of the disturbing star, and hence the whole takes on a disk-like arrangement. When seen on edge the outline is narrowly elliptical. This discoidal form is well suited to give rise to a group of planets arranged also in discoidal form as is the case with our planetary system.

The spiral feature, it is to be noted, relates to the *streams* of knots and haze, and not to the *individual paths* of each separate constituent. These paths are held to be elliptical, in the main, and to be controlled by the center of mass of the spiral. The knots must inevitably be more or less rotatory, and when large they must control the immediate movements of the matter within their spheres of influence, and so there should be revolutions about sub-centers subordinate to the general revolution about the center of the nebula.

The spiral form cannot last indefinitely. If the central mass is large and the dispersion only moderate, the inner parts must revolve much faster than the outer ones, and so the spiral streams must wrap up, growing more and more involute till they merge into a disk and thus take on one of the forms of planetary nebulæ. In some cases the spiral must merge into a disk in a short period. But if the dispersion be great and little matter left in the central part, the differences in the rates of revolution of the several scattered parts may become small and the spiral wrap up at an exceedingly slow rate and hence its endurance be long.

The mathematical tests of Dr. Moulton clearly implied that for the evolution of a spiral nebula suited to the formation of the present solar planets, the approach of the disturbing star must have been rather distant, for the explosive ejections amounted only to an extremely small part of the whole and the dispersion was relatively limited. Really close approaches of massive stars when one or both have highly explosive habits and when the velocity of approach is exceedingly high and the path at the critical stage is a sharp curve, must produce effects of a higher order, and give rise to spiral nebulæ of a much larger and more dispersed type. Consider, for example, the case of a star of the smaller order passing through the Roche limit of a star of the more massive order. Let the stars have about the mean velocities of stars of the mature type before they appreciably affect one another. As the stars approach one another these velocities will rise to such a degree that when the smaller star is passing through the Roche limit of the larger star, its velocity may reach some few hundred kilometers per second—depending upon the masses of the stars—without making the case an unusual one. Neglecting dispersion for the moment, the smaller star must swing around the larger star in a sharp conic curve and all the while be subject to extreme differences of gravitative pull from the larger star. Under the Roche principle these differences would be sufficient to wrench the small star into fragments if it were merely a passive body held together by its own gravity; i.e. its self-gravity would be somewhat more than neutralized. It follows that in the process all the expansive potency of the star is set free for dispersional work. But this is not done promiscuously nor instantaneously. The star, during its approach, has suffered tidal elongation, giving rise to tidal cones fore and aft and to compression about the middle portion. The cones have grown higher and sharper, and the middle has become more and more compressed as the approach grows closer, so that when the Roche limit is entered the star is rather a fusiform bolt than a sphere. It is moreover constantly undergoing torsion by the changing direction of the mutual pull of the two stars. The tidal cones also are constantly lagging because a gaseous body is viscous. While therefore we may say that the total explosive force of the small star has been set free by the time it has entered the Roche limit, the explosive action has all the while been directed fore and aft by the differential way in which the gravity of the large star has acted. Since the tidal cones—the two muzzles of our gigantic piece of ordnance—constantly lag, and since the curve about the larger star is sharp, the projectiles are never shot directly at or from the larger star, but at a point in its rear and at a point opposite this. The ordnance itself however, is on a rapid swing and the successive projectiles take changed paths. This may help the layman to see how the projectiles successively shot forth during the swing will be related to one another at any instant. Theoretically, under these conditions, about all the substance of the smaller star will be shot away in the form of projectiles. The ordnance is at once missile and ammunition. Only the necessary incompleteness of the theoretical action leaves matter behind to form the nucleus of the resulting spiral. Spiral nebulæ with small nuclei are occasionally seen in the heavens. Of course they should be relatively rare, for a passage through the Roche limit cannot often take place, though it is a half dozen times as likely to happen as a collision.

While the picture of the fusiform bolt is fresh in mind, it may be observed that grazing approaches and glancing collisions are not instances of the touch or the overlap of spheres pursuing straight paths, as illustrations too often imply, but of the touch or the overlap of two elongated slightly curved fusiform bolts swinging violently about their common center of gravity on sharp conic curves.

Collisions must in the nature of the case be rare compared with dispersive approaches of the different types. They need only be mentioned here to fill out the series. A glancing collision is the next step beyond a grazing approach and must quite surely give a spiraloidal dispersion. A center-to-center collision must give a radial or irregular dispersion of extreme violence.

The spiralizing whirl given to an assemblage of matter in swinging about another assemblage is probably not confined to continuous bodies like the stars, but applies also to clusters or galaxies of stars when these closely approach and swing about one another. It probably applies even more effectively when the clusters pass through one another on curved paths. And so, if the view that some of the greatest of the spiral nebulæ are only extremely distant assemblages of stars, a view not without serious objections, should yet prove true, it would perhaps only be a higher expression of the workings of the principle of disturbing and distorting approach. It is to be borne in mind that assemblages about common centers of gravity, whether continuously or disjunctively organized, do not pass one another on straight lines and at even pace, but bend their courses into elliptic, parabolic, or hyperbolic paths and greatly hasten their speeds, while differential attractions arise and increase with approach and inevitably impress their own peculiar qualities on the conjoint action.

In assigning most spiral nebulæ to the incidental effects of the close approach of stars, our hypothesis tallies well with the fact that the number of spiral nebulæ greatly exceeds that of any other form. In announcing their great preponderance, Keeler remarked that they must be due to some cause of common occurrence in the heavens. In view of the multitude of stars, the diversity of their courses and the variety of their velocities, it is difficult to assign an occurrence of a highly potential kind that is likely to be more frequent than the close approach of stars to one another. But sufficient frequency is the least significant part of the coincidence in this case, for, to meet the requirements, the occurrences must not only have had sufficient frequency, but have had such a nature as to give these peculiar results, (1) a spiral form implying at once radial and tangential action; (2) a pulsatory effect, shown in streams of knots and diffuse matter, and (3) a double outstreaming from the center, taking the form of two arms issuing from opposite sides and branching diffusely in their distal parts. The heavens do not present a more distinctive deployment than the spiral nebula, and yet it is one of singular frequency, the dominant species of the nebular type. An eccentric collision is no doubt competent to produce a certain class of highly dispersed spiral nebulæ, as already remarked, but it is doubtful whether it is competent to produce all grades and types of spiral nebulæ, or even the majority of the forms, while the probability of its occurrence is relatively small. Even so far as it is competent and adequate, it appeals to essentially the same principles of action as those that actuate dispersion in cases of approach. It thus appears to be only the last term in a long series, the less catastrophic members of which constitute the majority of actual cases. Eccentric collisions seem too rare events to give origin to so dominant and so varied a group as the spiral nebulæ. They are therefore regarded as one source of spiral nebulae but not an adequate source. Disturbing approach may have a numerical competency from one million to ten million times as great as actual collision, and yet it is not clear that it has any surplusage of competency to keep up the supply when the evanescent nature of the smaller nebulæ is taken into account. This is on the assumption that the present supply of nebulæ is to be maintained by the present galaxy of stars in their normal inter-movements. If one great cloud of stars is now passing through another, as

Kapteyn has suggested, the number of recent dispersive encounters may have been exceptionally large and the present number of spiral nebulæ abnormally great.

In thus following out in some detail our conception of the origin of spiral nebulæ, we have wandered far afield from the planetary problem with which we started; let us return to the modest nebula that was drawn out, by hypothesis, from our sun and was destined to form the family of planets on one of which we dwell. As already implied, the material was sun-substance at the start, and of course in a gaseous state for the greater part, if not altogether. This gaseous matter was shot out in successive pulses by recurrent explosive action, and these pulses took the form of irregular knots attended by much highly scattered matter.

Pulsatory action in a persistently explosive body like the sun seems to be a normal habit and is well illustrated by the sun's present action in projecting "prominences." Such action is likely to become rhythmical if there are appropriate agencies. Such agencies may be assigned in the formation of the solar nebula. Every spheroid has a period of pulsation that is normal to it, and this period is quite certain to influence the periodicity of any impulsive agency that widely affects the body. Nagoaka holds that the successive explosions of Krakatoa during its catastrophic action in 1883, substantially coincided with the pulsation-period normal to the earth. The pulsation-period of the ancestral sun may be assumed to have influenced the succession of explosions made imminent by the increasing influence of the passing star.

There was perhaps a more influential factor. It is assumed that the plane of the orbit of the passing star crossed the plane of the ancestral sun's equator obliquely, for this seems to be implied by the present obliquity of the sun's equator to the invariable plane of planetary system, and also by the anomalously low rotation of the sun which probably implies a reversal of the sun's ancestral rotation. When the tidal cones developed by the star crossed the equatorial belt of the sun, they came into coincidence with its explosive belt and the effect was intensified by this coincidence. It was also affected by the superior centrifugal components of rotation that affected this belt. The concurrent explosive action that arose at this time should therefore have been exceptionally effective. This concurrence probably also fell in with a more or less perihelion position of the star at which time its differential effect was greatest. These concurrences may be the special reason for the greater size and distance of the major planets.

Unbalanced elements in the ejective impulses naturally gave rotation to the knots, and this united with whatever rotatory property they already had as parts of the sun, so that there was a beginning of rotation at the very start. The large knots necessarily influenced the movements of the smaller knots that were shot out with them and kept near them, indeed they fully controlled any that remained within their "spheres of influence" in the technical sense. The whirl of each bunch of knots sent forth by a given explosion would naturally tend to relate itself to a common plane and the knots would generally have a common direction of revolution, but reversals in some cases might obviously arise. Herein lies the basis of origin of the satellites.

On emerging from the sun, the ejected matter suffered great expansion and consequent cooling, and this was followed by further cooling as it traversed interstellar space. Much of the material should therefore soon have been reduced from its original gaseous state to the liquid and solid states; particularly must this have been true of the more refractory material which makes up the greater part of the earth and probably of the other planets. The highly scattered matter of nebular haze could hardly have remained long in any other state than solid or liquid, but it was of course at first in minute division. As the temperature range of the liquid state is small, we may call the cooled matter solid, for convenience. The knots may have retained the gaseous state in larger degree, but the irregular forms they present in so many cases seem better to tally with the view that they too were made up largely of minutely divided solid matter in orbital motion. Doubtless gaseous matter formed some appreciable part of the knots, while a multitude of isolated molecules outside the knots doubtless pursued independent orbital courses about them.

The nebula is thus conceived to have been formed in the main of molecules and minute bodies pursuing orbital courses about the solar center, and subordinately about the gravity-centers of the knots. The movement of these minute bodies was of the same type as that of the planetoids and planets and hence they have been called planetesimals, and the theory of which they are the distinctive working element, the planetesimal hypothesis. Those minute bodies that, in addition to revolving about the solar center, revolved also about the gravity-centers of the knots, may be called satellitesimals if one wants to be specially precise, but the term planetesimal is the generic one and covers the whole class of small bodies revolving in orbits similar to those of the planets.

We have now the working mechanism for the remainder of the evolution. All the rest follows as a matter of celestial mechanics, and the details need not be pursued here. The knots, as the natural centers of growth, gathered in the haze and grew to planets, planetoids or satellites. The eccentricities, obliquities and irregularities of the original planetesimal orbits involved many crossings and thus facilitated accretion. The shiftings of the orbits by the mutual attractions within the system led on constantly to new relations and further aided aggregation until most of the planetesimals were gathered into the growing planets, planetoids and satellites. Perhaps some planetesimals remain unassembled and contribute to the phenomena of the Zodiacal Light and the Gegenschein. The combination of a multitude of bodies in somewhat eccentric and irregular orbits led inevitably to fewer and more circular orbits. The nuclei that grew most came to have the most circular orbits as an obvious consequence, and this is well exemplified in the present planetary system. The planetoids are especially eccentric, while the small planets, Mercury and Mars, have more eccentric orbits than the great planets. As a mechanical effect, each nucleus moved into a larger or a smaller orbit in proportion as more planetesimals of larger or of smaller orbits were added to it, so that the growing planets tended to space themselves out automatically towards the less occupied feeding grounds. Probably the distribution of mass in the nebula gave rise to stable and unstable zones, and the planetesimal orbits were more or less bunched in the stable zones on account of this and thus also the growth and position of the planetary nuclei were influenced. Bode's law thus perhaps comes to have a physical meaning.

But about the directions of rotations of the planets! "Aye. there's the rub."

At the time this hypothesis was first entertained, it had been, for a long time, a standard doctrine that planets formed from coherent rings would rotate in the direction of their revolution, that is forward, while planets formed from bodies moving in independent orbits would have retrograde rotations. If this law holds, our planetesimal scheme of growth, well as it seems to work in so many particulars, fails seriously here, for six of the eight planets have forward rotations. The two others probably rotate obliquely backward, at least their satellites revolve in this way. These last make trouble for the ring hypothesis, to be sure, but still it has greatly the advantage over the planetesimal hypothesis *if* the reasoning back of the alleged law is sound and applicable. It runs in this wise:

In bodies that rotate as a unit, like a ring, the outer part moves faster than the inner part, and besides, every portion of the outer part goes once around the inner parts in every rotation of the ring. If therefore the ring is made to collect into a spheroid in any normal way, the spheroid should inherit a forward rotation. On the other hand, if a ring-like belt is made up of small bodies revolving in independent orbits, as do the particles that make up the rings of Saturn, the inner bodies must move faster than the outer ones, and if these bodies are aggregated in a normal way, it was held the resulting rotation must be retrograde. Here then, there seems to be a lion in the way of all orbital hypotheses, and the planetesimal hypothesis is a most declared type of this class.

But is the reasoning applicable? In the case on which the reasoning is based, the orbits are circular. The whole line of reasoning, as well as the ring hypothesis itself, seems clearly to have had its initial suggestion in the rings of Saturn, and very naturally so, as they seem to be remnants of the process of evolution providentially left for our instruction. Roche and Maxwell, however, showed on theoretical grounds that they teach something very different, and Keeler showed by the spectroscope that Saturn's rings are formed of separate solid bodies and not of gases as was assumed in the Laplacian hypothesis. The orbits of the particles that make up these rings are nearly circular and if massed by some systematic process into single bodies these might not unlikely have retrograde rotations; that would depend however on the precise way in which the particles were brought together. But we need not dwell on this case for it is exceptional; the Saturnian rings were developed under the conditions postulated by Roche and are a peculiar feature. Most orbits in the heavens are not circular and strictly concentric, as are these, but are elliptical, and the planetesimal orbits were by hypothesis notably elliptical. Now the velocity of a body in an inner elliptical orbit is indeed on the average higher than that of one in an outer elliptical orbit of the same type, just as in the case of circular orbits, but *at the points* where an inner elliptical orbit cuts an outer orbit, and where alone the bodies in these orbits can come together, the velocity of the body in the *outer* orbit is higher than that of the body in the inner orbit, *precisely reversing the application of the law.* This may be demonstrated mathematically, but the layman may prefer to visualize it. This may be done in the simpler cases. If a notably smaller elliptical orbit is placed concentrically within a larger orbit of the same type, there can be no collision. It is only when the major axes are so moved that a more or less aphelion or distal portion of the smaller orbit is made to coincide with a more or less perihelion or proximate portion of the larger orbit that collision can occur. If the dimensions be so selected that the precise aphelion point of the inner orbit can just touch the outer orbit at its perihelion point, it is easy to see that from this point the body in the inner orbit falls back in its onward course little by little toward the central body because its velocity is insufficient to maintain its aphelion distance. On the other hand, the body in the outer orbit moves steadily farther and farther from the central body in its onward course because its velocity is more than enough to maintain its perihelion distance, i. e. the common distance of the two bodies when they were together. If the orbits appreciably cut one another, the inspection reveals similar relations of the two velocities but less clearly, and in other cases mathematical demonstration may be the only recourse. That will show, however, that this relation holds very generally but not universally.

The actual rotatory effects of the union of two bodies in elliptical orbits vary with the precise conditions of their union. Keeping in mind that the body in the larger orbit moves the faster at the critical point, it is clear that if a collision occurs when the body in the smaller orbit is *approaching* the junction, the rotational effect will be forward, but if the body in the inner orbit has *passed* the junction, the effect will be the opposite. In a large number of cases both phases are quite sure to occur. The total effect when a multitude of planetesimals are added to a knot will be determined by the mean effect of all. The areas within which collisions tend to forward rotation are greater than the areas of the opposite class, and thus the probabilities distinctly favor forward rotation, but irregular or special distributions make possible retrograde or oblique rotations.

Quite as important as the direction of rotation is the fact that velocity of rotation is not measured by the simple sum of collisional effects of like sign, but rather the algebraic sum of effects of opposite signs, and so the rotation may be low or high according to the propositions of the opposing phases of collision.

Now these features fit the case in hand, for the velocities, axes, and directions of rotation of the planets are quite various and do not conform to the systematic requirements of concentration from a common source. Rotations, slow or fast, forward, backward or oblique, with axes differently inclined, are all consistent with concentration from orbits such as are postulated by the planetesimal hypothesis. There was indeed a lion in the way, but he was chained to a very special and exceptional case.

Perhaps the most important test that can be brought to bear upon theories of the origin of the planets is found in the planets themselves, the ultimate product; in our earth in particular, because it is accessible to close inspection. The Laplacian and the planetesimal hypotheses have been carried down to their specific planetary applications, and have offered us definite stories of the early stages of the earth. These stages form the first chapter of earth history. The harmony of the stories with the later events of the self-recorded history, bear critically on the verity of these stories of earth genesis.

The series of Laplacian pictures is very familiar: (1) a globe of gas; (2) a globe of white hot lava enshrouded in a vast atmosphere; (3) a globe crusted over and covered by a nearly universal ocean overhung by a still deep moist atmosphere; and then (4), a series of slow internal and external changes. Having grown thus gradually out of the fluid state, the concentric arrangement of material normal to fluidity should have dominated the whole evolution and have had marked expression in the final product presented for inspection and verification today.

The series of planetesimal pictures departs widely from these: A nebular knot formed a nucleus at the start, partly gaseous, partly orbital, amounting, it may be, to a third or a half of the final mass. An early concentration of the knot into an earth-nucleus was followed by a very slow growth from the scattered planetesimals afterwards. The long series of infalls of planetesimals generated much heat, but chiefly in the upper zones of the growing atmosphere, whence it was easily and promptly radiated away. The magnetic and inelastic material was brought in faster than the non-magnetic and non-elastic, because magnetic attraction supplemented gravitative attraction, and because the orbital motions of the inelastic planetesimals were faster reduced by mutual collisions than those of the elastic planetesimals. And so the metals and the basic rock-material gathered more largely toward the center, while the more elastic material gathered later and more largely into the outer parts. The accessions were very heterogeneous notwithstanding. The planetesimals plunging into the atmosphere became ignited by the stroke and were largely dissipated to dust which floated at the will of the winds until gravity or precipitation brought it to the ground or the sea. This flotation had a more or less sifting effect, separating in some little degree the heavier from the lighter material, thus building into the very body of the earth a differentiation of specific gravity. This differentiation was abetted by the growing hydrosphere, and both atmosphere and hydrosphere were localized in their activities by the increasing deformations of the earth body. These united processes led thus on to continental embossments of lighter materials, and to abysmal sags of heavier materials. Radioactive matter, lodging at first promiscuously in the heterogeneous mass of the growing body, formed a multitude of self-heating centers. These, co-operating with other sources of heat arising variously in the self-compressing body, started local liquefaction in such material as was specially fusible or soluble, and these liquid parts, under the kneading strains of the earth, worked outward and initiated volcanic action, the radioactive matter partaking in the ascension and thus concentrating toward the surface. Life conditions arose early, and no doubt life soon followed and participated in the processes of growth. Thus slowly the earth grew to maturity and merged into the later history recorded in the known strata. The whole may be shortly summarized as a slow-growing earth-body, bearing a slow-growing hydrosphere, enwrapped in a slow-growing atmosphere.

Critical comparison of these two series of pictures must be left to special students of the earth and to time. Certain vital features of recent determination which will largely control future opinion relative to the genesis of the earth, are worthy of special attention: (1) the undeniable evidence of an alternation of cold and warm climatic stages following one another from the earliest date to which climatic evidences reach, now raised to demonstration by a long list of competent observers; (2) decisive evidence of the deep differentiation of the specific gravity of the earth-material, brought out by Hayford's analysis of geodetic data; (3) evidence of the concentration of radioactive material in the outer part of the earth, brought out by Strutt, Joly, Holmes, and others; (4) the determination of the earth's high rigidity, initiated by Kelvin and others, supported by seismic data gathered by a host of observers, supported also by the pendulum studies of Hecker, and now brought to a full demonstration by the brilliant co-operative work of Michelson, Gale and Moulton on new lines. All these new developments are welcome from the viewpoint of the planetesimal hypothesis. Whether the terms of the older hypotheses can be revised to fit them or not, it does not fall to me to say.

The foregoing relates to the origin of our present planets and satellites. A few words may be added relative to other forms of planetesimal genesis, and to the origin of the comets and meteorites. Elsewhere I have endeavored to show that, on the surface of a great rotating body of hot gases, the molecular activities necessarily give rise to krenal flights of molecules, i. e. elliptical excursions outward from the body, which are checked by gravity and returned to it without the collisions that usually terminate molecular flights within a body of gas. These krenal flights are especially promoted in the equatorial belt when centrifugal separation is imminent. Occasional collisions are inevitable in the course of the krenal flights, and some of these flights are thereby converted into orbital flights. Thus the dominant types of molecular flights are: (1) *within* the atmosphere, intercollisional; (2) at the *summit* of the collisional atmosphere, krenal, (3) in the *outermost* zone, orbital. The orbital atmosphere can only be formed from those molecules that have exceptional velocities, and hence its molecules carry exceptional energy and moment of momentum. The transfer of these exceptionally endowed molecules from the collisional atmosphere to the orbital atmosphere makes relatively heavy drafts on the energy and moment of momentum of the rotating spheroid. The transfer is accelerated by every acceleration of rotation, and the draft of energy and moment of momentum is thus accelerated as the critical point of centrifugal separation is approached. This accelerated draft seems to be such that the equatorial velocity never quite reaches the stage at which separation *en masse,* or even partitively, can take place by simple centrifugal action, but only by this indirect mode. The molecules that pass thus individually into orbits have paths that vary much from one another and are scattered widely throughout the sphere of control of the spheroid. They do not form a simple ring close about the shrinking spheroid, as in the familiar Laplacian conception, nor do they follow closely the analogy of the small bodies that make up the Saturnian rings. They constitute a variety of planetesimals, with elliptical orbits promiscuously crossing one another, and subject to aggregation in much the same ways as the planetesimals of the spiral nebulae, save that there are here no nebulous knots to serve as collective nuclei. This last is a vital point, for, in the absence of collecting nuclei, the aggregates are likely to be many and small, rather than few and large as in our planetary system. The planetary family thus separated from a gaseous nebula in the course of its condensation should consist of a multitude of small planetoids of eccentric orbits and rather diverse planes. A family of this type, on the near approach of a star at some later time, might be thrown into inextricable confusion and its members be liable to pass through the Roche limit of some other body of their own system, or of the new system, and to be torn into fragments which, as clustered groups, would be given very eccentric orbits. Such clustered groups of fragments are thought to constitute the nuclei of comets and from these gaseous emanations, developed by the heat of the sun, form comas and tails. Later, by dispersion, the fragments are scattered into meteorites.

This, in hasty terms, is the planetesimal conception of the origin of a family of planets, or rather planetoids, generated by centrifugal action from a spheroidal gaseous nebula while it is condensing into a sun. Such an origin belongs to the planetesimal genus of hypotheses in being strictly orbital, but the mode is distinctly different from that initiated by a passing star, and evolved through the form of a spiral nebula.

Early in this paper it was intimated that the special problem of the planetesimal hypothesis was the origin and growth of the present planets only, but that the concept must, none the less, be in accord with the greater events of cosmic evolution. A few words on this point seem required to fill out our theme.

The origin of our sun, and of suns in general, was definitely set aside as not falling within the special problem for whose solution the planetesimal hypothesis was offered. The origin of suns must probably, none the less, be related, in some suggestive way, to the processes and principles on which the planetesimal hypothesis is based. It will have been noted that the planetesimal hypothesis postulates an orbital state of the nebular matter. It is thus founded declaredly on orbital dynamics. In the phraseology of the naturalist, it belongs to the orbital genus. It is perhaps entitled to be regarded as the type of that genus, since it found its field by throwing down the doctrinal bars that shut off the orbital state from competency to give rise to forward rotations.

But suns are the great examples of gaseous bodies, and as such, are controlled by gaseous dynamics in contradistinction to orbital dynamics. There do not therefore seem to be obvious grounds for supposing that the stars came into being by an orbital process. Certain of the stars may indeed be concentrations of the large knots of the great spiral nebulæ, but these great knots are assigned to explosive separation from still greater gaseous bodies, and the real genesis of the gaseous state of the knot goes back to the origin of the great suns from which the nebulæ are supposed to have sprung. The suggestion of Kapteyn ("Scientia," Vol. XIV, N. XXXII-6, pp. 345-357) that the irregular nebula of Orion has qualities that fit it for an initial place in the helium series of stars, seems to tally well with the view, entertained earlier in this paper, that center-to-center collisions of stars, or other massive bodies, would give rise to irregular or radiant nebulæ. When one considers the prodigious velocities at which the great stars must collide, it is perhaps not too much to suspect that extreme dissociation attends the collision, and that this may be sufficient to give rise to the spectral effects which appear in the hydrogen-helium-nebulium nebulæ, and these may lead on to the spectral characters that appear in the helium stars and in the series that follows them. This speculative conjecture seems to find a measure of support in the succession of spectra observed in the Novæ. If this be warranted, the origin of this class of stars falls into the final place in the series of stellar approaches, the supremely close approaches, the head-on collisions. This brings the whole into a series of harmonious relationships. The dynamics of the last term, however, are of the collision-rebound or gaseous type, not of the orbital. A center-to-center collision is, however, an event much less frequent than are such approaches as are held to give rise to spiral nebulæ, and yet the stars greatly outnumber the known spiral nebulæ. Perhaps a reconciliation of this discrepancy may be found in the probable fact that the stars endure longer than the nebulæ, and in the multiplication of stars by spiraloidal separation into great knots that later condense into suns of a smaller order.

A further respect in which the stars seem to fall concordantly in with the orbital scheme of evolution, though not themselves of the orbital genus, seems to be disclosed by the recent discovery that the velocities of the stars are correlated with their spectral types, and these, in the opinion of some, are correlated with their ages, and in the opinion of others, with their masses. In either case, the relation is referred to the mutual influence of the stars in their approaches to one another as time goes on, these approaches not being usually near enough to call forth dispersive action. This class of approaches may be assigned a place at the distal end of the series of approaches, while the less distant order of approaches form the smaller spiral nebulæ, the still nearer approaches the larger spirals, the penetrations of the Roche limit, the grazing approaches, and the glancing collisions, the still more effective members of the spiraloid series, while the center-to-center collisions form the extreme climax of the series, giving rise to irregular and radiant dispersions attended by extreme dissociation. The center-to-center collisions obviously destroy a large part of the motion of translation of the colliding stars by converting the energy of translatory motion into energy of dispersion. If, as suggested, the attendant dissociation develops the primoidal spectral state appropriate to a new stellar cycle, the coincidence is suggestively happy.

The evolution of suns is of a higher order than the evolution of planetary systems. The evolution of organized star clusters and stellar galaxies is of a still higher order. In these, suns are but the units. In the dynamic organization of star clusters and galaxies there is a return to the orbital realm. And here again, the fundamental agency may prove to be the Janus-faced function of gravity acting paradoxically and partitively as a dispersive as well as centralizing agency. It has already been mentioned in passing that galaxies swinging near one another, or interpenetrating one another eccentrically, may develop spiraloid configurations on principles closely like those assigned to the origin of spiral nebulæ. If this view is justified, or so far as it is justified, our planetary hypothesis finds a correlative in an undeveloped gallactic hypothesis.

It will perhaps be generally conceded that the energies that express themselves in orbital activities transcend those that express themselves in gaseous activities. In like measure, orbital cosmogony seems to transcend gaseous cosmogony in dynamical potency. But there are interchanges between them and no doubt an equilibrium between them. That both have fields whose immensity and intricacy transcend all human grasp goes without the saying.

Symposium on Public Health Problems

PUBLIC HEALTH PROBLEMS

Dr. J. H. Beard, Health Officer, University of Illinois

From their ages at death individuals may be divided into two groups: the premature and the senile. In the former, death occurs during growth, in early maturity, or in the great period of activity and is largely preventable. In the latter, the age of productivity is passed, senescence is at hand, and passage of the Great Divide is the law of Nature. It is the purpose of this symposium to consider the premature group in some detail as to its causation, prevention, social, economic, and medical aspects.

It is estimated that two and a half million children are born annually in Continental United States. Of this number about 300,000 will die during the first year of life. One of every eight children die before they are a year old. A new born child has less chance of living a week, than a man of ninety; of living a year, than a man of eighty.

Over 500,000 people die of communicable disease each year in this country; over six million are sick as a result of avoidable infection. Such a loss of life and health, if localized, would completely depopulate Cleveland and would cause every citizen of Minnesota, Wisconsin, and Kansas to seek medical attention. The immediate death rate and illness of infectious disease are probably no more important than their complications and sequelae. Measles and whooping cough may prepare the soil for tuberculosis; scarlet fever for renal disease; tonsillitis, pneumonia and syphilis for cardiac failure; infectious disease in general, but syphilis in particular for degeneration of the vascular and nervous systems.

Our industries are making considerable progress in the protection of workers from the illness and accidents of occupation. There are, however, each year about 25,000 deaths due to industrial accidents and 700,000 injuries involving a disability of four weeks or longer. One-third to one-half of these are estimated (by competent authorities) to be preventable by proper safe-guards, inspection and control. Each of the thirty million workers in this country lose on an average annually, nine days from work on account of sickness, more than twenty-five per cent of which is avoidable. This great economic waste should cause capital, labor, and the community to realize that of all the instruments used in the production of wealth and happiness, none is so delicate, so sensitive, or so indispensable as the human machine. The capitalist will find it excellent economy to carefully supervise its operation, to prevent it from being injured by dust or corroded by chemicals. It will be an invaluable advantage to the employee to learn its use so as to protect it from destruction by ignorance and carelessness. The nation must preserve it, or forever give up the dream of commercial supremacy.

Diabetes, cirrhosis of the liver, cancer, vascular degeneration organic heart and Bright's disease are becoming more frequent before sixty. Many individuals are dying prematurely when as a result of training and experience, they should be of the greatest value. Thirty-six per cent of the deaths between forty and fifty and fifty-nine per cent between fifty and sixty are due to so-called degenerative diseases.

The expectation of life has increased for all persons up to a point between thirty-five and forty. For all ages above forty, there is a constantly increasing diminution of the duration of life, varying from six months at forty, to three years and three months at eighty-five. Tissue heredity may be a factor in the reduction of expectancy after forty. Its importance, however, must be small as compared to the influence of environment, the intemperance of food and alcohol, the harmful effect of occupation and the latent injuries of infectious disease.

The lack of personal hygiene, irregular employment, improvidence, bad housing, and low physical stamina cause a high mortality of the mentally defective. Over one million of our population is made up of the unfit, delinquent, insane, and criminal. We have 187,000 inmates in our hospitals for the insane; 480,000 prisoners; and, approximately 500,000 feeble-minded. These are the drift-wood of industry; the retarders of classmate and teacher; the procreators of the unfit; and, under our present social system, the most common cause for the travesty of justice. Syphilis, alcohol and heredity are potent factors in the production of mental deficiency, a condition, therefore, largely preventable.

THE ECONOMIC IMPORTANCE OF PREVENTABLE DISEASE

The economic cost of preventable disease is appalling. All children dying before the tenth year represent a total loss, Values have been created and destroyed without giving return. Society is demanding each year greater skill and increased efficiency. The larger investment in the training of the individual makes the loss most extensive. Nearly one-third of the deaths due to typhoid fever and one-fifth of those caused by tuberculosis occur in the high-school-university period of life. The time of the greatest expenditure in the preparation of the individual to enter service.

The toll of syphilis, typhoid fever, and tuberculosis is heaviest during the period of greatest usefulness. Syphilis shortens the expectancy of life 5.5 years. It may fasten itself upon the posterity of the individual, increasing degeneracy, encouraging poverty, and promoting public charges. It erects about 15-20 per cent of our asylums for the insane and taxes the nation for their maintenance. Tuberculosis and typhoid cause 90 per cent of their deaths before sixty; make tens of thousands seek public charity or spend large sums to care for themselves when they should be producing.

Industrial accidents and illness among workers are annually responsible for the loss of a billion dollars in wages and expenses for medical care.

The great economic loss due to the death of individuals before they have become an earning power, and of those dying during the productive period of life, is small, compared to the stupendous loss caused by invalidity, unemployment, decreased efficiency, and the cost for the care of the sick and defective.

PREVENTION

Whether we consider personal hygiene; the rural portions of the country with its problems of home and school sanitation, or, our cities with their social and engineering difficulties in the control of disease; prevention is a question of money, education, and the use of available scientific knowledge.

Within natural limits community health should be in direct proportion to the economic status of the individual and to the financial support received by constituted health agencies.

This is especially true in the reduction of infant mortality; in the promotion of industrial hygiene, and in the prevention of epidemics.

If we are ever to have preventive machinery commensurate with scientific knowledge; education of the public and of future community leaders must be pushed with greater vigor. The relation of preventable disease to social and to economic welfare requires that no student in our colleges or universities should complete his education without a thorough elementary knowledge of hygiene and sanitation.

It is of little importance, for what field the institution is preparing the future leader; to be successful he must have continued good health. If he studies Spanish and Business with the future planned for commercial expansion in Latin America, his success may largely be determined by whether he is bitten by a mosquito that may give him yellow fever, malaria or dengue. If engineering is his profession, the condition is the same, whether at Panama or on the Rand, the success of his achievement will depend upon his health and that of his employees. Should he become an agriculturist, to protect himself, his family and his community, he must meet the problem of rural sanitation. Should he select pedagogy as a vocation and should not recognize the relation of errors of refraction, defects of hearing, under-nutrition, and mental retardation to class repetition, he can not attain the community leadership that should be his heritage. Should he worship at the shrine of Mars, other things being equal, his eminence as a commander will be in direct proportion to his sympathetic co-operation with the sanitarians of his command. Should he seek to be a captain of industry, to be able to meet modern competition, he must have knowledge of industrial and vocational hygiene. In short, there can be no rule of efficiency that does not include the gospel of health.

Finally, if hygienic living is to supersede the fierce struggle for existence in a large part of our population; if infant mortality is to be decreased to a proper level; if rural sanitation is to be elaborated; if senility is to be kept beyond forty-five; if workers are to engage in industries without injury to health or to the reduction of their period of productivity; if communicable disease is to be prevented; if we are to have more students in our colleges and universities than we have of the unfit in our institutions for the defective; our future leaders must be taught as never before, the use of available scientific knowledge in the promotion of health and in the production of mental and moral superiority.

INFANT MORTALITY AS A PUBLIC HEALTH PROBLEM

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One might say infant mortality is not a public health problem: it is THE public health problem. Infant deaths (that is, deaths of babies *after* their birth but under one year of age) constitute one-fifth of all deaths at all ages, and, physicians tell us, at least half of them are preventable. Deaths before birth are said to be even more numerous than infant deaths.

Some years ago France, appalled at the small margin between births and deaths, took steps to lessen the number of infant deaths, and Germany and England have not been far behind her. Congress, in creating the Children's Bureau, assigned to our own country the task of studying this question. In spite of all the study that national governments have given the subject, the problem is not yet solved. The hopeful thing though is that in some places where serious efforts have been made a reduction in the infant mortality rate has actually occurred.

The great loss of life in this disastrous war has so thoroughly aroused public interest in the subject in Europe that one of the war economies most prominently urged and generally accepted there is economy in babies.

Few Europeans today discount the value of war equipment, yet England's practical men and women are urging that "babies are of greater import than battalions and truer dreadnaughts." Germany designates its present reinvigorated efforts for the conservation of infant life as "movements of increasing and improving national efficiency." France tells her citizens that the combat against such of their enemies at home as alcoholism, tuberculosis and infant mortality is of pressing import and of vital necessity, and that infant mortality is now a problem of the life and death of the nation and all other problems are secondary.

These countries and even Belgium, with all her burdens, and the small neutral countries divert attention from details of fighting, and appeal to patriotism in language that every one understands. Dr. Louis C. Parkes, before the Royal Sanitary Institute, estimated that two years of war cost the five principal belligerent nations (England, France, Russia, Germany and Austria-Hungary) nine millions of males of military age. Adding losses sustained by other countries he brings the total up to twenty millions. The people in Europe are told to "Make up for the terrible wastage of war by conserving all the young life possible"; that "The child should have a fair start in life and arrive at maturity physically fit to take his part in the heritage of the Empire"; "The nation needs men, more men, still more men, and the child is father to the man"; "The nation survives in its young," and so on.

We think with horror of the number of American lives lost in Mexico, or on the high sea and in the danger zones and some of us demand action—to prevent these losses. Why should it take the awful shock of the unexpected or of war to make us see things? Why should not our health officers try to make our people see that our complacence in a steady calamity of more than one third of a million infant deaths yearly, is a terrible indictment? The conscience of Europe is touched by its infant deaths—it thinks it needs men to win its wars.

We like to think it is an American belief and ideal that every child has the right to be protected from disease and to have a fair chance in life. When all of us fully realize that steps to lessen infant mortality are the most fundamental in the whole program of the conservation of national vitality, we will demand that health officers everywhere act. By demanding that they act I mean vote them funds for their work.

There are people who say that any attempt to reduce infant mortality is an interference with natural selection which tends to lower the average health of survivors. But a human being is not merely the sum of his ancestors. If this were true perhaps there would be but one type of mammal or one type of life. By using "the words nature and nurture for the terms heredity and environment"[1] and thinking of a living being not as nature alone, nor as the sum of nature and nurture, but as the product of nature and nurture, we can, I think, more readily see that effective work in the reduction of infant mortality requires the ascertainment of the social, economic and civic factors involved.

An infant with the most favorable heredity will most certainly succumb if exposed long enough to the fumes of illuminating gas, hence we guard it against such exposure and we guard it also against exposure to damp and to cold draughts—even though there be no respiratory taint in its heredity. Things that kill and weaken do not invariably attack the unfit, they sometimes kill the fit or make them unfit.

The Children's Bureau has no administrative functions. It has been ordered by Congress to "investigate and report," and it is seeking to ascertain the degree of coincidence that exists between various social, economic, and civic factors, and a high or low infant mortality rate.

Its method of studying infant mortality is to secure data directly from the mother by visiting her after at least one year has elapsed since the birth of her child, even though the child may have been stillborn or may not have survived a full year. Some of the questions are very intimate and personal, but our refusals have averaged less than one per one thousand mothers interviewed.

Our findings thus far indicate that a high infant mortality rate is a definite, significant symptom of defective social and economic conditions, but it is exceedingly difficult to measure the relative importance of each factor.

On account of poverty a mother may remain ignorant of the simple rules of hygiene that might promote her own and her baby's health. Or, on the other hand, she may well know the advantages of fresh air, cleanliness, sunlight, and proper food for herself and baby, but be without the necessary facilities for ventilating her home, or without time or means to secure cleanliness and other wholesome conditions that she appre-

1 C. W. Saleeby, M.D., "Nature and Nurture," Nat. Health, London, Mar. '16.

ciates and desires. Babies die at a greater rate where these advantages are lacking.

A high death rate is coincidental with house congestion. Congestion implies all sorts of other unfavorable conditions and is usually a result of poverty. It might be relieved to some extent, however, if suitable homes were available at a moderate rate.

Artificial feeding in the early months of life also has an important share of the responsibility for a high infant mortality rate. The cessation of breast feeding is largely traceable to ignorance, but such ignorance is not confined to illiterates Either because they cannot afford competent advice on the subject or because they fail to realize the importance of feeding, mothers, acting on their own or their neighbor's mistaken judgment, sometimes discontinue breast feeding because they fancy their own milk is insufficient, or that it does not agree with the baby, or that it makes very little difference in any case. Some mothers stated that when they got up from child-bed too soon and had to take up tasks, that taxed their depleted strength, their milk left them entirely. Sometimes the discontinuance of breast feeding in the early days or months of a baby's life is absolutely essential. A contagious disease or another pregnancy may make it necessary to give the baby artificial food. But we believe a vigorous educational campaign in favor of breast feeding is urgently needed.

The influence of unfavorable prenatal conditions is evidenced by stillbirths and by numerous deaths in the early days and even early hours of life, as well as by the frequency with which physicians certify prematurity, congenital debility and congenital malformations as a cause of death. Dr. Saleeby says, in effect, that one might say of a child whose mother had worked in the lead industry during her pregnancy, "better dead"—if the child happens not to have been born dead. Health officials should try to reach prospective mothers in a community and make known to them the dangers of such work during pregnancy. If the episode of birth were the beginning of life we might disregard these deaths and begin preventive work after a child enters the world. Why not consider the advisability of that measure which is now being advocated abroad for compulsory notification of pregnancy so that infants need not be born unfit because their mothers were not cared for during pregnancy? It is important, moreover, to impress the mother in advance of the baby's arrival, with the urgency of breast feeding from the earliest possible moment after birth.

Education, by means of the publication and distribution of properly prepared health literature, in the languages spoken in the community, may do something to improve the health not only of the prospective but of the nursing mother as well. Of course this will not avail where a woman's poverty will not permit her to have the necessary nutrition and care. If such a poverty group is large, the remedy frequently lies in the hands of the community itself. For example, a community need not permit industry to operate in such a manner that it absorbs the time and strength of a large part of the population and yet returns, in the form of wages, so little that the individual workers are unable to purchase the right to live in sanitary homes in healthful localities and to provide for themselves and their children a supply of clothing and food adequate for health and comfort. Any industry is a parasite on the community when its workers must herd together in unhealthy places and become a menace to the public health and morals. Children born in such surroundings, it has been demonstrated, die at an abnormal rate. Literature alone will not help a mother to protect her baby if her husband's low earnings force her to labor and live under all the conditions of their resulting poverty that are so detrimental to health. Unless the community evolves a plan of regulating the industries within its limits which, while employing, consume mentally and physically the people whose hands labor to build and enrich them, it can never adequately reduce its infant or other death rate, or its expense of caring for defectives, dependents and delinquents.

Writers and speakers in recent years have so insisted upon the uselessness of the excessive number of infant deaths that the public is ready to regard infant mortality as an index of the efficiency of public health administration. Any health officer who now convinces his community of the truth of New York' motto, "Public health is purchasable," and then makes it realize that a direct attack on infant mortality will, as a by-duct, create a healthier community will have done a great work.

THE PREVENTION OF DISEASE

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This title is broad, and I have taken the privilege of using only a portion of it, that which by inference applies to the communicable diseases.

Occupational diseases, diseases due to neoplasms, degenerative diseases due to the wear and tear of life, to dietary faults and to narcotic drugs, surgical conditions and a considerable number of other morbid conditions cannot be further referred to.

COMMUNICABLE DISEASES

ONE. Isolation and Quarantine.

The oldest and most generally effective measures for the control of communicable diseases are isolation and quarantine. The rationale of these measures has a three fold basis, viz:

1. Prevention of contact. A large proportion of these diseases depend for their dissemination upon contact of the patient with other humans.

2. Biological antagonism resulting in germ death. An attacking force of pathogenic organisms is successfully combatted by the defensive forces of the human body and usually perishes in toto in the case of a large number of diseases which are styled "self-limited."

3. Disinfection of discharges. Body discharges may be disinfected when proper isolation is maintained, thus destroying a common source of disease spread.

Specific Instances.

There are no communicable diseases in regard to which quarantine and isolation are not enormously useful measures, and there are some in relation to which these are our chief and perhaps only preventive agencies. Among the more common of such are measles, scarlet fever, mumps, chickenpox and whooping cough.

Two. Control of Carriers.

1. Lower animals as carriers. Some diseases may be brought under practically complete control by the control of the animal species which are their sole means of dissemination. Such are yellow fever, and malaria, disseminated by mosquitoes, the stegomyia and amopheles, respectively; typhus fever, which is louse borne, and bubonic plague which is carried from rodents, especially rats, to man, by fleas. To this list may be added Rocky Mountain spotted fever which is conveyed to man by a species of tick.

2. Human Carriers. Aside from the agency of patients in spreading diseases, we are forced to recognize the fact that persons who have acquired a large degree of immunity may harbor, especial in body passages, disease germs which when transplanted to non-immunes, may have pathogenic results often of an epidemic character. There are such typhoid and diphtheria carriers. There are such epidemic cerebro-spinal meningitis and possibly acute poliomyelitis carriers.

The venereal diseases, especially syphilis and gonorrhoea, are conveyed at times by those who are not suffering in an obviously acute manner from these diseases, though they cannot be strictly said to be immune carriers.

The control of human carriers is obviously fraught with difficulties. But we hope that the growth of enlightenment will give society the power to identify and control such carriers and that the increase of good will among men "when this cruel war is over," will make all carriers ready to be cleared of any agency in the spread of disease.

Three. Control of Diseases by Biological Agents.

There are reactions and reinforcements which may be produced or introduced into the human system which are positive in their preventive effects. Vaccination in the case of smallpox; anti-typhoid and anti-paratyphoid inoculation in the case of these diseases; anti-tetanic serum in tetanus and diphtheria anti-toxin are examples of positive control of the respective diseases. To these may be added anti-plague, antimeningococcic and anti-dysenteric sera of large curative and prophylactic value, and preventive because bactericidal in the human body.

Tuberculin is a valuable agent in the treatment of some forms of tuberculosis though only in a limited way curative or preventive.

Serum from those who have had acute poliomyelitis has been hopefully used in those attacked, though this agency is still in an experimental stage.

Very hopeful is recent word that for the two most common types of pneumonia, there is now possible a curative serum of very great potency.

FOUR. Sanitation.

Sanitation always stands as a barrier to all communicable diseases. Water, milk and fly borne diseases are easily preventable by rendering free from human and organic waste all sources of food and drink.

Polluted water is not only a typhoid source but perhaps less so than it is a source of the enteric diseases of infancy and childhood—which slay more people than does typhoid.

The unspeakable fly, filth born, filth bred and filth bearing, is a busy, ubiquitous distributor of whatever disease germs the body may excrete.

Personal hygiene is a central factor in disease prevention, especially hygiene of the hands. The Mosaic legislation says nothing of hygiene of the teeth, though it well may have done so. However, it is too late now to pass the suggestion to Moses. However, Moses passes the suggestion to us, and it were well were it heeded as Divine Command, that we should not "eat with unwashed hands"; neither should we cook with them, and especially we should keep them out of our mouths when eating is not the order.

FIVE. Education.

We look to educational processes for our greatest gain in disease prevention. "The people perish for lack of knowledge."

With education must go both information and moral culture. The old chivalry of man toward women, the old modesty of women toward men, and all the moral urgency of ethics and religion are needed to save us from the blighting and almost universal venereal disease peril.

SIX. Inspiration.

This last because many people ill with many of the long-drawn-out communicable diseases fail of cure and remain sources of infection as men fail everywhere from lack of persistence.

There is enormous and everbrightening hope for the tuberculous who have the moral courage to persist in the regime which we now may establish in almost every household.

Quackery fattens on the ignorance and especially the impatience of its victims. Trying this and trying that breaks the golden chain which every way bind the tuberculous patient around the throne of God.

Many are cured of tuberculosis; and all who are cured have no miracle wrought and find no portable and salable "cure," but do find cure in an intelligent regime patiently and persistently followed.

RURAL SANITATION

Surgeon Mark J. White, U. S. Public Health Service

Rural communities comprise the farm, the hamlet and the village, or the unincorporated, in contradistinction to the incorporated community. Sanitation is the practical application of measures for the preservation and promotion of public health.

Concerning the value of sanitation, employers find it profitable to maintain and safeguard the health of their employees, and to provide good working conditions for them in order to obtain maximum efficiency. Sanitation, therefore, is a valuable aid in money making and money saving. It is this important feature of the value of Sanitation which it is desirable to advertise, so that business men will use it in their business. Every experienced and wide-awake business manager realizes that if he provides sanitary work room, with good air and light and space, and free from noxious and harmful gases, dust, noises, etc., he can more readily retain his skillful employees, and that it is to his financial benefit to keep his employees healthy and fit in order to get their best efforts. The more perfect the sanitary conditions of a home, a factory, a mine or a store, the more comfortable and attractive the occupants find their environments, and the greater are their disposition, desire and ability to do good work. Environment is a potent factor in human success, and sanitation improves environment.

While it is clearly the right and function of the State to make and enforce its own police regulations, it is lamentable that this function is not more uniformly and adequately performed. There are several reasons for this failure, but the principal one is that the populace do not appreciate the practical value of sanitation, and therefore neglect to provide sufficiently for its enforcement.

The Federal Government, having legitimate interest in the economic development and general welfare of the nation, and appreciating the urgent necessity of developing more fully the agricultural industries, has undertaken to make the rural communities more attractive and more profitable. This educational activity in no wise whatsoever interferes with the jurisdiction of the State, but it materially aids the State authorities in extending, developing and maintaining sanitary conditions. In the furtherance of the "Back to the Farm" movement, the Federal and State authorities are co-operating, and those of us who are engaged in public health work realize that as the rural communities become more densely populated and the lines of communication become more numerous, the occurrence and prevalence of disease will seriously menace the success of the movement, unless adequate sanitation is provided and actively maintained. The more frequent and easy the communication between rural communities, the greater the likelihood of the introduction and spread of disease, not only of man, but of domestic animals.

But the purpose of Rural Sanitation is not only to establish and maintain conditions conducive to health, but to eradicate diseases which prevent the safe residence in certain sections. Many fertile acres cannot be cultivated profitably because such diseases as Malaria, Typhoid Fever, Hookworm Disease and Rocky Mountain Fever too seriously interfere with those who undertake the work.

It is a matter of common observation that the sources of infection in many cases of typhoid fever and malaria which actually develop in our large cities, are traceable to rural communities such as summer resorts, roadhouses, picnic grounds, and the small towns and villages which the city residents have visited. Insanitation in rural communities is a constant and growing menace to the public health and to business prosperity. The touring car, automobile truck and interurban cars are bringing the communities into more frequent communication, and it behooves the people to take out sanitary insurance as well as fire insurance, for they are both business propositions. Sanitation is a business matter, and not a sentimental fad.

Insanitation in certain rural communities is closely related to and dependent upon insanitation in the incorporated towns whose taxpayers support inactive mayors, councils and health officers. Too often do farmers go into town to purchase supplies and carry back to their homes typhoid fever and other preventable infections. Such misfortune may happen during the busy season when the farmer needs all the help he can get to till the soil and carry on his other activities. It is bad enough if he loses the service of but one of his helpers, but such is not, as a rule, the only misfortune, for if his premises are insanitary, the chances are that a depot of infection will be established on his farm from which other members of his household or employees obtain the disease. And if he happens to be a dairy farmer, how easily does he distribute these infections in his dairy products, which are often sold as pure, rich milk, and delicious ice cream, to the sons and daughters of the progressive taxpayer. But the taxpayer gets what he pays for, and the people are the taxpayers.

We have, however, undertaken to bring about the establishment and the maintenance of sanitation, and we shall succeed.

RELATION OF PUBLIC WATER SUPPLIES AND SEWERAGE TO PUBLIC HEALTH

Paul Hanson, Chief Sanitary Engineer
Illinois State Board of Health

Public water supplies of one sort or another are of great antiquity, and the most notable examples of the early public water supplies are those built by the Romans, the most notable feature of which were high and beautiful stone aqueducts for crossing valleys. The aqueducts were necessary in those days because suitable piping had not been devised. The remains of these aqueducts cannot but excite admiration for the engineering courage of those days. During the middle ages public water supplies practically ceased to exist, and even the purpose of the Roman acqueducts was forgotten. In the sixteenth century, however, public water supplies were installed in London and Paris, but the distribution systems were limited, and the water was not delivered to houses.

Practically no advance was made until the early part of the nineteenth century, when the introduction of cast iron pipe, and the development of pumping machinery made possible the public water supply as we now understand it. Even so, during the early part of the century, progress was very slow, and in 1850 there were but 83 public water supplies in the United States. Beginning about 1870 water works were installed in rapidly increasing numbers. The Manual of American Waterworks for 1896 shows a total of about 3200 water supplies, and a recently published Waterworks Directory indicates that there were in 1914 over 5,000 public water supplies. We are now beginning to accept the viewpoint that no municipality is too small to have a public water works.

Notwithstanding the fact that even in ancient times there was an appreciation of danger to the public health from the use of impure water, this danger was generally disregarded until very recent times. As late as 1905 or 1906 most public water supplies, instead of being a protection to public health, constituted an exceedingly great menace to public health. Water supplies were installed primarily for fire protection and general convenience, and not as a means for securing a pure drinking water. Generally an adequate quantity for large cities could be more cheaply and readily obtained from rivers than from the ground by means of wells or springs, or from carefully guarded watersheds, and as the health danger was little appreciated, river water was generally used.

The first effort at treating a water for purification purposes was made in London in about 1830, when some sand filters were installed which were not very different in design from some of our modern plants. The object of these filters, however, was primarily to remove the visible turbidity, and little thought was given to the possibility of removing disease germs. However, it was a matter of observation that the filtration of the water improved the public health and this gave an impetus to the further use of purification works. In the 70's, following the clear enunciation of the germ theory of disease by Pasteur, there developed an appreciation of why filters produced an improvement in health conditions, and methods were developed, principally by Frankland, for examining the bacterial efficiency of water purification works.

Even so, progress lagged discouragingly behind knowledge and it required the frightful epidemic of Asiatic cholera in Hamburg in 1892 to thoroughly awaken the world to the dangers of impure public water supplies, and to give an object lesson in the difference between filtered and unfiltered water. The epidemic at Hamburg is an oft-repeated story, and while the lesson of the epidemic has been retold by many other epidemics, yet the magnitude, the dramatic character, and its influence upon water works practice and public health activity, renders it pardonable to again repeat the main facts.

Hamburg adjoins Altona. Hamburg obtained at that time its water supply from the Elbe River, and delivered it to the consumers without purification. Altona also obtained its water supply from the Elbe River, but the water was passed through slow sand filters before being delivered to the consumers. In some way the river water became heavily infected with the organisms of Asiatic cholera. An epidemic broke out in Hamburg involving within a period of two months 16,800 cases, and 8,600 deaths. In Altona there were approximately 500 cases and 300 deaths, most of which gave a history of having used water in Hamburg. As a bit of confirmatory evidence of the effect of the public water supply, there was a block of buildings in Hamburg housing 400 people, and supplied with water from Altona. These people were exempt from the disease. As in the case of all communicable diseases, its ravages were not confined to Hamburg, but tongues of the outbreak shot out to other places and even reached the port of New York.

Stimulated by the example of the Hamburg epidemic, there developed a movement in the United States for better water supplies, and it also caused certain legislatures, notably that of Ohio, to empower state boards of health with authority to supervise the installation of water supplies with a view to protecting the public health.

The early filtration works were of the so-called slow sand type, and were extensive in area, costly to build, and not readily adaptable to the treatment of very turbid waters. American ingenuity came to the rescue of this situation in the early 80's by the invention of the so-called rapid sand filter, assisted by preliminary chemical coagulation. These filters were able to give good results when operated at rates approximately forty times as great as rates permissible with the slow sand filters. Because of their small size, it was practicable to introduce means for flushing the filters, thereby thoroughly cleaning the sand at frequent intervals.

At first these filters were regarded with skepticism by engineers, but a series of experiments in Louisville, Kentucky, in 1897, conducted by Fuller, showed that when correctly designed, they could produce results equal to those obtainable with slow sand filters, and moreover they could handle waters of very high turbidity. Rapid sand filters were thus firmly established as an acceptable and satisfactory means for the treatment of municipal water supplies.

Following the Louisville experiments numerous filtration plants were installed in various cities of the United States, all of which, unfortunately, were not efficiently designed, or efficiently operated. Even the poorest, however, unquestionably constituted a great protection to the public health, and assisted in the growing movement for purified water supplies. It is but proper that acknowledgment be made to the various filter companies that built and installed these filters for much educative work incident to their promotional activities, and it is perhaps pardonable that sometimes their zealousness in making sales warped their better engineering judgment.

As the basic patents on rapid sand filters expired, rapid sand filters were built more and more according to the designs of technically trained engineers, and we find the best examples of filter practice among filter plants installed in this way.

As an indication of the rapid progress in the purification of the public water supplies in this country, it may be stated that in 1892 not over 500,000 people in the United States were supplied with filtered water and most of the filters were of very questionable efficiency. According to figures compiled by Johnson, about 2,000,000 people in the United States were supplied with filtered water in 1900. At the present time approximately 20,000,000 people are supplied with filtered water, and these plants built since the earlier period show a marked improvement in both design and operation.

Striking as the above figures are, they do not tell the whole story of progress towards securing pure water supplies, because many cities have abandoned impure supplies in favor of supplies naturally pure, and others have protected existing supplies by storage and watershed patrol and diversion of sewage in a manner to adequately protect their purity.

In the year 1906, a hitherto unused means for protecting the purity of water supplies was developed, namely sterilization by means of hypochlorites. It was found that a very high bacterial reduction in a water could be obtained by the application of six to twelve pounds of hypochlorite of normal strength to a million gallons of water. The means for applying the hypochlorite are very simple and so there became available a method for treating any water supply so as to render it at least safe at a trifling expense. Soon afterward chlorine gas was used for sterilizing water, with effects equal to those obtained by means of liquid chlorine. Chlorine did not come into general use, or threaten to displace hypochlorite until within the past few years, because only recently have reliable and effective means been devised for applying the chlorine gas to the water. The use of chlorine is now generally regarded as more satisfactory than the use of hypochlorites, and with present war prices for chemicals, it is considerably cheaper than treatment with hypochlorites.

The use of cheap sterilizing agents has not, as was at one time feared, displaced filtration as a means of water purification for several reasons. First, the public having been educated to the superiority and ready availability by means of filtration of a clear and limpid water, now as a rule demands that such water be furnished, and in fact, muddiness has been as great a friend to water supply improvement as has the fear of disease. In the second place, sterilization with chlorine and hypochlorites has its limitations in that it usually imparts a taste and odor to the water to which it is applied, especially when large quantities must be used to counteract the effect of heavy pollution, much organic matter, and high turbidity.

It is therefore becoming the custom in connection with all public water supplies where turbidity and color must be removed, to place the main reliance upon filtration, and to use a sterilizing agent as an auxiliary or finishing treatment, and as an additional factor of safety.

The real test of the effect of purified water supplies on the public health is to be found in its influence upon communicable diseases that may be water-borne. The most important of these diseases in the United States at the present time is typhoid fever. Because of the relative hardiness of the organism of typhoid, this disease has not been so easy to eliminate from the country as cholera.

In a survey of vital statistics relating to typhoid fever in the United States, Johnson has shown that in 1900 the typhoid fever death rate in the registration cities of the United States was 36 per 100,000. In 1915, the typhoid fever death rate in registration cities was 15. Thus there has been a reduction of 58 per cent. This remarkable reduction is believed to be due entirely to improvements in public water supplies, because these cities that have always had a pure water supply show only a slight decrease in the typhoid fever death rate.

We see better the real effect of the improvement in the public water supplies by considering individual cities. In Philadelphia the typhoid death rate before the installation of filters was approximately 50 per 100,000. At the present time it is about 13 per 100,000. In Cincinnati the typhoid death rate before the installation of filters was about 50 per 100,000, and at the present time it is approximately 8 per 100,000. Many other instances could be cited, but the limitations of this paper will not permit.

With present knowledge regarding the influence of public water supplies on the public health, and the methods whereby water supplies may be purified, the maintenance of an impure public water supply can be due only to ignorance and negligence. Unfortunately there are a number of communities, principally of small size, which exhibit either this ignorance or negligence. There are 20 such cities in the state of Illinois, When it is considered that an impure public water supply not only affects the citizens of the community in which the supply exists, but also affects visitors to that town, and causes the town to become a focus of infection throughout a wide area, it is perfectly plain that the state at large has an interest in the matter, and that state boards of health should have ample power to demand that no public water supply be installed unless it is obtained from a source of assured good quality, and that any existing public water supply that does not measure up to modern sanitary standards, should be purified or replaced by a supply of naturally good quality. This power exists in most states east of Illinois, and in many west of Illinois, but has not been specifically granted in Illinois. The public of the country is now fully educated to the desirability of such regulation and there is no reason why it should longer be withheld.

Sewerage systems seem to have quite as great an antiquity as waterworks, as evidenced by the world-famous Cloaca Maxima of Rome and the supposed tile pipe sewers recently discovered on the Island of Crete, which were used by a pre-Grecian civilization. These earlier sewers very nearly approximate in their character and purpose the modern sewerage system. But like water works, the sewerage system as we understand it in modern times, is a relatively recent development very closely paralleling the development of public water supplies. In fact both from the sanitary and utilitarian point of view a sewerage system should be regarded as a concomitant part of a waterworks system, and vice versa, a waterworks system should be regarded as a concomitant part of a sewerage system, for the reason that neither of these utilities can be properly operated or give satisfactory service without the other.

The prime object and advantage of a sewerage system from a sanitary point of view is to quickly, inoffensively and effectively remove human wastes, thereby preventing them from constituting a nuisance or endangering public health. Notwithstanding the fact that the best of engineering ability has been devoted to the perfection of sewerage design and construction, and that it is now possible to design and build such systems that are economical, good in operation, and an absolute guarantee against danger to public health, insofar as such works can affect the public health, yet in our practices, especially in the rural communities and smaller cities, we are little further advanced than the most primitive savages.

Many efforts have been made to show by statistics the effect of a sewerage system on public health, but these efforts have not generally been successful, because it has not been possible to separate the influence of the sewerage system from other influences, and moreover it is very rare that full advantage is taken of the presence of a sewerage system by compelling the use of the system by all property owners, wherever the sewers are available. In many instances, also, the sewerage system is not sufficiently extensive to permit full advantage being taken thereof. However, it is possible to observe tendencies, even though an exact numerical value cannot be placed upon such tendencies, and there seems to be no room to doubt that a properly designed and properly operated sewerage system has a very great value in protecting the public health.

On the basis of extensive observations throughout the United States, the United States Public Health Service has reached the conclusion that in cities where the public water supply may be regarded as safe, the installation of a complete sewerage system will reduce the typhoid fever death rate in northern cities to ten or under, per hundred thousand, and in southern cities the reduction will be to twenty or less per hundred thousand.

The principal evil growing out of the extensive installation of modern sewerage systems is the pollution of streams. Many streams in the United States have been so grossly polluted as to be fit for no other purpose than as a receptacle and an open drain for putrefying wastes. This situation is due entirely to the fact that benefit from the installation of adequate sewage treatment works accrues to the down stream neighbors of a community using the sewerage rather than to the community itself. Once in a while a city may modify its method of sewage disposal in order to prevent polluting its own water supply, and befouling its own water front; but rarely does a city of its own volition do anything to protect the water supply or the water front of its neighbors.

It would therefore appear very clearly that the matter of sewage disposal, has an inter-community relation, and by virtue of this fact, becomes a matter that should be regulated by the state, or in the case of interstate streams, by the nation.

By way of summary it may be said that with a pure public water supply serving all of the people in a given community to the exclusion of private supplies less pure, and with a complete sanitary sewerage works serving all the people and used to the conclusion of human waste disposal methods less efficient, typhoid fever will be virtually wiped out, and other communicable diseases of an intestinal character will be reduced in like proportion. Complete extermination of these diseases may be expected when food supplies, more particularly milk, are under absolute sanitary regulation, and when persons harboring the germs of this disease, may be properly controlled.

CANCER AS A PUBLIC HEALTH PROBLEM

DR. J. F. PERCY, GALESBURG

Of all the public health problems that confront the so-called civilized portion of mankind, cancer is admittedly one of the most important.

Up to the time of the present war, it was estimated that at least 30,000 scientific men and women were devoting their time to unraveling the mystery of its causation. As to what this is, there is absolutely nothing known at the present time. One thing seems to be positively known about cancer, viz: that in its beginnings, it is a local disease. Whether this local condition is caused by a germ or a cell is, however, not known. The theory on which the advocates of either the germ or the cell idea of its causation is based is most convincing until one reads the views and arguments on the other side of the question.

There is a popular notion that a tumor and cancer are two different conditions. This is not true. Tumor means any growth. Every cancer is a tumor but every tumor is not a cancer. For the purpose of this paper I am going to assume that cancer is due to the misplaced activity of the body cells at the point of origin of the disease.

As you will readily recall, the tissues of the body are made up of many cells. They have been likened to the bricks in a house, one upon the other in a marvelously orderly arrangement. But they differ from the bricks in the wall of the house in that they are never still. They divide and subdivide indefinitely. As soon as the mother cells are worn out, daughter cells take their place. One beautiful characteristic of these developing cells is that they always respect their neighbor cells and never invade foreign territory. Each kind of tissue in the body, whether it is bone or muscle, nerve structure or skin, has its own peculiar cells. Each of these groups of cells does its own work and follows its own cycle of life. When a tumor that is not cancer, develops in any one of these four groups of cells, it is always made up of the cells characteristic of that tissue. But when a tumor develops that the expert pathologist, aided by the eye of the microscope, pronounces cancer, the whole orderly arrangement of the cells in any of these tissues is wholly changed.

The minute anatomy is no longer normal for that special tissue. Disorderly arrangement is substituted for orderly arrangement. The cells grow, cell upon cell. They crowd together in wild disorder. Those in the center of the mass are jammed so closely together that they are deprived of their nourishment from the body fluids and die; and as a result we get the common picture of ulceration.

This process of visible destruction is one of the too well known horrors of the advanced case of cancer. When this breaking down of the tissues commences because of deprivation of the blood supply, it is increased and hastened by the entrance of the pus producing organisms. This always indicates the later and usually hopeless stage of cancer. Unfortunately the victim of the disease up to this advanced stage suffers no pain. Did pain characterize the early stages of cancer, its possessor would insist upon its immediate removal. As a result, in the vast majority of cases, there would be no "late stages" of the disease. When this process of ulceration is initiated it of necessity also involves the blood vessels and lymphatics. When these open channels are broken into, the debris of the disease, i.e., the cancer cells and pus organisms, enter the blood stream and the changes in the individual patient begin to be marked. He shows even to the ordinary observer that he is sick. He loses weight, he no longer cares for food, and his skin loses its normal look and becomes dry and sallow, often a lemon yellow. When these broken down cancer cells get into the blood stream they may be arrested in any vessel that is too small to permit them to pass on. When this occurs they start a new growth in this new environment and they grow with seemingly increased virulence. It makes little difference where the new growth starts, in the lip or in the female breast, when these cells or germs get into the circulating blood they may stop in the liver or spine, or in the walls of the intestine and at once begin their characteristic mischief like a German soldier transplanted to Belgium or France or Serbia. These, then are some of the reasons why the cancer cell is the anarchist among cells. It is the supreme disturber and destroyer of the orderly processes of normal physiological growth.

What starts the aberrant growth of cells which, when we recognize it, we call cancer? An endless amount of valuable literature has developed about this marvelous scientific enigma. The theory most generally accepted at the present time is that most malignant growths have as the exciting cause of their development some form of irritation. There are many curious and apparently significant facts lending strength to this theory. As an illustration of this eighty-five per cent of the cancers of the lip develop in smokers. Fifty per cent of the cancers of the stomach are found developing from the edge of a previous ulcer. Dr. Fibiger, of Denmark, noticed that the native rats that died around the sugar warehouses of that country never had cancer of stomach or intestines; while the rats that came over in the ships from America and died, frequently had cancer of the stomach or intestines. In looking about for the explanation, he discovered that the American rats often ate American cockroaches. He then imported some of these cockroaches from America and fed them to the Danish rats, with the result that these rats also developed cancer of the stomach and intestines. This led to the further investigation of the cockroaches found in America, which disclosed that they frequently harbored a small parasitic worm which was not found in Danish roaches. The irritation caused by the intestinal worms undoubtedly was the explanation of the frequent presence of malignancy in the intestinal tube of the American rodents. Many more instances could be cited where the development of malignancy seems to be coincident with the production of a chronic irritation. Cancer of the kidney is one of these where presence of stone in fifty per cent of the cases probably accounts for presence of cancer. In eighty-five per cent of the cases of cancer of the gall bladder, gall stones are found. Cancer of the groin is very common in chimney sweeps, and in sailors. In the first-named the soot, together with the loop of rope in which they swing, produces the necessary irritation and this is found, i.e., the irritation from the rope, true also of the sailors. In Kashmir, a province of India, the natives carry a charcoal stove under their cloaks and against the skin of the abdomen to ward off the cold. The most frequent form of cancer, therefore, in this region of the world is that of the skin of the abdomen. In China cancer of the pharnyx is very common among the male portion of the population, while it is almost unknown among the women. The explanation is that the men eat at the first table at meal time when the rice is hot, while the women eat at the second table when the rice is cold, thus escaping the irritation produced by the hot rice. Cancer of the tongue is frequently found with bad teeth. The so-called black moles, when irritated, frequently give rise to a most vicious and destructive form of cancer. Dr. A. J. Ochsner, of Chicago, in an address before the American Medical Association three years ago, made the interesting statement that there would be much less cancer of the stomach when Americans stopped eating so much manure with their food, referring more especially to the use of uncooked vegetables that had been raised on ground fertilized from barn yards and privies.

There is no reliable evidence that goes to show that cancer is in any measure contagious. The writer saw the late Dr. Senn, of Chicago, have a rather large piece of active cancer tissue, which he had just removed from the breast of one of his patients, transplanted under the skin of his own arm and sewed in. The whole mass gradually disappeared and the doctor died some fifteen years later from causes that in no way could be related to his courageous experiment. The question of heredity as related to the cancer question is still a mooted one. From statistics it would appear that those who have had cancer in their family stand a little better chance of not having it than those who have never had a case in the family. But statistics of families in this country are based on too meagre data and we would do well to question it when based on this kind of evidence. When we get to the point where we have vital statistics that cover the disease over a period of at least one hundred years, we shall be in a better position to draw conclusions on the basis of heredity.

This statement is more to the point when one is familiar with the unique scientific investigations of Miss Maud Slye of Chicago. This worker has made an exhaustive study of cancer as it affects mice. Her work in this connection would also seem to show that the disease is not transmitted by inheritance. Her investigations also certainly show—and she is authority for the statement—that in mice at least a predisposition to its development is positively inherited. Experimenting with thousands of mice, Miss Slye has succeeded many times in breeding in and breeding out, at will, cancer in mice, and made it succeed as an experimental problem depending on what strain she selected with its known hereditary predisposition.

Another significant fact in the work of this original investigator, at least as far as it applies to the study of the problem of cancer heredity in mice is that it is not the second or the third generation which shows up the predisposition to cancer development in families, and what it is to be; but the fourth, fifth or even sixth generation that emphasizes or controls the determining factors.

So when the human family finally arrives at a knowledge of predisposition to cancer as a family problem they may be immeasurably aided in the study by knowing what diseases troubled not only their grand parents, but the great grand parents as well.

It is a curious fact also in the enigma of cancer that a little injury to the body is more frequently followed by cancer than a severe one. Cancer rarely develops from a fracture of one of the larger bones of the trunk; but a comparatively slight bruise of one of these bones may develop the disease at seat of the injury and this too, months or years after its receipt. Just why this is so, can not in our present state of knowledge be explained. Why the supposed irritation of a slight bruise should be more potent in this regard than a more extensive and severe one merely illustrates the difficulties under which we labor when we try to explain some of the facts which now seem to be fundamental in the development of this real scourge of the race.

In the beginning of this paper it was stated that there was only one thing known positively about this condition, viz., that in the beginning it is always local. Cancer never commences as a large mass. At first it is so small as to be microscopic in size. More than this, it is marvelously slow in the vast majority of cases, in its development; if on the surface, its removal or destruction is one of the simplest problems in all of medicine or surgery. But right at this stage usually commences the great tragedy of cancer as it affects the individual patient. It is usually not removed when it is a little insignificant growth, and because it is not we have the real explanation of the title of this paper, "Cancer as a Public Health Problem." The problem is, to get the individual would-be sufferer to act early and quickly. But suppose there is doubt as to the real character of the growth? The answer issimple. If an experienced physician or surgeon is in doubt as to the nature of the growth, the patient should be given the benefit of the doubt and have it removed at once. If the abnormal growth is permitted to develop until there is no doubt as to its nature, effective treatment is futile in just the degree that its removal is delayed.

If it progresses to the stage where the neighbors or the casual passer-by can make the diagnosis, its destruction becomes the greatest problem in surgery, and the necessary treatment frequently required is so heroic in its character as to make the surgeon and the layman alike question the wisdom of making the attempt.

When we remember in an acute way how awful and how hopeless the latter stages of the disease are, we shall better appreciate the wisdom back of the official motto of the American Society for the Prevention of Cancer when it says: "In the Early Recognition of Cancer lies the only hope of Cure."

Should there be any little mass that persists, or, if sore, that heals suspiciously slowly; any lump that can not be accounted for; any discharge that is unnatural, i. e., persistent or offensive or bloody, find out, if you value the joy that comes from freedom from suffering, what it is that is back of it.

Why women especially will hide a tumor or ignore an abnormal discharge is one of the mysteries of every physician's professional life. One can not help but question whether there may not be in cancer a toxic product which affects the brain of the sufferer in such a way that he will not or cannot sense its relationship in an intelligent way to the doom due to neglect that awaits him. It is well known that the tubercular are usually optimistic even when well advanced in the disease and probably the same explanation will hold good in regard to cancer, that it in its progress elaborates after all a beneficent toxic substance which will rationally explain their unwarranted hopefulness.

Therefore, and to repeat: Early recognition, combined with adequate removal, usually means a comparatively easy and complete cure. Late recognition and delayed treatment always means suffering that can not be described by words, or written by the pen, and it also means sufficient morphine to ease the patient away into, at best, a slow and miserable death.

The ravages of tuberculosis in all the centuries of the past were immeasurably reduced by public education as to the best means for its suppression. The same means must be adopted to diminish the ruin and waste of good human blood and tissue from cancer. In five years, by thorough and persistent teaching of the public, the physicians of Germany increased the number of cancer patients who could be treated with an increasing hope of relief from forty per cent when they started the propaganda, to eighty per cent.

Reliable statistics show that one out of every eight women that we pass in the street and who have reached or passed the thirty-fifth year of age, will die of some form of cancer, and that one man out of every twelve will die in the same useless way. If what was said in the beginning of this paper is true, and the best recognized authorities agree that it is true, that the beginnings of cancer are always in one little, local spot—what is the most practical and hopeful thing to do in order to circumvent the trouble? The answer is that every man and woman should be thoroughly and completely examined twice a year after they are twenty-five years of age.

From its practical side we do not consider it incongruous to see a dentist twice a year in order to prevent the pain incident to decaying teeth. Why should the same thing not be done in order to be sure that cancer is not developing somewhere on the outside or under our skins? It is most unfortunate that the onset of cancer and tuberculosis is not ushered in by pain as one of the very first symptoms, as is true of some forms of diseased teeth, instead of its being among the very last of the symptoms which close the chapter of life in the sufferer from cancer. Pain is a beneficent thing when it starts us on the road that will steer us away from the conditions that are back of it whether physical or moral.

In the modern treatment of cancer four methods are recognized as of value. The selection depends on the stage of the disease when the patient first presents himself for treatment.

The first of these is excision of the growth by the knife; second, the X-Ray; third, the use of Radium; fourth, the application of heat as devised by the author of this paper.

In the small growth of cancer the knife, made to cut wide of the disease, still holds, in the opinion of many real surgeons, the first place. The operation is much quicker, the convalescence rapid and the resulting scar much less prominent than by any other operative method. The chief danger in the use of the knife, as far as the final results are concerned, is always the possibility of a small nest of cancer cells outside of the main growth being invaded by the knife, and the knife thus infected with the disease spreads it into new areas. In other words, the knife vaccinates the disease into places where it did not exist previously. This is known to surgeons as a process of auto-transplantation of the disease. It is this fact, always feared by the surgeon, that has given the knife treatment of cancer most of its reputation for not curing the disease. But the fault usually has been that the surgeon has attempted to cure the disease with the knife when it was too far advanced to safely avoid this coming in contact with and scattering of the cancer cells and inoculating them from the edge of his cold steel knife into places where they previously had not existed. But in suitable cases the cold steel knife has permanently taken away from the cancer victim a serious menace to his life.

The three remaining methods of treatment are mainly used in those cases of cancer on the borderland of operability with the knife, or that other great majority of cases which are utterly inoperable with the knife. The X-Ray, Radium and the heat method will all destroy a cancerous growth utterly if the malignant mass is in a situation where the treatment can be applied efficiently. Failure of efficient application is the chief trouble with all these methods. Radium or X-Ray, even in large doses, cannot be made to destroy a large mass of cancer because sufficient penetration cannot be obtained. A large mass of cancer in the liver cannot be reached by either the X-Ray or Radium. This is also true of cancer of the stomach or of the abdomen.

The most efficient method of treating cancer today is by a combination of the four methods mentioned above. If the knife is used it should be followed by the use of the X-Ray or

Radium, because these agents can be made to destroy a small focus of cancer if it should remain after the major portion has been removed by the knife.

As has already been pointed out the weak point in the use of the cold steel knife in cancer is the possibility of scattering the disease by its use. In order to avoid this danger the author devised a knife which is heated by electricity. Wherever this knife touches cancer it kills it so that there can be no dissemination of the disease in new areas. A curious and interesting fact regarding the use of heat in cancer is that a mass of cancer is killed when the temperature in the growth is raised to 113° F. and maintained for ten minutes. So that cancer, if it is at all accessible, should be removed by the hot knife, and if it cannot be removed, it should be destroyed by raising the temperature in the growth to fully 113° F. This is far and away the most efficient means so far devised of dealing with the fully developed malignant mass. The small masses that may be left because contiguous to some vital organ or organs, as the large blood vessels or bladder or rectum, can then be reached by large doses of X-Ray applied by those thoroughly conversant with its application.

It has been known to physicians for generations, that if the sufferer from malignant disease should accidentally develop an intercurrent attack of erysipelas, he would also in a rather large percentage of cases be cured of his cancer. The reason for this has never been understood until Delbet of Paris, following some experiments on mice and rats suffering from cancer, announced that it was the heat or fever developed in the body during the progress of the erysipelas that caused the destruction of the malignant growth.

It is also an interesting fact that following the removal or the destruction of a mass of cancer by the hot knife or the application of heat the patient's suffering is practically nothing, completely cooked flesh does not complain.

So far I have very briefly outlined the cancer problem as it affects the public today. There seems to be no very secure foundation on which to base a prophecy as to the lines that further study of the cancer problem and its final treatment, based on this study, will take. Many trained men believe and numbers of them have tried to find a serum or an agent that will attack the condition through the channels of the blood. But so far nothing of striking effectiveness has been worked out.

I asked a great authority in pathology on the other side of the water, one of my teachers, many years ago, if the *cause* of cancer would ever be discovered and he replied after the manner of the oracle at Delphi: "The man who discovers the cause of cancer will be in a position to describe the anatomy of the human soul."

General Papers

SAFEGUARDING THE FOOD AND WATER SUPPLY —A FUNCTION OF THE STATE

E. H. S. Bailey, University of Kansas

Some protection of our food and water supply from accidental impurities or those that have been purposely added nas been regarded as of importance since the earliest times. The workmen excavating on the site of the ancient city of Samaria found the labels still intact on some of the jars of wines and oils with statements as to where the wine was produced. We are not much in advance of that time in requiring that the label on the food package shall bear a true statement as to its contents.

In England as far back as the time of King John (1203), laws were passed regulating the sale of bread, and in the following reign the "pillory and tumbrel act," as it was designated, was passed for the express purpose of protecting the public from the dishonest dealings of bakers, vintners, brewers, butchers, and other food purveyors. It was in force for more than four hundred years and very severe penalties were decreed for any violation of the statutes. "The punishment was made to fit the crime," as when the seller of impure butter was made to sit in the pillory and have the butter crushed over his head, and there he was required to remain until it had been melted by the sun.

In Germany, in 1435, a certain taverner and his wife were exposed on the pillory in a cask from which they had sold adulterated wine. This appeal to shame and disgrace has been replaced in the twentieth century by a fine and confiscation of the goods. Does it indicate a change in the incentives of the people?

Doctor A. H. Hassall, more than any other Englishman, should have the credit of arousing the people in 1850 to the appalling state of the food supply by his examinations, especially of coffee, cocoa, cayenne pepper, bread and confectionery on the market. The result of his investigations, published in The Lancet, led to the "Adulteration of Food and Drink Act," which was passed in 1860.

In this country Massachusetts was the most progressive state, and in 1883 enacted a pure food law. Other states followed this lead and the era of pure foods and drugs was at last fully inaugurated by the passage of the Federal statute in 1906.

The protection of public water supplies and the control of such supplies by national or state authorities, has also an interesting history. It was not, however, until recently that different states of the Union began to supervise the whole subject systematically and to favor legislation putting the authority to control the water supplies and the sewage disposal in the hands of Boards or Commissions composed of scientific and medical experts.

The question of the improvement of food and water supply may be considered under two heads:

(1) The necessity for improvement.

(2) What has actually been accomplished within the last decade.

It is evident from the history of the movement that the most logical and practical way of securing an improvement in the food supply is by the action of Federal, state, or municipal authorities. Something may be accomplished, but the public will not get along very far in the correction of abuses, by the education of the manufacturers and dealers in food products, as they have few inducements to reform.

If it is assumed that the food, as originally produced, is of good quality, how does it deteriorate or become unsatisfactory for use? This condition may be brought about by the carelessness or neglect of those who handle the food or by conditions of temperature or storage, so that the food is "rotten, decayed, or putrid," and thus a menace to health. All animal products, but especially fish, are exposed to this kind of deterioration. Fruits must also be carefully watched. It is true that cold storage has done much for the consumer by "carrying" food for one season to another, but it must not be forgotten that cold storage products "go down," as the saying is, very quickly when kept at ordinary temperatures. Much of the so-called ptomaine poisoning is no doubt from this source.

There has been a temptation to sell food under a misleading label. Apples grown in Missouri are marked as if grown in New York. Sardines in olive oil are really sprats in cottonseed oil, etc.

Again foods are "made up" to sell just as the actress "makes up" for her part on the stage and by the use of similar dyes, cosmetics, and beautifiers. The officials condemn this procedure on the ground that the food is "mixed, colored, powdered, coated, stained, or otherwise treated in a manner whereby damage or inferiority is concealed or whereby it is made to appear better than it really is." Thus, "orangeade" is made by the use of well water of doubtful origin, tartaric acid, and coal tar orange dye, on which liquid calmly float day after day the same identical slices of orange pulp.

It is probably heresy to say it in a great wheat-producing state, but there is really no excuse for bleaching good, wholesome wheat flour. Is it not painting the rose? Simply because there is a supposed demand for white flour, why treat the product of nature with chemicals to satisfy such a depraved taste? Maraschino cherries are first bleached by chemicals, then dyed some particular shade to suit the "color scheme" of the hostess. Oranges and grape fruit are picked while really green, rushed to market in cars so arranged that the fruit will be "sweated" in transit, and so appear to be ripe when they reach the breakfast table. The fine flavor of the fruit has never been developed, hence they are dry and tasteless.

The sale of light-weight packages has been largely corrected by the law which requires the weight to be stated on the package. The itinerant vender may, however, still peddle from house to house and sell you his produce in a badly dented tin measure or perhaps thirty-six pounds of apples in a so-called bushel basket, for the forty-eight pounds required by law. These are a few of the reasons why the state must supervise the sale of food products.

The author has had occasion recently to revise a book written about ten years ago, and was surprised to see how many statements made at that time in regard to the adulteration of foods were no longer necessary or even true. That is what food legislation has accomplished.

The spices on the market are almost always pure. Even ground coffee, if mixed with cereals or chicory, has a statement to that effect on the label. Corn flour is not substituted for wheat nor for buckwheat flour. There is little sale of preservatives for food. Oysters are shipped in sealed containers, iced on the outside, so that we get solid and not floated oysters. Extracts correspond in composition to the label. Condensed milk is not sold as condensed cream. Foods that are artificially colored or flavored with synthetic products are so labeled. What has a decade not wrought!

With reference to the water supply, Federal and state authorities have taken over the supervision of the water furnished to cities and towns, and the people have been protected—

(1) From contractors or engineers who would install water works in localities where the supply was unsatisfactory in quantity or quality, or at unwarranted expense.

(2) By having the water supply regularly tested by competent chemists and bacteriologists, instead of depending on the dangerous and ever-changing water from their own private wells.

(3) By having the water sold by private companies carefully analyzed to guard the consumers against contamination.

(4) By having the water furnished on railway trains tested for its purity.

(5) By a scientific investigation of the sewage problem for each locality and by advice as to the best practical method for getting rid of sewage and garbage.

And what, you ask, is the next step forward? Continue by practice and precept to educate the people; for public opinion will go far towards correcting the abuses that still exist in these matters. The co-operation and help of the people are always the chief factors in the success of such a movement. Laws against impure food and bad water are at best but the crystallized sentiment of the people against unwholesome and fraudulent products.

For the proper enforcement of these laws, a live Board of Health or Commission, absolutely unhampered by politics, or by the numerous changes that political methods always bring about, is positively essential. In those States where such conditions exist, and where scientific and medical experts have been allowed to work out these problems conscientiously, there has been the greatest measure of success and genuine progress.

WIRELESS TRANSMISSION OF MESSAGES IN THE OLDEN TIME

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The system of wireless transmission of messages which is now in use, and which is attracting attention as a modern wonder, is a modification of methods which have been in use since the dawn of history. They were, in fact, used, not only by, primeval man, but by other animals of that time. These earlier methods are still in use by descendants of those animals.

An illustration may serve as an introduction to a discussion of this subject. At our summer home at the northern end of Lake Huron, one of the companions of my grandchildren is a very intelligent dog. When we leave for our St. Louis home, the dog has for several years been escorted to the home of a farmer who lives among the hills and trees, about a mile from our lakeside home.

Last fall, when we were preparing to leave, and when some of the window blinds were being put in place, on the day before we closed the house, this dog began to express his disapproval. He had a mental record of previous events of a similar character. He had the ability of a prophet. He knew what was in store for him. After expressing his displeasure by many plaintive and prolonged sounds, he suddenly disappeared. There had been no attempt to train this dog to do what he did. He acted on his own initiative. He had received a wireless message, transmitted to him by means of ether waves acting upon certain nerves leading from his eyes to his brain, and thence to him, and he decided to act on the information which he had received. His young companions finally learned, on visiting the home of the farmer, that this dog had already retired along some of the Indian trails, to his winter home, without waiting for their services as guides.

On a former occasion this dog was an interested observer of an operation which he had never seen before. He was sitting in front of a large owl who had been captured in the grove back of our cottage,—who was taking a meal. It was his first meal while with us, in which it was necessary for him to tear the flesh into fragments. He was standing upon a piece of flesh which was clutched in his claw and was tearing it into pieces with his beak. A tame crow appeared upon the scene, and he at once made an attempt to invade the rights of property. The dog expressed his disapproval. To another dog, the message which he sent by wireless would have been understood. To the crow, this warning was in an unknown tongue. The dog at once made an attack upon the crow in defense of the neutrality of the owl, although he had made no formal agreement to do this. It was only by the active interference of others that the crow was saved from destruction.

This dog was not a robber. He would have accepted that food if it had been given to him. He had what we should call in a human being, a judicial mind. He was capable of receiving information which revealed to him conditions which in his opinion called for action.

There are today many animals, some of whom are properly classed as bipeds, who would consider themselves far above the level of this quadruped, who are certainly below him in ethical standards.

The early methods of wireless communication involved two conscious beings embodied in two independent masses of living tissue. They were submerged in two media which served as part of the line of communication between these two conscious beings. One medium is an atmosphere of gas which surrounds our earth. The other is the ether which fills all space.

In making use of the gaseous medium, each conscious being is provided with a sending and a receiving outfit. Both of these systems involve muscles and nerves which lead to a brain. This brain is in some unknown way, in operative relation to a conscious being. These conscious beings constitute sending and receiving stations. They are capable of conceiving and exchanging thoughts.

There are many people who are very greatly interested in the modern wonders in electrical development, who do not see anything wonderful in the conception of thought by a conscious being, or in the expression of a thought in words.

All physical quantities can be measured in terms of the fundamental units of mass length and time. We are unable to find any relation between a thought and any of these fundamental units. The same can be said of the conscious beings who conceive thoughts and present them to others.

The particular conscious being who is to act as a sending station can be located in space by the external appearance of that mass of living tissue which he inhabits. He responds to a name. We may call him John Doe. We cannot account for the fact that he presents himself in London, in that particular mass of matter, rather than in some other mass of living tissue in Calcutta. We may be fully informed of the chemical changes within that mass of living tissue which he inhabits, which are involved when he approaches and passes through a period of unconsciousness. We do not know what changes have in the meantime been impressed upon him. How is the conscious being connected with the nervous tissue through which external surroundings convey to him by wireless methods, messages which contain new information, and which enable him to conceive a new thought.

The falling apple is said to have suggested to Newton the thought that the moon was a falling body upon which tangential motion had been impressed, this giving it an orbital motion around the earth. He had given attention to circular and elliptical motion. He had probably learned that if a bullet were fired horizontally at the earth's surface with a velocity of 4.91 miles per second, it would continually fall towards the earth as all bullets do, but neglecting air resistance, it would revolve around the earth in a circle in one hour and twenty-four minutes. What must be the velocity at the moon's distance, if attraction varies inversely as the square of the distance? This thought having been conceived by Newton, there doubtless followed, unknown to him, a more rapid pulsation of his heart.

Nonliving tissue will respond to mechanical impulses, exactly as living tissue will do. Thus far, however, it has not been known to conceive a new thought, and then pass through a period of excitement as the consequences of the new discovery are considered.

The conscious being can impart his thought to others, by methods wholly different from those by means of which it was imparted to him. In some mysterious way he gives directive motion to a complex structure forming part of his habitation. The thought is expressed in words.

A dog can express his displeasure, and declare war. Dogs of all nations express themselves in the same language when they defy an enemy.

We have all heard the courteous call which the lord of the poultry yard issues to his many wives, when he discovers some delicious morsel of food.

We are not surprised at the clatter and roar of moving machinery or the clang of the blacksmith's hammer. Is it not wonderful that the slow movement of our vocal organs, composed of soft and yielding tissues, can produce the sounds of articulate speech? When the air is practically all expelled from the lungs, slight motions of the flexible structures of mouth and throat can impart to the air a complex and wonderfully modulated system of waves, which carry a thought.

These waves are in a general way alike for all persons who repeat the same message. But they have also modifications, peculiar to the structure and form of John Doe's vocal organs. When these waves reach the ear-drum at the receiving station, vibrations representing all of these general and personal peculiarities of the air waves, are produced in tissues connected with the brain of Richard Roe. He may be able to recognize a familiar voice. In addition he may learn that his friend has a cold. The voice may be that of a stranger, and yet he may be able to decide whether or not this stranger is an Englishman, a Scotchman or an Irishman. He might also obtain evidence that the speaker was either an American-German, or a German-American. In addition the thought which was conceived by John Doe is now in his possession.

Later he may receive other thoughts. He may for a time become unconscious of the fact that the earlier thought is still with him. The muscular and nervous vibrations aroused by the air-waves have ceased. The impression produced by the words may persist even if they carry no thought. In my boyhood days I learned by many repetitions of the words, the names of all the counties in New York. They were repeated in concert by the young seekers after knowledge. For half a century I gave no attention to this subject. The family had moved to a more western state. I then learned to my surprise that I could still repeat those names in alphabetical order.

Is it possible that all of these sound waves had made a permanent impression upon molecular structures within the brain? A camera picture representing several landscapes, images of which have been superposed upon the same plate, would not be very instructive.

The sound waves representing the names of all the counties in New York would be spread over a radial distance of more than eight miles, in every direction from their source. In the brain they are apparently superposed on the same tissue. Repetition from day to day impresses them more and more distinctly upon the receiving device, and there is no danger of an over exposure. And it appears that however much of the knowledge of the past we may have accumulated in the mental storehouse, this increases our capacity for acquiring more.

The sending of messages by means of air waves has serious limitations. The messages cannot be sent over a long distance. To avoid this difficulty, and to secure and preserve a more reliable record of the oral traditions of the past, another system of wireless transmission was devised. By this later method messages could be sent to any distance, and they could be handed down through centuries to follow. As an example we find in Jewish history, II Chronicles XXXVI, 22 and 23, and in Ezra I, 1-3, a statement that Cyrus, King of Persia, made a proclamation throughout all his Kingdom, and put it also in writing. In Ezra IV, V, VI, and VII, we have copies of letters passing to and fro between Kings of Persia and their subjects.

In this system of wireless transmission John Doe gives through brain and nerves a directive motion to certain muscles of hand and arm, instead of to vocal organs. The receiver of the message also makes use of a wholly different receiving apparatus, from that used in oral transmission. Ether waves having their origin in the sun now come from the sheet of paper on which thoughts are recorded. They pass into the eyes and form images of the ink-marks and of the paper which bears them, upon his retinal membranes. The message is not now a fleeting one. If he does not understand he can cause the image of each word to fall repeatedly upon the sensitive spot of his retina. These ether waves produce vibrations in nervous tissue leading to him through the brain along a wholly different channel of communication from that used in oral transmission. The tissues which are now active cannot respond to sound vibrations in air, and the tissues leading to him through the ear cannot respond to ether waves coming from a written message upon a sheet of paper. In either case the conscious being receives the same thought, if the same thought is sent.

He has learned how to operate either of these wireless systems and he can serve either as the sending or the receiving station. In this connection it may be pointed out that a conscious being can send a wireless message to himself. When one examines the directory of a telephone system, and learns by means of ether waves passing into his eyes, the telephone station and number which he wishes to call, he may save himself trouble if he will give oral utterance to the name and number of the station. He is thus making use of both systems. He is receiving a message through nerves leading from his eyes, and he is sending to himself the same message through the wireless system which is operated by means of air waves. The result is to impress the desired information much more clearly upon himself, than would be the case if he were to use only one of these methods. He is much less likely to forget.

It is well known that a telegraph operator can send or receive and write messages for hours, without having the faintest knowledge of the thoughts or words which he is sending or receiving. While doing amateur work in telegraphy I have found myself in the middle of a column of newspaper material with no knowledge of any statement or word which I had been sending. The only evidence that no mistake had been made, was the fact that the key at the other end of the line had not been opened in order that an interrogation point might be sent to me. I am told of one case in which an operator first learned of the death of his mother, when a telegram addressed to him, which he had received, written and turned over to the general office, was returned to him. In such cases the operator is not the receiver of the message. He is part of the unconscious machinery through which the message is transmitted.

In all of the modern systems now in use, the terminal stations are precisely those of the olden time. The older form of communication by means of air waves has been so modified, that long distance transmission is possible. An intermediate link has been added. It is called the telephone system. The thoughts are still impressed upon air waves at the sending station, and the air waves are reproduced at the receiving station. To the later system, in which the message written by the sender, is delivered to the receiver by the postman an intermediate link has also been added. It is the telegraph, or the later wireless system in which ether waves are used. The message written by the sender is still delivered to the receiver as a written message, but it is written upon another sheet of paper. The advantage gained is in the decrease in the time of transmission. The child of to-day has the assistance of its parents in gradually acquiring the capacity to think, and to express its thoughts in words. The human race has gone through the same process of evolution, and it has had no instructor.

By far the most wonderful parts of modern systems of transmitting messages are those parts which were in common use in the olden time.

THE PURPOSE OF SCIENCE TEACHING AT A UNIVERSITY

William A. Noyes, University of Illinois

A little more than a century ago shortly after the close of the Napoleonic wars, a young German, not out of his teens, went to Paris and secured admission to the private laboratory of Gay-Lussac. Liebig was a born chemist if ever there was one, but even he needed the inspiration of contact with one of the master minds in his science. After about a year he returned to Giessen, Germany, and founded there a laboratory which was new of its kind in the world. Liebig's conception of a chemical laboratory was not that of a place where the science as already known is taught, so much, as that of a work shop where student and teacher work together to find something new from the great book of nature. A. W. Hofmann, one of the students of that laboratory, was called by Prince Albert to London in 1845 as a Professor in the Royal College of Science. Ten years later W. H. Perkin was employed by Professor Hofmann to work as an honorary assistant. Perkin was not yet twenty, but he was so intensely interested in his subject that he was not content to work during the day with Hofmann, but fitted up a private laboratory in his father's house where he could work at night. There, in the course of some experiments which were begun in an attempt to synthesize quinine, he discovered a new coloring matter now known as mauve. He conceived the idea that this compound could be made commercially and used for dyeing silk and other goods. His father had enough faith in the young man to furnish him the necessary capital and thus was begun the manufacture of the coal tar dyes. It would have been thought that with all the initial advantage in England this manufacture would have remained in that country, but within a comparatively few years Germany became pre-eminent in the manufacture of dyes and at the beginning of the present war she was furnishing three-fourths of all of the artificial dyes used in the world. This was almost entirely because the laboratories founded after the model which Liebig had set furnished young men trained in methods of research, and such young men proved to be the ones who were best able to carry the manufacture on to success.

It will be seen from the above that the wonderful achievements of Germany in this field rest directly on the laboratory founded by Liebig in Giessen. We can go much further than this now and it is entirely clear that the tremendous efficiency of Germany the last thirty months rests on the same basis. It would be difficult to find a better demonstration of the important place that research work fills in our national life. Some persons may be disposed to say that all this is well enough for Germany, but it does not apply to American conditions. Two or three illustrations of similar results achieved here may not be out of place. I take these illustrations from our experience at the University of Illinois, but parallel cases might be cited from many large universities in the country.

C. L. Wagner, who graduated from our course in chemical engineering in 1910, was employed shortly after by a Cement Company in the State of Washington. Something had gone wrong with their process and the company at that time had thousands of barrels of cement thrown back on their hands because it did not meet the requirements set for such material. Mr. Wagner, trained during his senior year in methods of research, was able to put his finger on the difficulty and soon he corrected it and the company has continued in successful manufacture of their material ever since.

In 1907 a graduate of Worcester Polytechnic Institute, who had spent one year in research work at the Massachusetts Institute of Technology, came here as a research assistant. Three years later he secured his doctor's degree with us, and was continued as an instructor and still later was raised to the rank of assistant professor in charge of the division of organic chemistry. Last year one of the largest manufacturers of coal tar dyes in America looked the country over to find a man who could organize a research laboratory for their work. They selected Dr. Derick, not because of his experience in manufacturing, but because he had shown unusual ability in the study of research problems in pure organic chemistry, and especially in the application of physical chemistry to the study of such problems.

Another man who came to the University as an associate ten years ago, was called last summer to organize a research laboratory for the study of applications of rare metals to industrial uses. In this case again it was not because of experience in manufacturing, but because he had become a recognized authority in the study of rare earths, a phase of research which is about as far removed from practical results as can well be imagined.

A man who graduated from our course in chemistry in 1906 and afterwards took his doctor's degree at the University of Wisconsin, is now State Chemist of the Illinois Food Commission in Chicago. Every man, woman and child in the State is dependent directly, or indirectly upon Dr. Klein for the maintenance of proper standards of purity in the food which we eat. Many other illustrations might be given of the way in which the universities of the country have contributed to the development of manufacturing and other interests. It is more than a question if the benefits which are derived from this kind of work are not very much greater than the benefit which accrues to the students who study chemistry in a routine manner at the university. Some of the men mentioned above were among the best teachers whom we have ever had at Illinois, and there was a very direct connection between their ability in research and their success as teachers.

PLANT ECOLOGY AND ITS RELATION TO AGRICULTURE

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I. CONTENT OF ECOLOGY

A. *Nature and Scope.* In beginning this discussion, a brief statement as to the nature and scope of ecology seems to be desirable on account of the hazy popular notions on the subject. Outside of a rather narrow circle one usually finds a total ignorance of the meaning of the word itself, and even among biologists, some are familiar only with the observational side, due probably to the early prominence of the "car window" school of ecologists, while others consider that the subject matter of ecology might better be divided between morphology and physiology, and frankly state their opinion that there is no such subject as ecology.

However, there seems to be a mass of subject matter belonging to neither department exclusively, but partly to each, which would fairly warrant the formation of another department. This has been named ecology, and may be defined as the science of the forms of organisms as affected by the factors of their environment. The connection with physiology is the closer of the two, and in fact, the two subjects overlap to a certain extent, but whether we call this overlapping segment ecological physiology or physiological ecology, the character of this subject matter is sufficiently different to warrant a separate category and different treatment.

The methods of ecology have been, of course, largely descriptive, but they are also becoming increasingly quantitative, employing in many cases elaborate and delicate instruments. The work is pursued both in the field and in the laboratory, and under experimentally controlled conditions, as well as under natural. The great task of ecology and the purpose of its observation and experimentation lies in the interpretation of the phenomena and the deduction from these data of the general principles underlying the reaction of plants to their environmental factors.

B. *Content of General Ecology.*

1. Autecology. This branch of ecology studies the plant as an individual, and is largely physiological in nature. It considers (a) the general results of the relation of the plant to its environmental factors, as shown in the division of plants into great classes according to their reaction to each of the leading factors. Chief among these is the moisture relation, expressed in the more or less familiar division into hydrophytes or water lovers, xerophytes or dry-climate plants, and mesophytes inhabiting an intermediate habitat. A similar relation to light and temperature divides plants into sun tolerant and shade-tolerant; heat-tolerant and cold-tolerant groups. The relation to the chemical elements in the soil is not so marked as was once thought to be the case, yet we still hear such words as "calciphiles" and calciphobes," and the terms probably represent to a certain extent a real situation. (b) Special relation to environment is shown by the structure and function of the organs. Whatever may be our belief as to the method by which variations are produced and fixed in plants, it is evident that structures correspond more or less to function and are conditioned directly or indirectly by the environment. A comparative study of plants in different habitats leads us to identify or construct from the imagination certain "normal" or original types of organs. We find also modifications of these types, which are either temporary, where the plant tissues are plastic; or permanent, constituting variations. In tracing the correspondence of these changes to environmental differences, we look for and frequently think we find what may be called ecological causes. The best illustration of this is shown in a comparison of organs, especially leaves, of hydrophytic as compared with xerophytic and mesophytic plants. Here there seems to be a very distinct correspondence between structure and the markedly different environments of these different habitats.

2. Synecology, which studies plants in the mass is largely concerned with distribution of plants, and may be regarded as an application of autecology in the grouping of plants within greater or smaller areas of the earth's surface. It may be divided into (a) "Phytogeography" in which the groupings are regional and the result of climatic factors, and (b) "Physiographic Ecology," in which the groupings are local, as the result of physiography with attendant climatic modifications.

These groupings are called Plant Associations and the fact that different associations follow each other successively is expressed in the term "Plant Succession."

C. *Special Ecology of Structural Groups.*

While all ecological groups have more or less specific reactions which are considered under their appropriate heads, there is one grouping which demands separate treatment because it is based on the most striking structural feature—the presence or absence of woody tissue, and also because of its practical relation to man's activities. Although verging more closely on agriculture, it may still be classed as ecology because the point of approach is from the side of the environmental relations. On the basis of woody structure we classify plants as trees and herbaceous plants with shrubs and lianas occupying an intermediate position, and it is at once evident that these two groups have decidedly different ecological reactions.

1. Ecology of Trees and Shrubs. This study would involve (a) a description of leading species with their habits of growth, characteristic structures, and ecological interpretation of the same. This would be the autecology of the group. (b) The synecology would involve the distribution and range of the leading species and their relation of ecological causes. (c) We might notice also the influence of the species on their environment, as illustrated in the influence of forests on soil moisture content through their control of run-off; and the influence of individual trees, as for example, the eucalyptus in the reduction of soil water; also the influence of forests on soil in the formation of humus and the effect of trees on wind, as in protection by wind breaks. (d) It could include also a classification of trees according to the character of their wood, including distribution of the different woods and methods of utilizing. Also a similar classification according to the character of their fruits, their chemical products, and their value for ornament.

2. Ecology of Herbs. Here should be studied (a) the general characteristics of herbs as distinguishing them from trees, with the ecological differences involved under the heads of shoot, root, flower, and fruit, with the characteristic differ-

ences between perennials and annuals; (b) a study of herbs as classified according to their value to man, as: valueless or "wild," those of economic value or "cultivated," and those undesirable or injurious, which we call "weeds." Uncultivated herbs are of interest chiefly synecologically as the associates of trees in their different groupings and as indicators of the characteristics of the environment, as hydrophytic, xerophytic, etc. As the subject of taxonomy has to do chiefly with the wild herbs, it is frequently included under ecology today.

Cultivated herbs and their attendant, though undesirable forms, are considered more from the autecological side. Their reactions to and tolerance of extremes of temperature and moisture and chemical conditions, are of course of chief importance. Original habitat and distribution and to some extent taxonomic relations, are also important as indicating suitability for certain environments. This value is testified to by the systematic search for new varieties carried on by the United States Department of Agriculture. Herbs vary greatly in their reactions to environmental factors, and should be grouped as far as possible along the lines of similar behavior. Knowledge of these groups should be as complete as possible, but a thorough study of the ecological reactions of a few type genera and species should be included in any comprehensive course in ecology.

3. The ecology of lower types of plants is not treated separately, but on account of economic importance under the special subject of bacteriology, mycology, etc.

II. RELATION OF ECOLOGY TO AGRICULTURE.

A. *Purpose and Scope of Agriculture.* The subject of agriculture is extremely complex and even the terminology is not uniform in usage. Even the word agriculture itself is employed in a general and a special manner. It is used here in the general sense of the cultivation of plant products from the soil. Its complexity is made evident by consideration of the varied ends sought, which include size, strength, water content, and chemical contents of stem, leaves, roots, flowers, fruit, and special parts such as fibers, cork, etc.

The resulting subdivisions of the subject following largely the usage of Bailey's Cyclopedia of Horticulture, are: Agriculture (in its special sense), which includes the culture of grain, forage crops, bread stuffs, textiles, etc.; Horticulture, which includes fruits, vegetables, flowers, and ornamental plants; and Forestry which is the complete treatment of other trees, and includes the subjects of sylviculture, mensuration, and harvesting. Through all this complexity runs a general unity of purpose, namely, the preparing and maintaining of optimum conditions for the production of maximum returns. Therefore the processes and principles are in the main the same, being varied in practice for the different ends.

B. *Agricultural processes* with their ecological significance.

1. The preparation of optimum conditions. The preparation of the soil is the first condition, but as the principles are the same as those in the preservation of optimum conditions, it will be considered under that heading. The second important factor is the securing of suitable stock, either seed or vegetative, for which the criteria are the taxonomic relations and the reactions to the environment. The choosing of this stock is a question of balancing specific reactions of the desired plant with the factors of the necessary location, or vice versa. The securing of this stock is brought about either through breeding by pollination, or by grafting; and by choice, through the testing of known varieties, the selecting of the results of breeding, or the discovery of new varieties. Of course through all these methods runs the question of reaction to the desired environment. A third ecological factor in preparation of conditions consists in the choice of a suitable time and location for the culture.

2. The preservation of optimum conditions. (a) The condition of first importance is the soil. In its moisture content the maintenance of optimum moisture conditions is of course extremely important. The maintenance of its physical condition is popularly called tillage. The chemical composition is shown by analysis and experiments with plants, and is modified by the use of fertilizers and of other chemicals. The temperature of the soil is less considered, but may be determined by the use of soil thermometers. (b) Optimum conditions of light, wind, and temperature depend upon exposure and may be controlled by modifications of this exposure. Light is studied by light intensity experiments and controlled by screening or by thinning. The effect of wind is shown largely

by transpiration, measured by the atmometer, controlled by thinning or by windbreaks. Temperature is observed by the thermometer controlled by shelters and by protective covering. (c) The importance of disease as a factor has been recognized by the great development of the subject of plant pathology.

3. The third agricultural process is the harvesting of crops, in which ecology does not function very largely, except in so far as it may assist in the determining of the time of maximum returns.

C. *Nature of Contributions of Ecology.* Agriculture, as its name implies, is a practical process and its methods heretofore have been largely empirical. This may be observed by reference to any agricultural textbook or farmer's bulletin, where frequently processes are referred to as having been tested in certain localities and are recommended as having succeeded, or are condemned as failing. Even in our more recent Experiment Station work, the same tendency is shown in the accumulation of masses of data with too little correlation and generalization. The purpose of experimentation is to determine causes and draw general principles whose application will avoid the necessity of further experiments. Failure to generalize nullifies this purpose; in fact, unlimited experimentation is empiricism.

On the other hand, the ecological method is scientific, involving interpreting as well as observation. Its materials are largely the same as those of agriculture, and when its methods are applied to these materials, we have the only result that can truly be called "the science of agriculture." In so far as agriculture uses scientific methods, it is ecology.

D. *Illustrations from Definite Contributions of Ecology.*

Atmospheric moisture is observed quantitatively by means of the atmometer, which may be used as a measure of plant transpiration. Recent results show a most remarkable detailed correspondence between the curve of an open pan atmometer and that of a controlled plant of alfalfa. In soil moisture content the mechanical determining of the wilting coefficient by the centrifugal method is a valuable achievement, and is having an increasing application in the determining of the quantity of water to be applied in irrigation. The study of the extension of root systems is having an increasing influence in determining the relation of plants to the soil moisture content.

In light we have both the measure of the intensity of light by Wiesner and Clements, and recently the measurement of photolytic ability of light by a delicate apparatus devised by MacDougal. Under chemical content the recent work of Coville with blueberries is widely known on account of its publication in the National Geographic Magazine. One of the difficulties of this quantitative work lies in the fact that the factors all work together on the plant, and measurement taken of individual factors may not indicate the true effect of the same factor working with others. Livingston's suggestion of using the living plant as an index is aimed at overcoming this difficulty.

Along physiographic lines, Cowles' recent work on so-called lakes of the Mississippi Valley, has applied the principles of plant succession in a very practical way. The control of moving sand is best accomplished by application of ecological principles in the choice of plants for that extremely xerophytic habitat.

E. *Place of Ecology in an Agricultural Course of Study.*

Up to the present the method has been to use a little morphology, a chapter on plant activities, and then nine-tenths of the work on agricultural practice. In addition to that we would recommend the insertion of a section on ecological principles covering the content of ecology as outlined above, which should be general and theoretical, yet so related to agricultural practice as to form a suitable foundation for an agricultural course. A knowledge of these principles is fundamental to any real grasp of the subject.

In conclusion, emphasis should be laid on the fact that this discussion does not aim to criticise agricultural activities at present, but to emphasize what is now being done along scientific lines for the development of general principles underlying the practice of agriculture, and the importance of its extension as far as possible. Secondly, to point out the opportunity in this growing branch of botany and to urge the teaching of some brief but comprehensive study of the principles of ecology in all agricultural courses.

CONTRIBUTION OF THE COLLEGE TO HIGH SCHOOL SCIENCE TEACHING

John C. Hessler, James Millikin University

At the last Springfield meeting the speaker presented to the Academy a report on behalf of the committee on Secondary School Science. As he recalls that report he feels that he would like to state again its last sentence, to the effect that however great the benefits of the Academy may be in its stimulation of amateur and professional investigation, the members of the Academy can perform no greater service for the science of the future than to improve the quality of high school science teaching in their communities. The Academy has not been unmindful of the resources of the state, in the persons of the high school teachers of science. But in the attempt to realize upon these resources it has been peculiarly unfortunate. Many of those present will remember our last experience. After sending out to science teachers some hundreds of notices regarding the work of the Academy, together with sample copies of the Transactions, the net return was, possibly, two or three applications for membership. The result seemed to prove conclusively that the teachers of the state are not in sympathy with science.

To say that the Academy was disappointed over the failure of science teachers to respond to its efforts is to state the case mildly. But instead of consoling ourselves with having done our duty, it behooves us to study the science situation more deeply and to learn the status of the average science teacher. The lists of accredited schools issued by the State Department of Public Instruction and by the Examiner of the State University are a revelation to one who is not familiar with high school conditions. Especially is this true if one considers the number of teachers in many of the schools, with the resultant large number of subjects to each teacher. Nowhere is the burden heavier and the effect more deplorable than in the science department, with its supposed laboratory method. A visit to a few of the smaller high schools and, alas, to some of the larger ones as well, verifies abundantly the suspicion aroused by the accredited lists. The fact is that only here and there can one find high school science being taught in a really efficient and inspiring manner.

Let us look at the situation at closer range. Let us suppose that the teacher was trained to teach chemistry. He will be found teaching physiography, physiology, zoology, botany, perhaps also physics, in all of which he has had practically no preparation! He is fortunate if he is not called upon to teach science after preparing himself especially in English or history. I know whereof I speak. If you ask the teacher how he comes to be so far from home, he responds that he is expected to take the work assigned him. Since he had studied something of one science, he is expected to know science in general, especially if the school cannot afford more than one science teacher. Or if the school boasts of a science "faculty," he happened to be the last one engaged and was obliged to take what the other science teachers wished upon him.

But what of the pupil under this regime? Taught by a teacher who does not know his subject, who does not discriminate between the essential and the non-essential (it would be laughable, if it were not pitiable, to hear some of the absurd things stressed in such cases), a teacher who is merely holding his job until he can get into a position in which he can teach his specialty, the pupil learns science as he too often learns algebra and Caesar and composition, as things to receive grades upon, to pass off, and never to be bothered with again. Nothing of science as a life to be lived, a home to be improved, a community to be inspired, a great quest to engage in for the years to come! Is it not true that only vision and enthusiasm on the part of the teacher are at all likely to arouse vision and enthusiasm in the pupil, as only life can beget life?

But this is only one side of the subject. Suppose that the student prepared in chemistry gets his chosen job and has the opportunity to teach chemistry only; what kind of chemistry shall he teach? Shall he teach it as chemistry adapted to the life of the community, or as the ideal philosophy of the investigator? Shall it be a chemistry that takes account of the child's point of view, that fits the child's progress in science, or is the teacher to feel that the first thing to teach the pupil is the last thing he himself learned at college?

Let us understand at this point that it is of no use for us to blame the young high school teacher for the situation in which he finds himself. He is but adapting himself to conditions as best he can. If the speaker has seemed to any to be spending too much time in criticizing the existing order, let such take note that the criticism is not intended to be carping, but has a constructive reason for its justification. For the imaginary, yet real, picture drawn in earlier paragraphs of this paper has its background in statistics. From an article by Professor Carl Hartman in School Science and Mathematics for the current month (February, 1917) it appears that 13 per cent of the teachers of Texas teach one or two subjects; 22 per cent teach all the science offered; 20 per cent teach all the science and all the mathematics, and 50 per cent teach all the science and at least one other subject.

These figures are not peculiar to Texas; they only corroborate results obtained two years ago for Illinois. Moreover, they show conclusively that there are practically no science specialists in the high schools. If we wish to seek an improvement in the quality of the teaching done, we must go back of the teacher to the public that takes advantage of his inexperience to pay him a small salary, and above all we must go back to the college or university that prepares the teacher for his profession. In this connection Dr. Hartman observes that "the universities and colleges are, in the main, failing to take advantage of their opportunity of training teachers for these schools, for the reason that they tend to train specialists rather than high school teachers of science."

This last observation brings us directly to the subject of the paper. What can the college contribute to science teaching in the high school? It can, in the first place, recognize the problem. Here, in an organization devoted to *all* science, we can see it more clearly, perhaps, than in the college faculties from which we come. The self-evident remedy, if experience and reason teach us anything, is that the college and the undergraduate departments of the university must adapt a part of their instruction in science to the training of their graduates to be *teachers of science* rather than teachers of *a* science. But how can this be done? One way that suggests itself is that the college can expect those of its students who have any idea of teaching to take elementary courses in several sciences rather than to specialize in one. This will break the hearts of some instructors in advanced courses, but these may have to stand aside.

There is, however, a still better way of solving the problem. The college can select from its faculty a man who can appreciate the specialist's point of view and who can yet see the science field as a whole, a man who can make for this purpose a re-synthesis of science out of the fragments into which, for purposes of intensive study, it has been broken. This man can present to students of the third or fourth year a course in the "Teaching of Science." As a prerequisite, students should be required to take courses in both the physical and biological branches of science. The course could include a rapid survey of the special sciences from the high school point of view. The salient principles of the sciences, the text books available, the laboratory facilities to be expected, the adaptation of simple apparatus where the more technical is not present, the methods of presentation, the results to be expected from students—all these could form part of such a course. In this way the elements of some sciences not ordinarily taken by college students, such as astronomy, may be added to the graduates' equipment.

The adoption of such a course will mean that in many colleges a specialist in one science will have to give the course in science teaching; in the larger schools a man will be found who can devote himself to this work. And the student in the larger school need not give up specialization, either. But to the student who majors in biology the teaching course will give aid in the physical sciences, while to the student of physical science it will give the necessary minimum of biology. To both classes the course will give the equipment and point of view needed for the presentation of introductory science, or general science, in the junior high school or in the first year of the ordinary high school—a need not met by any college science courses of the present time.

Some may suggest that several members of the faculty should join in giving such a course, each presenting his specialty. To such the reply is that this ought not to be a vaudeville performance; there must be *one* teacher. If the college is unable to muster enough unification of purpose to give such a course, it can not fairly expect the student to do so. Another objection will be that the specialist will not be willing to devote himself to such work, yet every month or two, even now, we hear of a science specialist who goes over into science education in a university school of education. The arrangement proposed means that it will no longer be necessary for the teacher of science to leave the university in order that he may become a specialist in the teaching of science.

As the inexperienced high school teacher will inevitably teach in the high school the thing last studied in college, let that last thing studied be a unifying course rather than a specialized one. The result will be a rounding out of all the preparatory work done by the teacher. As a high school pupil he will have begun with an introductory science and will then broaden out into the special sciences of the later high school and college years. Last of all, without abandoning the special skill he has gained, he will yet come to feel, before he goes out to present to the next generation the truths of science, their essential unity. This will make of the graduate not only a better teacher, but a better man or woman.

THE CONTENT OF A GENERAL SCIENCE COURSE

J. F. Groves, University of Wyoming

As a result of a more or less general dissatisfaction in first year high school science courses, a number of enterprising science teachers have developed first year courses in general science for their classes. The marked success of these courses and a growing demand for text books on the subject have induced several of the members to reduce their material to book form. The result is that we now have several texts on this subject which, to the uninitiated, present quite a diversity in content and arrangement. Since the available material for such a course is so extensive, the question of selection is somewhat embarrassing. The way in which these different authors have answered this question presents an interesting situation.

In order to show how this has been done, we have attempted to make a comparative analysis of a number of these texts as shown in the accompanying diagram. We predict that such an analysis will be strongly resented by the authors of these texts. They undoubtedly will claim that they have attempted to embody the explanation of the most common phenomena of the child's environment without regard to any particular science to which these phenomena belong. We must confess that considerable difficulty has been encountered in trying to make the data conform to such analysis. Certain topics often involve the presentation of a phenomenon from one field and an explanation of the underlying principle from another field.

A comparison of the total number of pages devoted to the various subjects by these authors indicates in a mechanical way the average emphasis given to the different subjects. Undue emphasis should not be given, however, to such totals without keeping in mind several important facts.

First, reference to the table indicates that approximately one-half of some of the texts are devoted to material usually presented in one of the special sciences. Nevertheless, many schools claim that their course in general science is not based on or organized around any special science. It will be noted also that some of the large totals are not due to special emphasis by all of the texts, but to a predominating emphasis by one or more texts.

Secondly, the selection of this main theme around which the course is organized may be determined by the chief interest of the author because he feels that he can present the subject better in this way. This fact is in no way considered a criticism and we feel that teachers should be given much freedom in selecting texts adapted to their chief interests.

AN ANALYSIS OF GENERAL SCIENCE TEXTS

Author	Publisher	Preliminary	Astronomy	Bacteria & Hygiene	Botany	Chemistry	Geology & Mineralogy	Physiography	Physics	Physiology & Hygiene	Sanitation and Hygiene	Zoology	Appendix	Glossary	Index	Total
Barber	Henry Holt Co.	VII	0	70	?	43	7	135	232	37	67	?	4	10	9	607
Caldwell and Eikenberry	Ginn & Co.	(14)	0	19	61	12	?	84	73	9	11	26	0	0	6	306
Clark	American Book Co.	8	0	5	5	32	?	21	222	38	12	?	0	0	11	354
Elhuff	D. C. Heath & Co.	VIII 8	7	12	45	34	?	45	170	46	23	27	4	6	5	432
Hessler	Benj. H. Sanborn	(13)	?	34	30	64	?	50	136	87	32	26	10	4	12	465
Pease	Chas. Merrill Co.	12	33	0	40	20	23	72	88	?	?	18	0	0	9	315
Snyder	Allyn & Bacon	XVII	15	5	48	?	?	321	29	18	?	18	6	0	10	470
Total		87	55	145	229	205	23	728	955	235	145	115	24	20	62	2969

Thirdly, there doubtless is variation in opinions as to the course which should immediately follow this first year science. At least one author states in the preface of his text that certain material has been omitted almost entirely in order that it may be taken up in a subsequent course. This is probably more particularly true of the biological group of sciences.

Fourthly, it seems that few if any of the authors intend all of the material presented in their texts to be used in any class. Since the subject so easily permits of variations, it seems not only feasible but in some cases advisable that the indivdual teachers should modify the work according to their several needs.

Fifthly, a comparison of the laboratory experiments arranged by the different authors to accompany their texts reveals some differences in emphasis from that made in the text. Additional problems and experiments which are provided may be omitted in some cases and extended at more or less length in others. Since the laboratory work either as demonstration or as individual exercises comprises an important part of the course, we feel that the teacher should use considerable choice in selecting laboratory material.

We wish to acknowledge the help of normal students and assistant teachers in preparing this analysis. We invite criticism of this paper from authors and interested teachers.

COLLECTING SNAILS IN THE SOUTHWEST

James H. Ferriss, Joliet

The intended purpose of this effort is to show the way to the Great Southwest—the collector's paradise, the explorer's dream—to picture its accessibility, its comforts, with a mere suggestion of its delights and great possibilities—to offer encouragement to the hungering seeker and point the way to a possible remedy for those who complain of the decadence in natural science.

Commencing either south or west of Kansas, the abrupt change in both animal and plant life has a beginning. To the scientific gent who desires to add to the store of knowledge, or carve for himself a name in an endurable form, here lies the territory inviting his energies. A railroad ticket for a round trip from Chicago to Los Angeles, or San Francisco, or both, good for four months with convenient stop-overs, commencing about July first, has been costing about $70.00.

Better groceries and supplies can be purchased at most any town or switch at eastern prices, and transportation rates by auto, wagon or pack animals, are reasonable and the walking good. The packer or teamster is a guide also, with an understanding of the trails and water supply, whether American or Mexican.

Do not look for a servile person, dancing around to collect your coats, hat, goloshes and tips, for he is a free American, a much self-respecting citizen, good as any man. He may wear goatskin chaps and perform Buffalo Bill stunts, but probably not. The average will be a plain, practical helper, with less eccentricity than the every day corn husker. Treat him as a fellow citizen, sensibly, with an open mind, and by all means let him boss the transportation, do the cooking and select the camp sites. I have traveled more than thirty vacations in wild places after this good health, by wagon, canoe and pack train, and sometimes alone and on foot, and do not recall an unfortunate experience or a seriously cross word.

And the scenery I have met, and the floral displays, and the beauties of landscape plots, just as nature left them, is something not to be described in words, by myself. "Pray, pray without ceasing," my parson says. I do—I pray for the Southwest the day long and dream more prayers by night. At my only meeting with Dr. Mearns, old and feeble, tears came instantly to his eyes. "Oh, I want to go to Arizona so bad!" he said, and it is ever so. The traveler who has left the railroad, caught the incense of the desert or camped in the forested hills, ever longs to return. He will dream of the strange katydids fiddling in the night, the sweet notes of the canyon wren, the brilliancy of the trout in the mountain parks, and the flaming skies of dawn and sunset.

Unless one is a student of plant life, or the train should pass through canyons, it may not be a pleasing prospect to the collector from a car window. Perhaps should he stay over but a day or two the spell of the mountain, the lure of the desert, would not be overwhelming. It is to sleep in the open, to dig, and reflect, to climb and ponder, to muse and dream week after week and month after month that works the spell.

The first comers in the Huachuca mountains, and the Chiricahuas, found two snails in each range. I have assisted in finding forty new to science in one and nearly as many in the other. Lemmon camped one summer in the Huachucas and returned for other visits. He did not find all the ferns in the range, but found more than his successors have rediscovered.

Here are probably more beautiful and exclusive ferns, cacti, agaves, than in any other part of the nation, and ever will be, unless Mexico by vote comes into the Union. For the collector in botany, conchology, archaeology, mineralogy—birds. reptiles, insects, watermoles, and the student in astronomy, and the experimenter in arid agriculture and horticulture here is the ultima thule.

Leave the train in southern Arizona and the explorer may pass through a different society of plants, a different association of birds, reptiles and rodents every half hour through the day. With plants the Yuccas will probably be the main feature, near the tracks, and may be a low growing species, or tall, or both. Something happens with soil or drainage perhaps and the next society along the trail will be a thicket of mesquite or cat-claw no larger than gooseberry bushes, or it may be a forest of the same with trunks from one foot to five in diameter, and ninety feet in the diameter of shade. Then a meadow perhaps where the haymakers with mowing machines gather profitably a wild harvest. As suddenly a wide belt of creosote brush may cover the ground. The mesas slanting down from the base of the mountains have the great collections of Cacti and of many families. The base of the mountain itself is the home of the Agaves, perhaps the low growing forms of but a few inches in height, or the larger with a flower stalk of thirty feet and one hundred pounds of bloom. Perhaps half a dozen species, low and tall, and here too, the giant cactus, occasionally sixty feet in height, with forty branches. The ferns have their beginning here also with perhaps half a dozen species, the societies changing in the ascent to the peak as rapidly as the desert vegetation has changed below them. *Cheilanthes Wrightii* the first and *Pteris aquilinum* of the western form, the last.

These mountains from the railways may seem mere hills of naked clay, but if from eight to ten thousand feet above the sea they are heavily forested. At the base the Desert willow, cotton wood and sycamore hug the streams, with junipers, pinyons and manzanita on the hill sides. The madrone, walnut, oak with a shade perhaps of one hundred feet, and alders as high, appear in the next zone and then, last of all, the yellow pine, Douglass fir, blue spruce, a dozen or more cone bearers in all. Here in fact is the ideal forest, with trunks eight feet in diameter and branches one hundred feet above, so dense the sun is a stranger.

In no public park have I seen the equal of the natural park effects in the canyons, along the river banks and upon the table lands at high altitudes. But the changing order does not end with mere elevation. The south side of a mountain is unlike the north side; the east side of a canyon has a different tree association than the west. In bird societies and reptiles, no two canyons in my experience, were alike. In half a dozen years no cardinals were seen and then three species appeared in the same canyon. No rattle snakes were seen and then five species were obtained in one season and there are as many more to get.

It is no exaggeration to say that every plant or creature west of Kansas is different from its kind eastward. The oaks, the pines, and spruces, the ravens, flickers, black-birds, blue birds, humming birds, quail and robins, the gophers, squirrels, snakes, toads and fishes, the insects good, bad and disgusting. The English sparrow and the house fly seem cosmopolitan and it is possible that the crow and bittern and some of the swimming birds are also nation wide.

No sightseer has been disappointed with the Grand Canyon, it is claimed, and not to be wearisome or wasteful of time it may be well to snub off with the prediction that no explorer in natural history will be disappointed with Arizona. This state is the high point of the southwest. Here from the four winds the orders and races meet. Very few pass over.

I have seen enough of the southwest to realize that comparatively few of its secrets are known to me. Here may be found the highest peaks of the states and the lowest valleys below the sea level, and both in the same county. One may travel in one day on foot from a torrid climate to the cooling breezes of the northern lakes. Here apparently may be found all known varieties of land, soil and climatic conditions, and then some. If one in this generation volunteers to tell the whole story of the southwest it will be well to hold his case over for further consideration.

This much is known that for the explorer the weather at an elevation of eight to twelve thousand feet is perfect, from the first of June till October. If there is dampness it will be but a shower. In winter the lowlands are comfortable. The field of research has not been exhausted. The pioneers are hospitable and helpful. Come on in—the water is fine.

Papers on Botany

THE CHESTNUT IN ILLINOIS

William Trelease, University of Illinois

Among a collection of exquisitely prepared photographs of trees and sections of their wood presented to the University of Illinois some years ago by Mr. B. T. Gault, of Glen Ellyn, the chestnut, *Castanea dentata,* is represented from between Olmstead and Caledonia in Pulaski County. So far as I have been able to learn, this is the only place in the State where chestnut trees are known to occur except where they are known to have been planted by man. Inquiry in the river counties has brought the statement by several elderly men that in their youth they knew the chestnut as wild "in the hills of Pulaski County": but these statements have resolved themselves into reference to a single grove near Olmstead.

It was in this grove that, in 1900, Mr. Gault photographed a tree apparently four-and-a-half or five feet in diameter of trunk, and prepared a wood specimen from one of its branches about three inches and a half in diameter. A tree of this size may have been between 200 and 250 years old. Even if this estimate of its age (based on an average annual addition of a wood ring an eighth of an inch thick) should be a little high, it is evident that such tree must have antedated by very many years the occupation of this part of the country by white men.

Pulaski County constitutes the middle of the extreme southern part of Illinois, along the Ohio River which separates it from Kentucky, and by an air line not over 65 miles below the mouth of the Wabash River, which separates it from Indiana.

In Indiana the chestnut is said by Deam to reach Gibson and Posey Counties, which constitute the point between the Ohio and Wabash Rivers at their confluence. In Kentucky, Garman shows that it reaches Crittenden and Ballard Counties in the western part of the State along the Ohio River; the former between the points where the Wabash and the Cumberland Rivers discharge into the Ohio; and the latter between the mouth of the Tennessee River and the point where the Ohio empties into the Mississippi. Ballard county in Kentucky is separated from Pulaski county in Illinois merely by the Ohio River.

The chestnut occurs at Olmstead, so far as I know, in a single mixed grove some 80 acres in extent, on rolling clay hills traversed by a rather deep and steep ravine which cuts into the gravel by which the surface soil is said to be underlaid generally in this region. The tradition is that at one time this grove contained numerous large trees, of which the one photographed by Mr. Gault may be considered a sample. These trees have been cut out for their timber, and only young trees now remain; but the older trees have seeded freely through the grove and the young trees present every appearance of spontaneous seedlings in a chestnut association. A census of the more evident components of the vegetation of this grove, made in the summer of 1916, showed the presence of the following species:

Trees—*Acer Negundo, A rubrum, Carya ovalis, C. ovata, Castanea dentata, Celtis Mississippiensis, C. occidentalis, Diospyrus Virginiana, Fagus grandifolia, Fraxinus Americana, Gleditsia triacanthos, Juniperus Virginiana, Liquidambar Styraciflua, Liriodendron Tulipifera, Morus rubra, Platanus occidentalis, Prunus serotina, Quercus alba, Q. Muehlenbergii, Q. pagodaefolia, Q. rubra, Q. velutina, Robinia Pseudacacia, Sassafras variifolium, Ulmus alata, and U. Americana.*

Shrubs—*Asimina triloba, Cercis Canadensis, Cornus florida, Corylus Americana, Ilex decidua, Lonicera Japonica*—an introduced plant abundantly established in the southern part of the State, and in open parts of this grove competing here and there with the poison ivy in holding the ground surface, *Psedera quinquefolia Saint-Paulii, Rhus copallina, R. Toxicodendron, Tecoma radicans, Vitis bicolor*—about the edges, and *V. cordifolia.* The grove is bordered in places by brambles, though these do not penetrate to any great extent into its rather densely shaded interior.

Among the herbaceous plants most in evidence were a number of ferns,*Adiantum, Aspidium, Asplenium, Botrychium, Phegopteris* and *Woodsia*—and such flowering plants as *Desmodium, Geum, Hedeoma,* and the introduced *Belamcanda,* which, like the Japanese honeysuckle, is abundant generally in the South.

The association in which the chestnut occurs in southern Illinois is such as would be expected elsewhere where these

Plate I. *Verbesina alba* L.

species grow. It is interesting, though, to note the occurrence together of such characteristically upland trees as *Celtis occidentalis and Quercus Muehlenbergii* with their characteristically bottom-land congeners, *C. Mississippiensis* and *Q. pagodaefolia.*

So far as can be seen, this Pulaski County station presents a natural extension of the recognized range of *Castanea dentata,* though for some reason the tree is not known to extend beyond this single grove, less than a mile from the Ohio River. How it crossed the river is a matter for conjecture only, but propinquity suggests the belief that it entered the State from Kentucky.

Quite apart from the general consideration here presented it may be noted that, as would be expected, no signs of the chestnut blight were found in the Olmstead grove.

DWARF SHORE FLORAS

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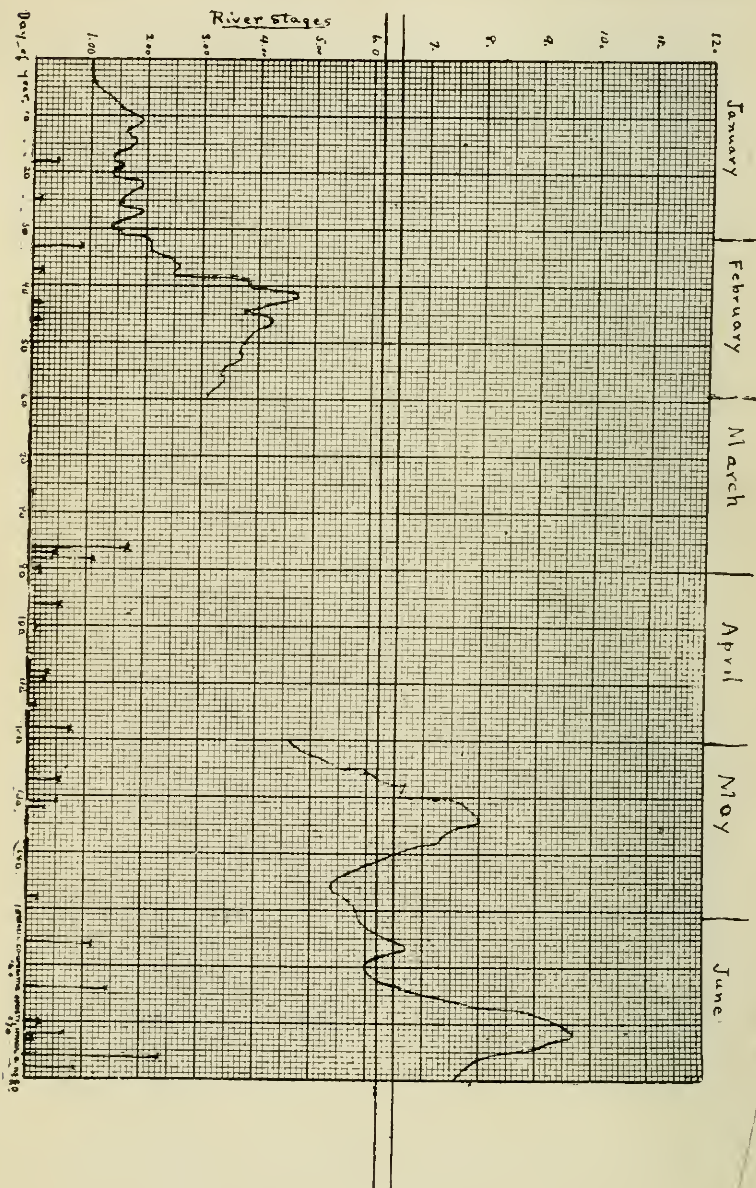
Among the areas characterized by well-marked plant associations or societies recognizable by ecologists, two, the temporary woodland ponds and the low area along shores of rivers and lakes, resemble each other in that their members generally represent remarkable adaptability in their relations to water supply, and both are accordingly regions of polymorphic or dimorphic species. Along shore-lines of permanent bodies of water stratified polymorphism, or variation of the same plant in different levels is frequent, as exemplified in the water plantain, *Alisma plantago-aquatica* L. and several *Potamogetons* which have three forms of leaves, the thin semi-transparent submersed, or often linear phyllodes, the flaccid floating leaves and stiff erect aerial ones, or which is exhibited most strikingly by the water parsnip, *Sium cicutaefolium* Gmel. with its finely cut lower leaves, serrate medium leaves, and almost entire upper ones. Dimorphic forms such as the water Star-Grass, *Heteranthera dubia* (Jacq.) MacM. are also present. In the temporary woodland ponds, although stratified variation is present, the water parsnip being a member of the pond region also, there is a more marked tendency toward seasonal dimorphism; in one fairly common and characteristic form, the yellow water-crowfoot *Ranunculus delphinifolius* Torr. we have indeed, during the high-water season, a stratified variation; but there is a metamorphosis also, the plant during the dry season being represented by the so-called var. *"terrestris,"*



a plant of entirely different aspect from the aquatic form. On these ponds it is that seasonal dimorphism reaches perhaps as great perfection as is found anywhere in the vegetable kingdom, in the "mud liverwort," *Riccia lutescens* Schwein. The change of this plant from an elongate creeping thallus with inconspicuous slender rhizoids into a butterfly-shaped floating thallus, well furnished with conspicuous balancing scales and reproducing itself, much like an amoeba, by bipartition, and the process of its change—all the heavier posterior portion sinking and dying while a newly developed spongy heart-shaped apical portion survives to develop into the floating form—is almost as remarkable as the metamorphosis of a butterfly. The change is indeed so striking that even among good botanists this floating form is frequently, if not generally mistaken for an entirely different plant, the floating liverwort, *Ricciocarpus natans* L. and, to increase confusion, the just mentioned liverwort, which is never found in temporary bodies of water, but only in lakes, rather infrequently produces a creeping form simulating the dry-pond stage of the mud liverwort.

A more remarkable effect of the region along shore, however, is the influence it exerts, not upon the members of its native flora, where great variability might naturally be expected, but upon such plants as have strayed down from the neighboring uplands, plants which here suffer a modification, not in their form, but in their size. In many cases plants, which on their native uplands, reach to a respectable stature, here undergo such diminution that they often barely exceed some of the larger species of moss. This diminutive flora is likely to be almost or entirely overlooked during the general growing season, and attracts attention to itself only after the frosts of autumn have cut down the tender herbage of the surrounding country. After this has happened, the humble plants along shore, protected by their closeness to the warmer earth and adjacent water surface, remain still unscathed, their leaves retaining the verdure of summer, and their blossoms the brightness of their prime. Even at this season, when they show up at their best, they are an inconspicuous group, and are usually discovered only when looking for something else, such as pebbles or shells along shore. During the survey of the Lake Maxinkuckee region, the writer become tolerably familiar with minute representatives of several plants, the most noteworthy being the common black nightshade, *Solanum nigrum* L., horseweed, *Leptilon canadense* (L.) Britton, Eclipta, *Verbesina alba* L. and various sticktights, *Bidens,* and smartweeds, *Persicaria,* on the sandy bars and pebbly beach of the shore, but the diminutiveness of the plants was attributed to the sterility of the sandy shore, and little more attention was paid to it.

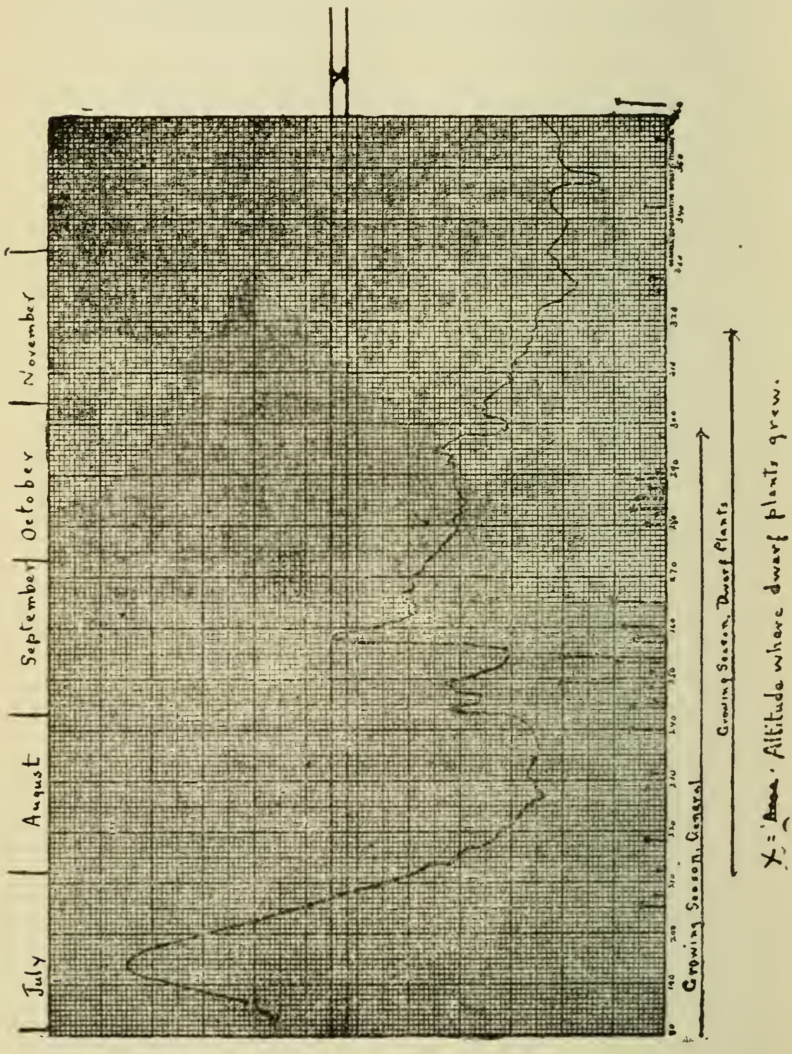


Plate II. *Artemisia caudata* Michx.

Inasmuch as the black nightshade was not found dwarfed in the region about to be more fully discussed, it may be worth while to mention it more fully in detail. Everyone is familiar with this plant, which is usually a rather large diffusely branching herb. The dwarf plants found at the lake were minute objects consisting of only two or three leaves, a simple stem, a flower or two and a full-sized berry. The small size of the plants was no more striking than their completeness, and the single berry would doubtless outweigh several times the entire remainder of the plant.

About October 21, 1914, while walking along the shore of of the Mississippi bordering the grounds of the Fisheries Biological Station at Fairport, Iowa, in search of the little mud liverwort, *Riccia lutescens* Schwein, a species usually rare along rivers, and generally absent at lakes or other permanent bodies of water and which, perhaps on account of its unusual habitat, was passing through a remarkable stage of its development, it was noted that a number of the common flowering plants of the region, representing a dozen or more not closely related species were remarkably diminutive in size, although fully developed and in flower and fruit. If it had not been for the search of the *Riccia*, the whole flora would probabry have been overlooked. Owing to the pressure of other duties, a few of the pygmy plants which were collected, were not taken care of at once, and allowed to spoil. On October 25th there was a rather severe frost which killed much of the tender vegetation of the general region. On October 30th and again on November 12th, this stretch of shore was re-visited and a number of the dwarf plants which were still verdant and flourishing were collected. Each subsequent visit to the place, until freezing weather had entirely wiped out the tender flora, tended to increase the number of species found, and—as the eye became accustomed to pick them out—to furnish specimens of still more minute size. In all the final collection contained representatives of 18 species, as follows, the nomenclature and sequence of species being that of the latest edition of Britton and Brown's Illustrated Flora:

1. Barnyard Grass, *Echinochloa crusgalli* (L.) Beauv.

2. Panic Grass, *Panicum*, sp.

3. Creeping Eragrostis, *Eragrostis hypnoides* (Lam.) B. S. P.

4. Low Cyperus, *Cyperus diandrus* Torr.

5. Awned Cyperus, *Cyperus inflexus* Muhl.

6. Pink Smartweed, *Persicaria pennsylvanicum* (L.) Small.

7. Rough-fruited Water Hemp, *Acnida tuberculata* Moq.

8. Carpet weed, *Mollugo verticillata* L.

9. Clammy-weed, *Polanisia graveolens* Raf.

10. Three-seeded Mercury, *Acalypha virginica* L.

11. Spotted spurge, *Chamaesyce maculata* (L.) Small.

12. Conobea, *Conobea multifida* (Mich.) Benth.

13. Long-stalked False Pimpernel, *Ilysanthes dubia* (L.) Barnhart.

14. Ragweed, *Ambrosia elatior* L.

15. Eclipta, *Verbesina alba* L.

16. Smaller or Nodding Burr Marigold, *Bidens cernua* L.

17. Beggar ticks, Sticktight, *Bidens frondosa* L.

18. Tall or Wild Wormwood, *Artemisia caudata* Michx.

The following are special notes on the plants encountered. Along with the notes is given the range in size as given in current descriptions, those of Britton & Brown's Illustrated Flora, 2nd Edition, and in the 7th edition of Gray's Manual, Revised by Robinson & Fernald. It is not believed the describer meant the dimensions given to cover the greatest extremes, but they are, however, given for comparison.

1. *Echinochloa crusgalli* (L.) Bauv. Barnyard Grass. Cockspur grass.

Rather common in the region in wet places. It usually forms a narrow fringe about the margins of the artificial fish-ponds on the Station where it grows tall, usually about 5 feet high. Often found along river and lake shores. "Culm 2-4 tall (Britton & Brown) "3-18 dm. high" (Robinson & Fer-

Plate III. *Bidens cernua* L.

nald.) This species in the dwarf form was rather frequent in the stretch of shore under consideration, the whole plants being little over one centimeter high and consisting only of a short culm, a few blades, and the head of a single spikelet or two.

2. *Panicum* sp?

Not common; a remarkably small form, the parts being so minute and material so scarce that identification was not satisfactory. One plant was only 17 mm. from root to tip of head.

3. *Eragrostis hypnoides* (Lam.) B. S. P., Creeping Eragrostis.

A rather common plant in the region in moist places, and, when conditions are favorable, especially abundant on mud flats between high and low water-marks, where it spreads extensively, forming large round mats. During the summer of 1910, low water prevailed without marked fluctuations of level, and shortly after the river had fallen the black, barren mud flats were quickly covered, as if by magic, by the minute seedlings of this grass which spread extensively over the flats, rooting at every point, the circular mats often being 18 inches or more in diameter. "Culms 1′-18′ long," (Britton & Brown) "2-5 dm. long," (Robinson & Fernald). Common along shore, the plants frequently being hardly more than 1 cm. long and bearing but 3 or 4 blades and a small spike.

4. *Cyperus diandrus* Torr. Low Cyperus.

A common plant of river and lake shores, thriving especially in moist sand. "Culms 2′-15′ tall." (Britton & Brown.) "Culms 0.5-4 dm. high" (Robinson & Fernald). Some very small plants hardly more than 1 cm. tall noted.

5. *Cyperus inflexus* Muhl. Awned Cyperus.

Fairly common in wet places, and generally reaching a normal size. "1′-6′ tall," (Britton & Brown). "2-20 cm. high." (Robinson & Fernald.) Dwarf plants very common along the stretch of shore, the entire plants exceedingly minute, hardly so conspicuous as a plant of the greater duckweed, even if that evident.

6. *Persicaria pennsylvanicum* (L.) Small. Pennsylvanica Persicaria.

Rather common and varying considerably in size, but all the plants markedly dwarfed. Several were greatly reduced, one with only two leaves and a single flower. Britton & Brown give the size as "1-3 tall." Robinson & Fernald do not mention the size.

7. *Acnida tuberculata* Moq. Rough-fruited water-hemp.

Like many other plants along the shores of the Mississippi, this species varies greatly in abundance from year to year, in favorable years being exceedingly abundant and in unfavorable years rather scarce. It is pretty closely confined to the stretch of shore between the base of the fringe of willows that mark the normal high-water line, and the low-water line. During the summer of 1910, a period of prevailing low water, the mud flats along the sloughs were left uncovered most of the summer, and great stretches were densely overgrown with this species. It is indeed one of the most remarkably variable, even under conditions of normal growth, of all our plants, many of the individuals being tall and erect, much resembling the common rough pigweed (*Amaranthus*) others prostrate, many with the flower clusters interrupted, others with these continuous in a conspicuous dense furry-looking spike, many of the plants green, others of all shades of red and purple reminding one strongly of a near relative, the Celosia or cockscomb of gardens, the whole mass giving to shores in autumn an appearance of a wild, barbaric mixture of splendor and somberness. Current descriptions do not give any lower limit of size. Britton & Brown say "Sometimes 10° high," and Robinson & Fernald make no mention of size. All the plants found on the stretch of shore were very small, some of them minute. It was a common plant and seven exceedingly small examples were collected, one 14.5 mm. long with a slender stem, 3 leaves and 4 flowers, a third specimen 31.8 mm. high, the others were about the same size. The year 1915, being a year of high water and rather few fluctuations, was not favorable for the development of the dwarf shore flora; however, at the edges of a slough known locally as Sunfish Lake, some very minute examples of this plant represented by little more than a little speck of purple, were seen. They hardly projected above the soil.

Plate IV. *Ilysanthes dubia* (L.) Barnh.

8. *Mollugo verticillata* L. Carpet weed.

Fairly common in the region of cultivated grounds, especially where the soil is somewhat sandy. Current descriptions do not give any "minimum" size. Britton & Brown mention it as "forming patches sometimes 20′ in diameter" and Britton's Manual mentions 5 dm. as the "maximum" size. Dwarf plants were abundant along shore; one measured 12.5 mm. or but little more than a half inch entire extent, and bore 6 leaves and 3 fruits.

9. *Polanisia graveolens* Raf. Clammy-weed.

Common in the vicinity along the railroad in ballast, where in spite of the barren dry soil it reaches a fair size. Rather uncommon along the river, although it is said to be naturally distributed along sandy and gravelly shores. Normal size as given in Britton & Brown, 6′ to 18′ high. One minute plant found, bearing a few leaves and a single pod. The pod was of normal size; it was, indeed, the most conspicuous part of the plant, and at first glance was taken for some sort of cocoon attached to a slender, delicate plant. It was by an attempt to pick up the supposed cocoon that the parent plant was discovered.

10. *Acalypha virginica* L. Three-seeded Mercury.

Several greatly diminished plants, consisting of only a short stem, 2 or 3 leaves, and flowers and fruit were obtained, but no comparative measurements taken.

11. *Chamaesyce,* probably *humistrata* (Engelm.) Small. Hairy Spreading Spurge.

A minute spurge, consisting of only a few mm. of stem, 3 or 4 leaves, and abundance of fruit, was common along part of this stretch. The fruits were markedly conspicuous, in some cases, indeed, the most conspicuous part of the plant. One entire plant measured 13.5 mm., the above-ground portion from base to tip of terminal blossom 4.4 mm. and it bore 2 dried cotyledons, 6 functional leaves and 2 fruits. Two other plants measured 13 mm. over all. Britton & Brown give measured normal size as "4′-12′ long." Robinson & Fernald give "8-18 mm. long."

12. *Conobea multifida* (Michx.) Benth. Conobea.

Only one plant found, it being only 24.6 mm. long and bearing several blossoms. Its natural habitat is said to be "long streams and shores." It does not appear to be common in the region. Britton & Brown give its dimensions at "4′-8′ high" and Britton's Manual mentions it as being "1-2 dm. high, very leafy," while Robinson & Fernald who do not mention size limits, speak of it as being "diffusely spreading, much-branched."

13. *Illysanthes dubia* (L.) Barnhart. Long-stalked False Pimpernel.

Numerous minute plants were present. One had a stem 5.5 mm. long and root about the same length, 6 leaves, 2 of them old, and shrivelled and probably representing the cotyledons, and 3 fruits. A second stemless plant had 4 leaves and 2 fruits, a third was 8 mm. high and 3 had flowers and fruits and 8 broad leaves. A fourth of the robust type had the stem about 5 mm. with 7 broad leaves and 2 fruits. Normal size given as "3′-8′ long" (Britton & Brown), or "1-3 dm. long (Robinson & Fernald.)

14. *Ambrosia elatior* L. Ragweed.

The well known ragweed was represented by a few dwarfed but markedly fruitful examples, ranging from only about 75 mm. high up to near the lower limits of the normal size. The normal size is given as from 1°-6° high (Britton & Brown), or .3-2.5 m. high (Robinson & Fernald).

15. *Verbesina alba* L. Eclipta.

This species, familiar to students of the floras of shores and borders of lakes often forms in favorable situations, tall well-branched plants. It was the most abundant of the dwarfed plants found along the stretch of shore under consideration. Between 100 and 150 examples of minute plants with only a few leaves and tipped with a small flower or sometimes bearing also several axillary flowers, were observed. The following measurements are fair examples:

a. 18.5 mm. in length, root and all, one branch, 4 leaves, one flower, aerial portion of plant 10 mm. high.

b. 18.5 mm. high over all; 2 pairs foliage leaves, cotyledons persistent, but dried; fruit consisting of 8 full sized achenes as a result of the single flower.

c. 15 mm. over all, 3 pairs of leaves, 1 pair dried cotyledons, 3 achenes.

d. 17.5 mm. over all, 3 flowers, cotyledons present but dried.

e. 15 mm. over all, 1 large flower, 10 achenes.

f. 10.5 mm. over all.

In wet sand along the shore of Lake Maxinkuckee, during the autumns of 1904 and 1907, exceedingly small plants of this species, bearing only 3 or 4 leaves and a terminal flower were collected. It was frequent about some of the Biological Station ponds where plants reached normal size. This is given as 6′-3° high (Britton & Brown), or 2-9 dm. high (Robinson & Fernald.)

16. *Bidens cernua* L. Small or Nodding Burr-Marigold.

Numerous examples along shore, one 30 mm. high with 2 pairs of leaves, one of which are the cotyledons and tipped with a minute blossom. A second with a stem 14.5 mm. high, 2 pairs of leaves, one of which are the cotyledons, and one blossom. Another, 19 mm. high, normal size "2′-3° high, consisting of many races differing in size" (Britton & Brown), "2-7 dm. high, very variable." (Robinson & Fernald.)

17. *Bidens frondosa* L. Sticktight.

Occasional along shore; it does not seem to be especially common in the locality away from the river. Known through many parts of the country as "Spanish-needles"; a local appropriate name is "boot-jack." Not so common as the former; small plants are often noted growing in piles of lodged driftwood or on lodged logs out in the sloughs. One plant bore 4 leaves and 1 flower; the stem was very short but too crooked to measure exactly. Normal size "2°-3° high" (Britton & Brown.) "Stems tall, 7 dm. or less in height." (Robinson & Fernald.)

18. *Artemesia caudata* Michx. Tall or Wild Wormwood.

Dwarf plants numerous—one plant measured 12 mm. or a little less than half inch over all and bore 1 persisting cotyledon, 5 leaves and 1 flower. Another perfect plant measured 18 mm. over all. The writer is most familiar with this species in dry sandy places where it grows to be a tall weed. Britton & Brown give the size as 2°-6° high, and Robinson & Fernald gives it as 0.5-1.5 m. high.

In addition to these dwarf species there are a few plants of the wild bean (*Strophostyles helveolus*) which had evidently germinated in late summer and bore a blossom or two. They were, however, far from mature.

Now, one striking feature of this dwarf flora was that while the dwarfs varied considerably among themselves as to size, the whole flora was markedly dwarfed, not merely single individuals here and there. This fact, along with the fact that several unrelated species were involved, indicated that some markedly dwarfing influence was at work.

In seeking an explanation, two obvious facts forced themselves upon the attention: one was the persistence of the cotyledons on many of the plants, indicating that they were not only dwarfed, but young precocious plants, and another was that the ground where they grew was considerably below the high-water line of the river, which covered the ground where they grew until considerable late in the season. They would therefore have a considerably shorter growing season than their upland relatives. Although, as will be stated more fully hereafter, this shortness of season is in itself hardly sufficient to explain adequately the dwarfness of the plants, it is one factor which we can give in terms of more or less precise measurement by a consultation of records of the weather and of the river stages. They are therefore given in considerable detail, especially as, on account of their measurableness, they can be represented in compact, graphic form.

The strip along which the dwarf plants were found growing was between about 6.21 and 6.50 feet above the low water mark. Now, during the early part of the season—from May 9th to May 22d, on June 6th to 8th and from June 14th to July 28th, the water was above the 6.50 stage. Even with

Plate V. *Bidens, Cyperus, Polanisia* and *Artemisia* the water somewhat below this stage, the play of waves, especially of the strong scouring wash made by passing steamers, would make the germination of seeds impossible.

It is therefore pretty certain that the dwarf plants in question could not have germinated until after July 28th, probably about the beginning of August.

Now, notes concerning the general vegetation of the region indicate that back from shore, where conditions were normal, the germination of spring seeds was fairly well under way about April 27th. This would almost certainly include *Ambrosia* and *Persicaria,* which are among the earliest of seeds to germinate, and probably the rest of the species represented. From this date the general growing season extended until October 26th, a period of 181 days, when it was terminated by a killing frost, the length of growing season being very unusual for this region. The growing season of the dwarf plants continued about a fortnight longer, or until November 14th. On account of their closeness, both to the ground and to the water's edge, they escaped the first few killing frosts and persisted bright and green until a slight freeze. This makes their growing period (from about August 1st to November 14th) about 107 days or 74 days shorter than that of the general vegetation. It was very probably considerably shorter than this; the germinating plants were not seen, and the plants were given the benefit of the doubt by assuming germination with remarkable promptness after the receding waters had left the ground bare where they were found. A part of the ground where they grew was indeed partly submerged by a 2 days rise September 15-17, and it is barely possible that the plants sprang up after that time, giving them a growing season of only 39 days. Their exceedingly small amount of growth and their persisting cotyledons makes this short season seem not improbable.

The plants collected were preserved in two forms (1) as dried specimens and (2) preserved in formalin, as it was feared that some of the more diminutive ones might be easily lost among the herbarium sheets. There is appended photographs showing some of the dwarf plants natural size, and a chart showing river stages, rainfall, and the boundary-lines of the dwarf-plant area.

The factor just considered, i.e., shortness of the growing season, appears indeed also to account in part for individual dwarfing of upland plants. Thus on the Biological Station grounds one frequently finds growing side by side normal size and extremely dwarf forms of the same species. Plants which are noteworthy in this respect are the Shepherd's purse, *Capsella bursa pastoris* L., Peppergrass, *Lepidium virginicum* L., and the Golden Corydalis *Capnoides aureum* (Willd.) Kuntze.

The Peppergrass and the Shepherd's Purse flower and fruit throughout the entire summer. The seedlings of some of the earlier maturing pods germinate early in autumn, and form stout conspicuous rosettes. which winter over in this form and in spring spring up into tall, robust plants. Seeds from the later maturing pods do not germinate however until spring, and appears as a rule to form short-season, comparatively puny plants. In Golden Corydalis, the individual plants have an exceedingly long period of bloom, from early spring until midsummer and one finds ripened pods and unopened flower-buds on the same plant. The seeds from early-ripening pods germinate in early autumn to form rosettes while those from the later ripening pods do not germinate until spring, when they frequently form puny plants, with 1 or 2 leaves and a blossom.

Still, shortness of season cannot entirely account for dwarfness and early ripening. We know that while late planted corn will mature more rapidly than the same variety planted earlier, that there is a fixed limit which cannot be trespassed, and the farmer who would plant his seed at date of germination of our water plants mentioned in the earlier part of our discussion, would reap—not dwarf corn, but would find his crop cut down by frost when still green and immature. Among land plants moreover, we have dwarf perennials, such as dimunitive wild crabs, cedars, hackberry, etc., where the length of the growing season can cut no figure; and we know that the seedling of a large seed produced by the underground cleistogamous flower of the hog-peanut is a veritable giant compared with the frail "spindling" brother from the small aerial seed.

The case of dwarfing, frequently individual, among upland plants, appears on the whole to be a complex and diversified problem, assignable to numerous causes. The case of dwarfness in shore floras is more general and of larger aspect. Among other causes, a water soaked compact soil by inhibiting root-development may have an important part. Especially significant in this connection is the permanent dwarfing of forms which hug the waters' edge, such as some of the little water spearworts of the genus *Ranunculus*, or the genus *Hydrocotyle* among the parsnips, or, more remarkable still, that of the family Salvinaceae amosg the Pteredophytes of which one representative, *Salvinia*, is aptly described as "floating like *Lemna* on the surface of stagnant waters," and the other, *Azolla*, as "appearing like a reddish hepatic moss." Finally this process of diminution reaches its consummation and approaches most nearly the vanishing point among the Lemnacea, all of which are small, in the rootless and leafless *Wolffia* which in general appearance reminds one of *Volvox* rather than anything else, and the dimunitive *Wolffiella* which bears a close superficial resemblance to some of the low plankton algae such as *Aphanizomenon*.

THE PRIMROSE ROCKS OF ILLINOIS

H. S. Pepoon, Lake View High School, Chicago

The 9th day of April, 1905, the writer was tramping down the narrow, cliff-confined valley of the west branch of Apple River, spying out the bird life of this sheltered locality, and more than incidentally, keeping both eyes open for the early blossoms of Hepatica, Dicentra, Claytonia, Sanguinaria and other bluff and valley species of plants. His attention was attracted to the peculiar coloration of a huge vertical cliff of limestone across and rising directly out of the river some fifteen rods from the point of observation. The whole face of the rock for perhaps twenty feet vertically and extending fifty or sixty feet horizontally was a solid hue of pale lavender purple. A "close up" inspection revealed thousands of small rosettes of delicate leaves, and springing from the center of each from one to four delicate slender scapes bearing from one to five small lavender colored blossoms. Only once before had any similar wild plants been encountered and they were the mealy primrose, growing on the rocky shores of Northern

Lake Huron. Evidently the new kind was a primula and a later verification made it the *Primula Mistassinica,* or dwarf Canadian primrose.

The number of plants growing on the exposed cliff was almost incredible. Some comprehension may be gained when confession is made that, remembering a good friend who was making extensive collections for herbarium purposes, four hundred and four entire plants were gathered without in any way showing that a vandal hand had even attempted to thin the ranks. So close together were the plants that practically a mat was formed by the rosettes. The leaves overlapping in all directions, as each root was on average not over two inches from a neighbor, there must have been on that favored area of rock surface not less than forty thousand plants, and these at the time above named were at the climax of their bloom, the color effect being therefore a most natural result.

A further exploration of the valley disclosed two other cliffs where a scattering growth of the plants was found, but in neither place was there any approach to the prodigality of plants, luxuriance of growth or profusion of flowers found on the first discovered area. Presumably there are other localities along this branch where the species may exist, but the fact remains, that though repeatedly visited since that year, and at all seasons, no other such find has ever been made and at this one cliff only have the plants ever been found in later years in any abundance. It is true, this lack of similar abundance and bloom may be due in large part to the great difficulty of determining from year to year the date of the maximum display. The flowers are very ephemeral and the whole cycle of the plant from beginning growth to scattered seed is barely six weeks. The varying seasons bring on the climax at different dates, the time alone when the color display is marked, and one would actually be compelled to camp on the grounds yearly for ten or more days to discover the same glory that was a purely accidental find of 1905.

Growing, as the plants do, on cliffs that are essentially vertical, there can be no question but that most of the seeds produced are lost through the agency of gravity by being precipitated into the underflowing stream. Only a mere pittance would lodge in the zone of favorable conditions. The

The Primrose Rocks on West Branch of Apple River area in question is a thick-bedded and very much weathered and eroded Platteville-Galena limestone, having many chert seams from which year in and out there continually oozes a lime-saturated cold clear water, giving the whole face of the Primrose section a very wet condition. In fact the conditions are largely the same as would prevail in a well drained swamp. Of disintegrating rock there is abundant supply, but of humus and ordinary soil there is practically none, and it is an interesting problem as to where the primula and other associated species obtain the nitrogen necessary for protoplasmic needs. The seeds that do germinate almost of necessity are caught by some portion of the rosette or lodge on the decomposing rock or in the numerous weathered cavities.

The constant water seepage, beside furnishing abundant moisture and certain mineral elements, has marked ameliorating effect on the rock temperature, both summer and winter. In summer the roots of the plant are kept constantly cool, even in the face of the hot afternoon sun, for all these primrose cliffs have a westerly exposure. In winter, on the contrary, the water keeps the immediate surface and surface rock layers above the freezing point, finally forming ice cascades that cover most of the cliff face, and these must effectually protect from the cold western blasts the delicate roots and crowns buried beneath them.

This primula, as a rule, grows in a nearly pure association, very few if any other species intermingling. Here and there, however, there are little islands in the midst of, or peninsula like tongues extending into the primrose growth from the margins. These are overgrown with various species of mosses, one or two liverworts, a Parnassia, Sullivantia, Potentilla fruticosa, Hypericum Canadense, Epilobium lineare, Steironema quadriflorum, Lycopus Americanus, Mimulus ringens, Pedicularis lanceolata, Galium boreale, Campanula uliginosa, Lobelia Kalmii and Senecio obovatus. It is to be especially noted (as set forth in *Cliff Flora of Jo Daviess Co.*) that the above list is of typical swamp or marsh species, but which all through this particular region elect largely to grow on wet cliffs and with even greater luxuriance than when inhabiting the ordinary level swamp.

There is practically no danger of extermination facing this pretty species for its home has absolutely no value to man and only the wild climbing folk can by any possibility obtain precarious footing where it dwells in peace. The hog, that arch enemy of the wild plant people, can never tread these cliffs and the average human plant hog is too solicitous of his neck or extremities to venture on these slippery steeps.

In conclusion, a brief statement of the geographical distribution of our plant will be interesting. Gray, Britton, Bailey and others agree in giving it a far northern range extending well into the arctic regions of North America and reaching the United States in Northern Maine, Vermont, New York, Upper Michigan, Wisconsin, Minnesota and so North West to the Saskatchewan. This remarkable southern extension into the northwestern Illinois, therefore, is Mistassinica's "farthest south" by over one hundred miles from any neighboring station. The inference is drawn that this station is a remnant of a vast horde of the plant that in preglacial days occupied much of the rock region of Northeastern North America, the glaciers having obliterated most of these plants, the Illinois locality escaping because the ice destroyer did not there encroach.

PORTO RICAN FUNGI, OLD AND NEW

F. L. Stevens, University of Illinois

While numerous collectors have focused their attention on the flowering plants and ferns of Porto Rico, comparatively little study has been made of the lesser cryptogams, especially of the fungi.

Mr. A. A. Heller collected fungi in Porto Rico in January and February, 1900, and the collection is reported upon by F. S. Earle[1]. Heller's collection of December and January, 1902-1903, are reported also by Earle[2]. Earle also made reports of his own observations on the fungi of the island[3]. Olive and Whetzel reported upon several species of rusts which they collected in Porto Rico in the summer of 1916.[4]

1. Muhlenbergia 1:10, July, 1901.
2. Bulletin of the New York Botanical Garden, 3: 301, June 30, 1904.
3. Annual report of the Office of Experiment Stations, 454, 1903.
4. American Journal of Botany, 1:44-52, January, 1917.

Mentions are also made of the more conspicuous of the fungi affecting economic plants in various bulletins of the Porto Rican Agricultural Experiment Station and reports of the Board of Commissioners of Agriculture.

In addition to the above, reports have been made upon my own collections by Arthur, J. C.[5]; Young, Esther[6]; Garman, Philip[7]; Stevens, F. L.[8]

Several other articles based on this collection are presented at this meeting.

In the present report are listed only fungi not noted in the above mentioned articles. My collections are as yet far from being determined, and this list represents merely part of the few specimens that have been studied. Unless otherwise indicated, the specimens were collected by the author, and the numbers given are those of his collection as deposited in the herbarium of the University of Illinois.

For determination of the flowering hosts I am greatly indebted to Dr. N. L. Britton and Mr. Percy Wilson; for fern determinations to Miss Slosson, for grass determinations to Mrs. Agnes Chase. The Hymenomycetes were determined by Dr. W. A. Murrill, the Myxomycetes by Dr. T. H. McBride, the Ustilaginales by Dr. G. P. Clinton.

Myxomycetes

Diachea Fries

Diachea leucopoda (Bull.) R. on *Pitcarnia angustifolia,* Sta. Ana, 6683; on Pitcarnia sp., Preston's Ranch, 6705.

Physarum Pers.

Physarum sp? on Opuntia sp., Guanica, 320.

Comatrichia Preuss.

Comatrichia langa Peck., on (?), Porto Rico, no number.

Tilmadoche Fries

Tilmadoche compacta Wing, (probably), Porto Rico, no number.

5. Uredinales of Porto Rico based on collections of F. L. Stevens, Mycologia, 7: 168-196, 227-255, 315-322; 8: 16-33. Sept., Nov., 1915; and January, 1916.

6. Studies in Porto Rican Parasitic Fungi. Mycologia, 7: 143-150, May, 1915. Studies in Porto Rican Parasitic Fungi II., Mycologia 8:42-46, January, 1916.

7. Some Porto Rican Parasitic Fungi I., Mycologia 7: 333-340, November, 1915.

8. The Genus Meliola in Porto Rico, Illinois Biological Monographs, No. 4, April, 1916, and Meliolicolous parasites and Commensals. Botanical Gazette, in press.

Phycomycetes

Chytridiales

Synchytrium De Bary and Woronin

Synchytrium decipiens Farl. on *Rhynchosia reticulata*. Quebradillas, 5128, Cabo Rojo, 2278. 2144.

Peronosporales

Albuginaceae

Albugo (Pers.) Russell

Albugo ipomoeae panduranae (Schw). Swing., on *Ipomoeae batatas,* Monte de Oro, 5732, Tanama Rio, 7886, Consumo, 894, Arecibo-Lares road, 7306, Manati, 7706, Corosal, 410, Luquillo 2780, Boqueron, 342, Guanica 340, 346a, Guayanilla, 5898; on *Ipomoeae pes caprae.* Santurce, 247, Dos Bocas, below Utuado, 6636, Guanica, 6834, Boqueron, 346, Mayaguez, 7502, Point Cangrejos, Stevenson, 5455. The Albugo on this host is especially conspicuous, causing much distortion of the parts affected. On *Ipomoeae tiliaceae,* San German, No. 5610. Garrochales, 3763, (Stevenson). On *Jacquemontia nudiflora,* Guayanilla, 5905, Mona Island, 6357. On *Ipomoea* sps. Rio Piedras, 5772, Peñuelas, 9142, Mona Island, 6236, 6208, 6080.

Albugo platensis (Speg.) Swing., on *Boerhaavea erecta,* Guanica, 319a, Guayanilla, 5896, Mona Island, 635.

Albugo bliti, (Biv.) Ktz. on Amarantus sp. Jajome Alto, 5679; on *Amaranthus viridis,* Rio Piedras, (Stevenson), 3870.

Albugo candida (Pers.) Kuntze; on *Lepidium virginicum,* Tanama Rio 7822, Comerio (dam). 5035, (Stevenson).

Albugo portulacae. On *Portulaca oleracea,* Mayaguez 7052.

Peronosporaceae

Peronoplasmopara (Berl.) Clint.

Peronoplasmopara cubensis, (B. & C.) Clint. On cucumbers, Rio Piedras 3621, (Stephenson). On *Luffa cylindrica,* Rio Piedras, 7004.

Cenangiaceae

Pezizales

Ephelis Fries

Ephelis sp., on *Erichloa subglabra,* Rio Piedras, 4195, (Johnston).

PHACIDIALES

TRYBLIDIACEAE

Triblidium Duf.

Tryblidium refulum (Spreng.) No. 6737.

ASPERGILLALES

ASPERGILLACEAE

Penicillium Link

Penicillium digitatum (Fr.) Sacc. On grapefruit. Palo Seco. 3976, (Stevenson).

MYRIANGIACEAE

Myriangium Dur.

Myriangium duriaci Mont. On white scale. Palo Seco. (Stevenson) 3886.

PERISPORIALES

ERYSIPHACEAE

Though diligent search was made for powdery mildews with perithecia, none were found in Porto Rico. The conidial stage occurred on many hosts and with great frequency. It is of course impossible to make satisfactory determination of the genera and species of these without perithecia. The following Erysiphaceae represent merely collections of Oidium and are given with the names of the species to which they may belong, i.e., with these species which are known to occur on these hosts.

Microsphaera Levéillé

Microsphaera euphorbiae (Pk.) B. & C. (?) On *Chamaesyce braziliensis*, Mona Island, 6100, Maricao, 4805, Peñuelas, 4176; on *Chamaesyce hypersicifolia*, Mona Island, 6405, Jajome Alto, 5639; on *Hibiscus sabdariffa*, Mayaguez, 5775; on Manihot, Preston's Ranch, 6606.

Microsphaera diffusa D. C. (?) On *Meibomia* sp. Rosario, 4801; on *Meibomia supina*, Utuado, 6867, Jayuya, 6075; on *Meibomia scorpiurus*, Manati, 5301, Guayama, 5332; on *Meibomia adscendens*, Utuado, 4420. *Crotalaria retusa*, Sta. Ana, 3967, Coamo, 843, 5105.

On *Meibomia tortuosa*, Peñuelas, 9146, on *Meibomia* sps. *Mona Island*, 6197.

Sphaerotheca Léveillé

Sphaerotheca humuli (D. C.) Burr. (?) On Verbena (cult.); on Rosa (cult.), Maricao, 767, 4005; on Cosmos

—; on Bidens, sp. Jayuya, 6074, on *Bidens reptans,* Vega Baja, 476, Maricao, 4483; on *Xanthium longirostre,* Añasco, 8740, Guayama, 5406; on *Melanthera canescens,* Utuado, 6039, 652, on *Ocimum micranthum,* Utuado, 8062.

Erysiphe Hedwig

Erysiphe cichoracearum D. C. (?) On Dahlia, Monte Alegrillo, 2358; on *Solanum torvum,* Rosario, 4816, Preston's Ranch, 6696, Cabo Rojo, 2239; Maricao, 2367, Arecibo, 6800; Naguabo, 9388, Peñuelas, 9161, 9145, Mayaguez, 7064, 7322, Hormigueros, 7363, Maricao, 8825, 9127; on *Cosmos caudatus,* Sta. Ana, 7614, Tanama Rio, 7868; on *Eupatorium microstemum,* Maricao, 4812.

Erysiphe polygoni D. C. (?) On Cassia sp., Utuado, 6051; on *Cassia occidentalis,* Guayama, 5330. 5416, Rio Piedras, 5771, Rosario 9497, Peñuelas, 9138, Arecibo-Lares Road, 7304, 7314, Cabo Rojo 9083, Manati, 4312, 5312; on *Cassia tora.* Maricao 2368, 8902, Quebradillas, 5625, Aguada, 5084, Peñuelas, 4897, Guayanilla, 5927, 5897, San German, 5802, Guayama, 5399, Adjuntas, 6021, Mayaguez, 3024, 3882, 9152; on *Phaseolus* sp., Mona Island, 6247, Mayaguez, 6749; on *Ph. adanthus,* Aguada, 5075, on *Vigna repens,* Mayaguez, 1856; on *Chamaecrista,* Peñuelas, 9159. On *Arraciaxannthorrhiza,* Indiera Fria, 3468.

Erysiphe galeopsidis (?) On Eupatorium, Ponce, 4265.

PERISPORIACEAE

Hyaloderma Speg.

Hyaloderma piliferum Pat. on Meliola sp., determined by Patouillard. Santurce, 1368. This specimen in the Bronx collection shows a Meliola with a Calonectria upon it, but the portion which I had did not show the Hyaloderma.

Dimeriella Speg.

Dimeriella erigeronicola sp. nov. Fungus superficial, epiphyllous, black. Colonies circular, 1-4 mm. in diameter. No effect visible on the leaf tissue. Mycelium copious, straw-colored, crooked, about 1.5 μ in diameter, septate. Perithecia black, numerous, globose, 64-102 μ in diameter, bearing numerous, 15+, appendages, mostly basal, which are similar in structure to the mycelium but darker in color, 1½-2 μ in diameter, somewhat crooked, septate. Ostiole minute but distinct. Asci cylindrical, 31-34x7 μ, 8-spored, obtuse. Spore two-celled, 7x1-5μ, hyaline or very pale yellow. Paraphyses numerous, fine, thread-like, crooked.

On *Erigeron spathulatus,* Quebradillas, 6821 (type), Maunabo, 2453, Yauco, 3240. El Gigante, 8522, Maricao, 8935; on *Erigeron pusillum,* Maricao, 8805.

Dimeriella olyrae sp. nov.

Fungus superficial epiphyllous. Spot none, the fungus coating the leaf surface evenly with black; mycelium yellow to dark brown, abundant, septate, crooked, about 3-4 μ thick with a tendency to aggregate into a film at spots. Perithecia numerous, 51-68 μ in diameter, black, slightly rough, each bearing 1-4, long, 234-300 μ, black setae. No ostiole. Asci ovate, 51-65x24 μ, 8 spored; spores inordinate, 17x7 μ, 1-septate, hyaline. No paraphyses.

On *Olyra latifolia,* Preston's Ranch, 6770 (type), Maricao, 3639, 190, 3472, 8959, 8942, Mayaguez, 7486, 7587.

This fungus is striking in the abundance of perithecia and the long, black setae on these. It clearly differs from *Dimerosporium oligotrichum* Mont. & Sacc. (Not Sacc. & Berl.) which according to v. Hohnel belongs to the Capnodiaceae.

Dimeriella cordiae (P. Henn.) Th. On *Cordia sulcata,* Mayaguez, 975.

Dimerium grammodes. On *Meibomia barbata,* Rio Piedras, 7007.

Perisporium Fries

Perisporium truncatum sp. nov.

Hypophyllous, forming smoky patches 1-2 cm. in diameter. Mycelium copious, superficial, brown, uniform, 7 μ, with septa about 50 μ apart, branches often at right angles. Hyphopodia none. Mycelial setae erect, simple, straight, septate, 310 μ long, 3.5 μ thick at top, 8 μ at base. Perithecia spherical, astomate, slightly rough, 109-202 μ, carbonous; cells about 17 μ in diameter. Asci ovate to cylindric, 125x34 μ, thin walled. Spores 2-septate, cylindric, 68-92x10 μ, hyaline when young, smoky or darker when old, rounded at one end truncated and with a ring around the other end.

On *Inga laurina,* Maricao, 3657, 7023, Mayaguez, 7049 (type), 7477, 7038, 7474, 9137, 974, 3905, 1076, El Alto de la Bandera, 8273, 7559, Coamo 605. On *Inga vera* Maricao, 762. It differs decidedly from *Zukalia fusispora* Pat. as described on Inga.

It is often overgrown by a fungus which has a fine white mycelium which weaves into a close mat forming white spots from a few millimeters to a centimeter or more in diameter.

Perisporium bromeliae sp. nov.

Spots hypophyllous, smoky, 1-2 cm. in diameter. Mycelium superficial, abundant, brown-black, septate, sparsely branched. Perithecia irregular, globose, 110-120 μ, no ostiole. Asci ovate fasciculate from base of perithecium, numerous, 50-58x20 μ, 4-spored, no paraphyses.

Spores fusiform, straw-colored, irregularly 0, 1, 2 or 3-septate, 30x8-10 μ, not constricted at the septa.

On *Bromelia pinguin*, Manati, 4329. (type), 1832, Utuado 6577, 8081, Mayaguez, 3912, 7573, 7034, 7094, 7426, Rio Tanama, 7999, 8106, Sta. Ana, 7613, Cataño 7708, Vega Baja 7719, Florida Adentro, 7679, Lajas, 7150, Hormigueros, 7370, Coamo, 8355, 8356, Maricao, 8925, Añasco 8751.

This is very common on the host in all parts of the island. The smoky blotches are so usual as to seem to belong to the plant. The perithecia are almost exclusively found in the furrows or grooves between the heavy veins.

This fungus in its perithecium clearly shows its relationship to the Perisporiales, but within that order its position is much less certain. The spores vary much in septation, being from 1 to 4-celled in spores which are fully mature. In the Phaeosporae there is a general resemblance to Cephalotheca but the ascus structure is not that characteristic of that genus. In the Phaeophragmiae where the fungus evidently belongs, it differs distinctly from Meliola in many respects, especially in character of mycelium and spores: From Schenckiella in spore characters: from Perisporina in mycelial and spore characters. Its agreement seems to be most close with Perisporium from the description of which it differs in its 4-spored ascus. Notwithstanding this difference, however, it seems best to place the species in Perisporium.

Perisporium portoricense sp. nov. Stevens and Higley. Fig. 1.

Colony, dark brown, round, scattered, hypophyllous or epiphyllous, sometimes amphigenous, 0.5-1.0 cm. in diameter or by coalescence occupying the leaf. Mycelium copious, diffuse, dark, smooth, hyphae branching at nearly right angles, 7-9 μ in diameter. No hyphopodia. Perithecia numerous, globular, black, gregarious, carbonaceous, without appendages, ostiole or paraphyses, surface slightly rough, 175-270 μ in diameter. Asci cylindrical, 8-spored, oblong, obtuse, stipitate, attached basally, 37-50x92-125 μ. Spores slightly curved, obtuse at apex, base somewhat acute, 3-septate, separating at septa, end sections more or less conical, 8-9 μ x 70-80μ.

Fig. 1. *Perisporium portoricense*. Asci and spores. 7489 (type). Drawn by R. Higley.

On *Calophyllum calaba,* Mayaguez Mesa: 7489 (type). Vega Baja, 4310.

The mycelium bears numerous curved hyphae standing upright. The ascus walls are hyaline and very thick except at the apex where there is a slight notch on the inner surface.

The fungus is peculiar in that sometimes it is quite strictly limited to upper surfaces, again to lower surfaces, while it is sometimes amphigenous. The spores when young show no indication of falling into segments and are straight and smooth. It is only in quite mature asci that they show the character as given in Miss Higley's drawing. In earlier condition and as more often seen they would indicate that the fungus belongs to the genus Perisporina of Henning.

Perisporiopsis gen. nov.

Type P. wrightii

Perisporiopsis wrightii (B. & C.) comb. nov.

Perisporium wrightii B. & C.

On Opuntia. Mayaguez, 6293, Ponce, 6778.

These specimens in their general appearance, which is very distinctive, agree closely with the excellent description given by Wolf of Texan material.[1] and with a sporeless fragment of Wolf's material which was loaned to me from the New York Botanical Garden. The rare character of spores of violet-color turning to brown with age, seems to make it certain that the Porto Rican specimens are co-specific. The affinity with the Plectascineae as shown by Wolf's drawings (Fig.c, p. 126, l.c.) and by my own observations, and the additional character that the spores are frequently muriform, prevent regarding this fungus as a Perisporium. It differs distinctly also from Meliola, Pleomeliola and Cleistotheca, and the above named genus is therefore created for it.

Perisporina P. Henn.

Perisporina lantanae sp. nov.

Fungus hypophyllous forming an abundant sooty coating, thickly strewn with perithecia. Mycelium dark straw colored to black, many septate, about 4 μ in diameter, without hyphopodia. Perithecia 110-130 μ in diameter when mature, when young, surrounded by an areola of radiating hyphae, densely beset with setae which in general nature are like the mycelium, varying from 70 to 480 μ long, about 7 μ thick at base, many septate, dark. Perithecial wall closely reticulate; perithecium irregularly globular, non-ostiolate. Asci 61-68x17-20 μ, 8-spored, inordinate. Paraphyses hyaline, filamentous, branched. Spores 2-3 septate, apparently usually 3-septate when mature, dark, 34-37x6-7 μ, two cells larger than the other two.

On *Lantana camara* Lares, 4924 (type). 4926.

1. Ann. Myc. 10:125, 1912.

Dimeriopsis gen. nov. Fig. 2

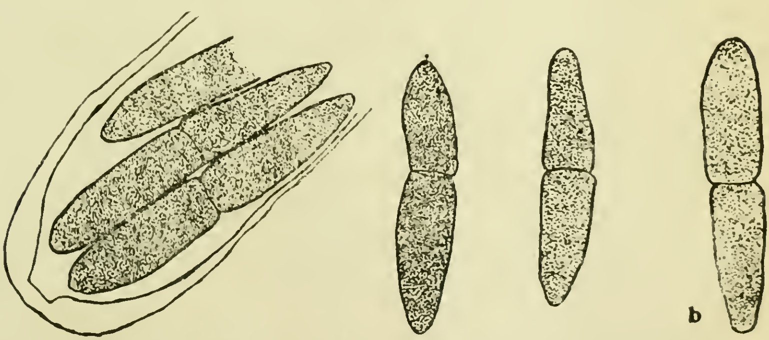
This genus of the Dimerineae is characterized by the development of the perithecia below a mycelial skin. Type *D. arthrostylidicola.*

Dimeriopsis arthrostylidicola sp. nov. Fig. 2.

Spots black consisting of superficial mycelium encircling the stems, 0.5 to 2 μ long. Mycelium coarse, 4-5 μ, somewhat crooked, brown, densely interwoven and matted in older portions, at edges radiate. Hyphopodia none. Setae 312 μ long by 10 μ thick, thick-walled, numerous on older mycelium. Perithecia 400-450 μ in diameter developed below the mycelial layer, sides and top well developed, of brown hyphae, base extremely thin, hyaline. Ostiole none. Asci numerous, 100-150x 25-30 μ, clavate, thick-walled, with a thin spot at the apex, 8-spored. Paraphyses present, filamentous, matted, gelatinizing. Spores straight to slightly falcate, inordinate, 2-celled, rarely 4-celled, dark brown, constricted at septa, 12-14x40-55 μ obtuse.

On *Arthrostylidium sarmentosum.* Monte Alegrillo, 4772 (type).

(a)



b

Fig. 2. *Dimeriopsis arthrostylidicola* (a) Tip of an ascus showing spores and the apical thin spot. (b) Spores showing the constriction at the septa, 4772. Drawn by J. MacInnes.

This fungus, clearly Perisporiaceous, in its superficial mycelium, and general characters falls within the Dimerineae,[1] and close to Dimerium. From this genus, however, it differs radically in charcater of the perithecium, very large size and peculiar shape of spores and the presence of abundant paraphyses. The most striking feature is that the perithecia develop below the mycelium, i. e., the mycelium over a considerable area coalesces to form a continuous black skin which is, however, only one layer thick; and below this skin in a partially de-

1. Theissen, Bot. Cent. 29:46.

veloped hyaline stroma are the perithecial cavities. In teasing a specimen the asci and paraphyses adhere together and often fall out entire, like the meat from the shell of a nut, leaving a mold of their form behind.

Meliola Fries.

Meliola melastomacearum Speg. On *Miconia impetiolaris,* Mayaguez, 3922; on *Heterotrichum cymosum,* Utuado, 4359.

Meliola sp. indet. On *Podocarpus coriaceous,* Maricao, 6774.

The mycelium here is unquestionably that of Meliola, but no perithecia are present. The specimen is worthy of note since no Meliola is recorded on this host or its family.

Meliola leguncularieae. E. On *Conocarpus erecta,* Mayaguez, 7201.

MICROTHYRIACEAE

The representative of this family, one of the most common in the tropics, will be the subject of a separate paper.

HYPOCREALES

HYPOCREACEAE

Hyalosphaera, gen. nov. type *H. miconiae.*

Hyalosphaera miconiae, sp. nov.

Spot indefinite, roughly circular, above pale to yellow, 3-10 mm. in diameter; below pale and coated with buff mycelium centers ashen-grey due to ascospore color, mycelium 5 μ, septate, branched, hyaline.

Perithecia, smooth, spherical to ovate when mature, hyaline, transparent, entirely closed when young, open at top when mature, 80-100 μ in diameter, without stroma or subicle; wall 4 μ thick at top, and sides, transparent, opening by apical rupture but without a differentiated ostiole. Asci clavate to oblong, obtuse, thin-walled, numerous, originating from the pseudoparenchymatous base of the perithecium, 8-spored, spores longitudinal. Paraphyses numerous, exceeding the asci, very fine, 1 μ. Spores linear, 2-3 usually 3, septate, smokey to brown, 40-57x5 μ.

On *Miconia laevigata*, Arecibo, 6804, Utuado, 6862, 6871, Maricao, 207 (type) 4822, Aguas Buenas, 302, Ponce, 4338, Yabucoa, 6705.

This fungus forms buff-colored spots over the lower surface of Miconia leaves and though its internal mycelium was not demonstrated, there are formed distinct spots on the host, areas that are yellowed or bleached. In the centers of the older spots are seen regions of ashen-grey appearance that might lead one to suspect the presence of a Cercospora. Examination, however, shows this ashen-grey region to be due to myriads of transparent perithecia containing dark ascospores. It is possible with a scalpel to lift from the leaf several square millimeters of the fungous weft, for microscopic examination. It proves to be made of an exceedingly loosely woven hyaline mycelium.

Borinquenia gen. nov.

Ety. from *Borinquen*, the ancient name of Porto Rico. Perithecium fleshy or membranous, ostiolate, reddish; asci fasciculate, basal, paraphyses present; spores linear, septate, brown. Type of genus the following:

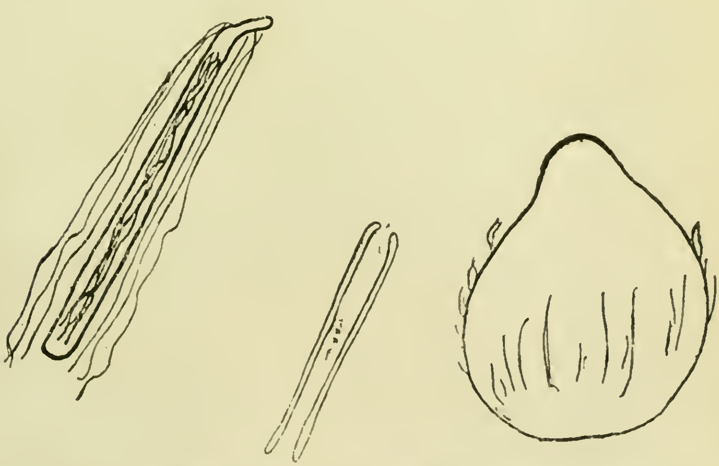


Fig. 3. *Borinquenia miconiae*. Perithecium, ascus, paraphyses and spores, 6871a (type). Drawn by J. MacInnes.

Borinquenia miconiae sp. nov. Fig. 3.

Spot none. Mycelium buff to tawny, superficial. Perithecia abundant, ovate, papillate, hyaline, wall pseudo-parenchymatous, rough with rather numerous short, coarse hairs, especially around the base, 180 μ high, 150 μ thick.

Asci numerous, cylindric, 60-55x7-8 μ, obtuse, thin walled, 8-spored. Paraphyses numerous, thread-like, 1-1½ μ, longer than the asci; spores linear, smoky, guttulate, obtuse, 55-65x 2-3 μ, usually crooked, septa not seen.

On *Miconia laevigata*, Arecibo, 6804. Utuado, 6862, 6871, (type.)

In the Saccardian classification, this fungus would fall in the Hypocreaceae-scolecosporae-phaeoscoleciae, in which there is only the genus Konradia from which it is clearly distinct. In the classification of Lindau it falls in the Hypomyceteae and near the genera Globulina and Torrubiella from both of which it presents marked differences.

Dexteria gen nov.

In honor of Dr. E. G. Dexter, whose liberal views so benefited Porto Rico.

Mycelium superficial or mainly so. Perithecium astomate, the wall reduced to extreme tenuity or becoming gelatinized and amorphous, thus leaving the asci naked or nearly so, at maturity. Type *Dexteria pulchella*.

The genus is somewhat like Colonectria but is distinguished from it by the gelatinization of the perithecial wall and by general habit.

Dexteria pulchella, sp. nov. Fig. 4.

Mycelium hypophyllous, reddish, superficial, scant; spot none. Perithecia containing from 18-25 asci. Asci when mature, naked or covered only by a mucilaginous residue of the perithecial wall. Surrounded at base by a few loosely intertwined strands of reddish-brown mycelium about 3 μ in thickness. Dimension of ascus exclusive of subtending mycelium 65-100 μ. Asci clavate to ovate to elliptical, 50x15-22 μ, 8-spored, obtuse, thin-walled. Paraphyses none. Spores linear, 35-42x4-5 μ, hyaline, 5-septate. Pycnidia similar in structure but larger, 110-130 μ, slightly darker in color, Conidia similar to ascospores but smaller, 17-21x3 μ, and 3, not 5-septate.

On *Paullinia pinnata*, Mayaguez, 1207 (type).

This fungus is barely visible as a brick-red discoloration of small areas of the lower side of the leaf. The lens shows this color to be due to myriads of minute perithecia and pycnidia intermingled.

Under the microscope the fungus appears as one of exquisitely delicate beauty. The basal wreath of hyphae marks on its inner side an almost exact circle. Within this circle the asci develop and remain together, covered by a structureless gelatine which when young barely reveals its origin in a loose network of fine mycelial threads. The perithecium is perfectly transparent. So transparent are all structures that the asci may readily be counted looking through the perithecium, either from above or below.

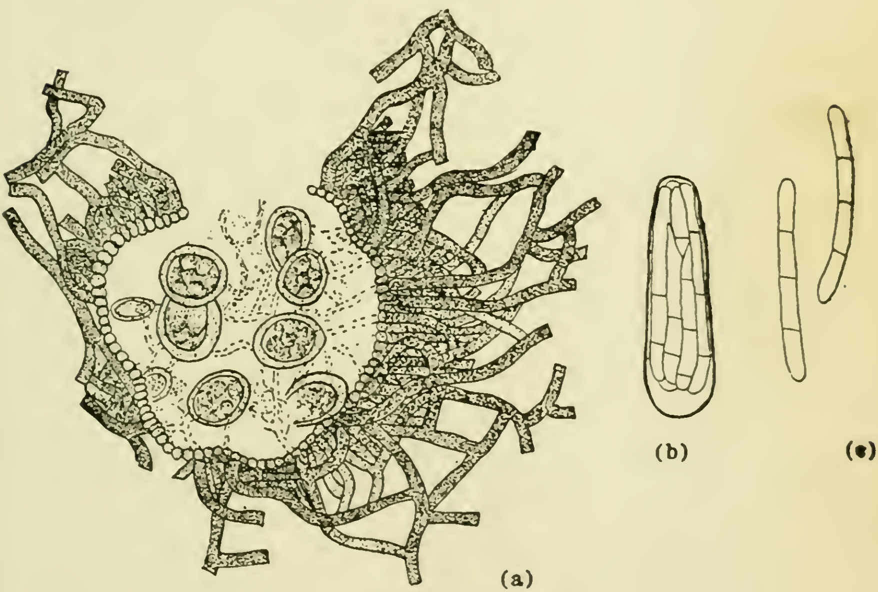


Fig. 4. Dexteria pulchella

(a) Perithecium showing wreath of hyphae surrounding the asci from which the covering has disappeared. The rupture on one edge was caused by the cover glass.

(b) An ascus.

(c) Spores. 1207 (type), drawn by J. MacInnes.

Nectria Fries

Nectria ochroleuca (Schw.) Berk. Sta. Ana, 6757.

Creonectria Seav.

Creonectria grammicospora (Ferd and Wge) Seaver. On dead wood. Rio Piedras, (Stevenson) 3896, 6736.

Megalonectria Sacc.

Megalonectria pseudotrichia (Schw.) Speg.

On host not named. Pueblo Viejo (Stevenson) 5064.

Specimens 1569 and 1193 had no perithecia but a Stilbum which is probably the conidial stage of *Megalonectria pseudotrichia.*

Ophionectria Sacc.

Ophionectria coccicola E. & E.

On scale on grapefruit. Pueblo Viejo, (Stevenson), 5145.

Stilbocrea Pat.

Stilbocrea hypocreoides (K. & C.) Seaver.

On rotten wood. Espinosa (Stevenson), 2425.

Balansia Speg.

Balansia discoidea P. Henn.

On *Aristida portoricensis* Mayaguez, 6011 (Mrs. A. Chase)[1]

Dothicloe Atk.

Dothicloe atramentosa (B & C). Atk.

On (Serrillo) *Andropogon leucostachyus,* Las Marias, 8211.

Dothichloe aristidae Atk.

On *Aristida portoricensis,* Mayaguez[1], 6011, Mrs. A. Chase, on *Ichnanthus pallens,* Maricao, 778.

Claviceps Tul.

Claviceps paspali S. & H.

On *Paspalum plicatulum,* Rosario, 3784, Ponce 4371, Cataño 5783, 4188, Añasco, 3536, Coamo, 4909, Mayaguez, 227. This sclerotial stage of Claviceps is as common on *Paspalum plicatulum* in Porto Rico as it is on *P. laeve* and *P. dilatatum* in the States. The species is very probably either *C. paspali* S. & *H.* or *C. rolfsii* S. & H.[2] but which of these it is impossible to determine without germinating the sclerotia, which was not done.

1. Host determined by Mrs. Chase. Fungus by Dr. Atkinson.
2. Stevens, F. L., & Hill, J. G. Three interesting species of Claviceps. Bot. Gaz. 50:460-463, Dec. 1910.

Ustilaginoidea Bref.

Ustilaginoidea usambarensis P. Henn. on *Panicum laxum,* Monte de Oro, 5708, 5671, El Alto de la Bandera, 4365, 4370, 8660.

Dothidiales

Phyllachora Nke.

Phyllachora graminis (Pers.) Fcl.

On *Paspalum conjugatum;* Vega Baja 9269, 9236, El Alto de la Bandera, 8720, on *Valota insularis* Quebradillas, 9228, 7260, Sta. Ana 7622, Vega Baja 9262, Coamo 8334, on *Paspalum virgatum* (?) Utuado, 8075, on *Arthrostylidium sarmentosum,* Utuado, 4388.

Phyllachora perforans (Rehm) Sacc & Syd.

On *Securedoca virgata,* Mayaguez, 7402, Rosario, 9491, Maricao, 8981. Specimens previously reported by Garman as on Abrus were on this same host.

Phyllachora scleriae Rehm.

On *Scleria pterota* Sabana Llana, 9370.

The specimen agrees well with the description given by Theissen and Sydow. The differences between this species and *P. cypri* Rehm are not large.

Sphaeriales

Sphaeriaceae

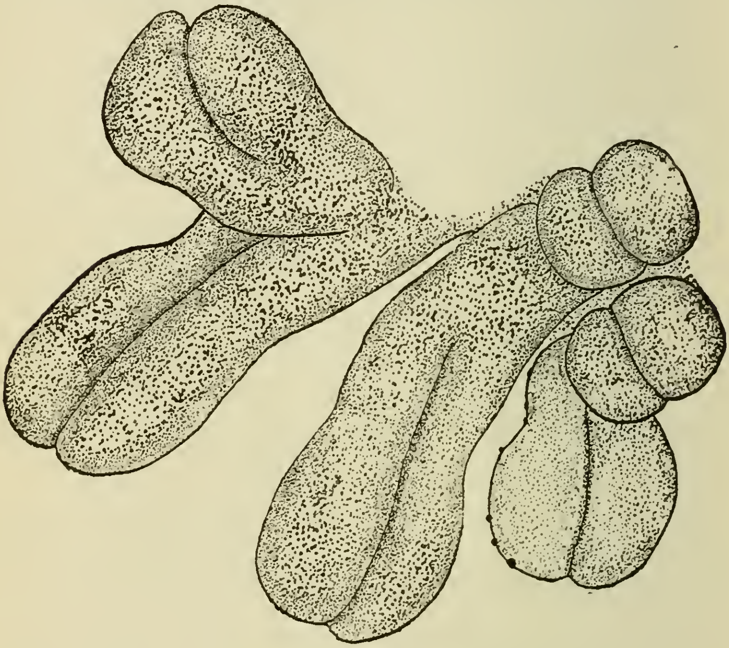
Phaeospora Zopf

P. cacticola sp. nov.

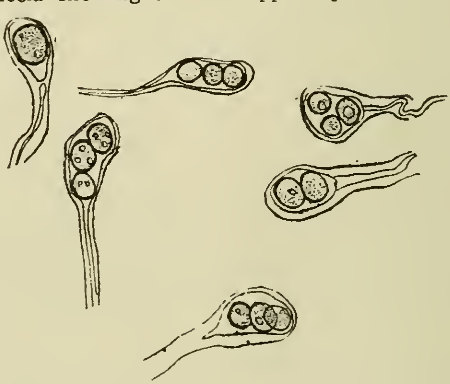
Spots 5-10 mm. long, entirely or partially encircling the stems, surface wrinkled, thickly covered with perithecia. Perithecia subcuticular, 80-150 μ in diameter, black, ostiolate and erumpent when mature. Asci oblong to elliptical, 60-75x13-25, thin-walled, 4-spored, inordinate. Spores elliptical to oblong, obtuse, 3-septate, dark when mature, 34-37x9 μ.

1. Host determined by Mrs. Chase.

Fig. 5. *Corynelia clavata,* var. *portoricensis* var. nov.
(a) Habit sketch showing colonies on leaf.



(b) Perithecia showing the two-lipped apex.



(c) Asci showing irregular form and variable numbers of spores. Drawn by J. MacInnes.

diameter, thick walled, dark, smooth, 1-celled. Conidia oblong-fusoid; otherwise as in the type. On *Podocarpus coriaceous* near Maricao. 784 (type,) 810, 6713, 6722, 3576, 4363, 8858, 5820.

This differs from *C. clavata* (L.) Sacc. which is reported on *P. thunbergii, P. elongata,* and *P. totarae,* in its narrower asci, larger spores, and few-spored ascus, and from the other forms of Corynelia, *C. clavata var. macrospora* Syd. on *P. milanjiani, C. areophila* (Speg.) Starb, on Podocarpus sp., *C. carpophila* Syd. on Rapanea in size of spores and ascus and number of spores per ascus.

Corynelia pteridicola sp. nov. Fig. 6.

Spots from less than a millimeter to 3 or 4 mm. in diameter, fungus usually though not always hypophyllous. Stroma small, 0.5-3 mm. in diameter, the central part falling out with age and the stroma thus becoming annular. Perithecia numerous, solitary on long stalks which arise from the stromata. Perithecial stalks about 500 μ long, 60 μ thick, sporogenous region about 160x95μ, beak extending about 200-300 μ beyond the sporogenous region. Perithecial stalk hairy with brown mycelium, 10-45x3 μ, sporogenous region and beak glabrous. Total dimensions of perithecial structure 900-1090x60 μ. Asci, thin-walled, irregular in shape, 8-spored, 20-27x7 μ. Spores spherical, dark, 1-celled, 4 μ in diameter.

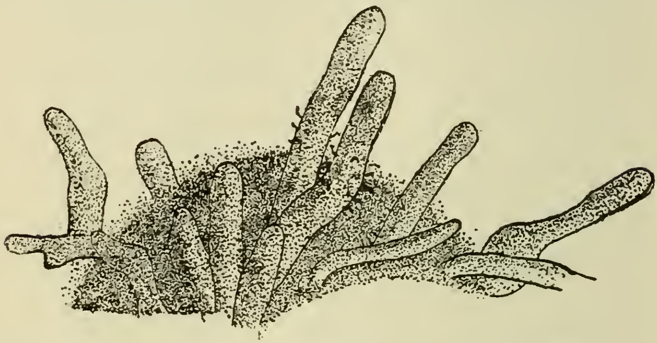
On Campyloneurum sp. Añasco, 3551.

The species differs markedly from other Corynelias in the size of its spores and in its long-stalked perithecia.

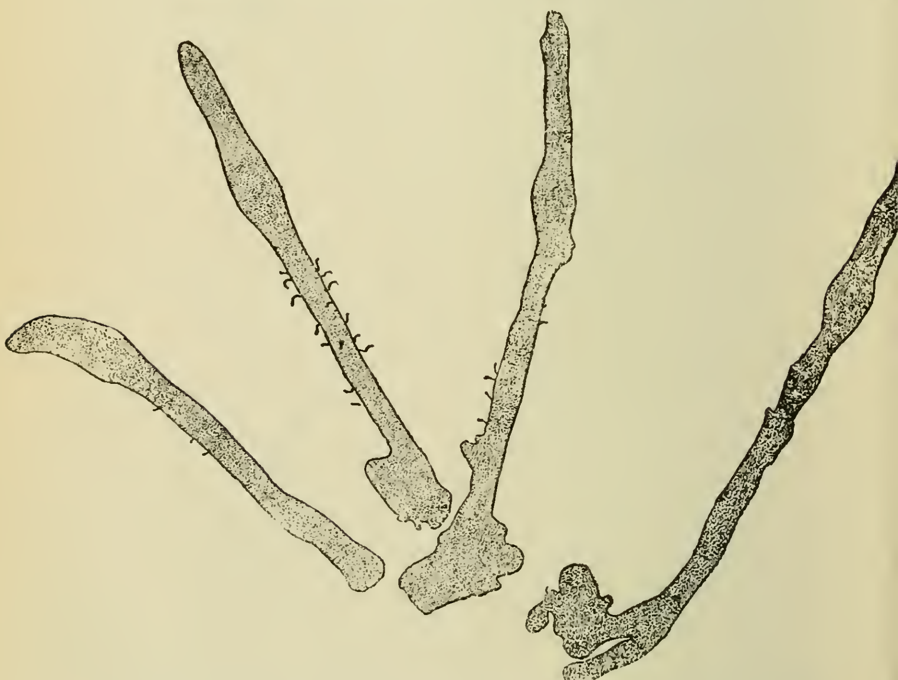
All the leaf tissue in a minute circular area is consumed and replaced by the fungus forming a stroma. From this arise numerous stalked perithecia. The central part of the stroma after sporing drops out, leaving only the opposite epidermis, or often a hole. The cavity thus formed in the leaf is surrounded by a ring-shaped stroma the thickness of the leaf or a trifle thicker and less than half a millimeter in breadth. This continues to produce stalked perithecia, advancing into new tissue and falling away in the older portions, thus a diseased spot a few days old is a hole surrounded by the ring of stroma which bristles with the numerous black, stalked perithecia.

Fig. 6. *C. pteridicola* sp. nov.

a. Habit sketch showing spot of young growth and a hole surrounded by the stromatic border and giving rise to perithecia.



b. Sketch to show perithecia arising from the stroma.



c. Stalked perithecia, the swollen part bears the sporogenous cavity. Drawn by J. MacInnes.

On *Rhipsalis cassytha*, Monte de Oro near Cayey, 5662 (type).

This fungus is remarkable for its very coarse, dark mycelium 7-9 μ in diameter, and for the manner in which the mycelium penetrates vertically through the thick cambial layer.

Herpotrichia Fuckel.

Herpotrichia diffusa (Schw.) Ellis and Ev.

On cocoanut debris, Espinosa. (Stevenson) 2626.

Rosellinia Ces. and de Not.

Rosellinia subiculata (Schw.) Sacc.

On rotten wood, Garrochales. (Stevenson), 2765.

Rosellinia aquila (Fr.) de Not.

On rotten wood, Rio Piedras. (Stevenson) 3355.

CORYNELIACEAE

Corynelia Achar.

C. clavata (S). Sacc. var: *portoricensis* var. nov. Fig. 5.

Asci long pedicilled, 70 μ, sporiferous part 34-41x14 μ, bearing 1, 2, 3, or 4, mainly 2 or 3, spores which are 12-15 μ in

A striking feature is the narrow limits of the diseased area, which comprise a region consisting of only a few host cells. Cells within the diseased area, however, become completely filled with the rather fine, dark-brown mycelium.

MYCOSPHAERELLACEAE

Mycosphaerella Johans

Mycosphaerella maculiformis (Pers.) Schr.

Sphaerella maculiformis (Pers.) Auer.

On *Inga vera*, Jayuya, 5996.

Spots sordid white, 2-4 mm. in diameter, bordered by a dark red to brown line. Perithecia numerous, scattered over the upper surface, subepidermal.

Mycosphaerella clusiae sp. nov.

Spots amphigenous, centers 3-8 mm. in diameter, ashen-grey to black, surrounded by a rose-tinted area, 3-5 mm. broad. Perithecia 40-80 μ in diameter, numerous, immersed below the epidermis and erumpent. Asci numerous, 8-spored, inordinate, 44-48x14 μ. No paraphyses. Spores 1-septate, hyaline, 14x4 μ.

On *Clusia rosea*. Maricao, 1374 (type), 8829, 8849, Lajas, 7136, Utuado 4587, Mayaguez, 7482.

The spots when hypophyllous are different in appearance from epiphyllous spots due to difference in stomatal relations. When below, nearly every stoma within the diseased area is filled by a perithecium, while above the perithecia are necessarily erumpent.

Mycosphaerella mucunae sp. nov.

Spots irregularly circular, dead, 1-2 cm. in diameter, marked conspicuously with a series of roughly concentric circles, about 2 mm. apart. Perithecia numerous, black, 78-94 μ in diameter, Ostiole distinct. Asci 8-spored, 34-40x8-10 μ. Spores long and narrow, 17-20x3 μ, 1-septate, obtuse.

On *Mucuna pruriens*, Añasco, 3535.

The concentric marking of the spots and the long narrow spores are especially characteristic.

Mycosphaerella maydis (Pass.)

On *Syntherisma sanguinale*, El Alto de la Bandera, 8255.

The present form agrees sufficiently well with the description of this species to enable us to regard them as the same. There are several species described on various gramineae of which the same might be said.

Guignardia Viala and Ravaz

Guignardia heterotrichi sp. nov.

Spots irregularly circular, 2-5 mm. in diameter, tan colored, bordered by a darker line which is about 1 mm. wide, center black, due to clusters of perithecia. Leaf tissue of spot killed completely. Perithecia clustered in centers of spots, occupying the mesophyll, black, 150-200 μ in diameter, ostiole small, 10-

15 μ, but distinct. Paraphyses none. Asci 51-61x14 μ, 8-spored, inordinate. Spores slightly olivaceous, 14-7x7 μ, ovate-elliptical.

On *Heterotrichum cymosum,* Preston's Ranch, 6768 (type), Maricao, 197, Villa Alba, 116, Utuado, 4359.

The spots caused are of very distinctive character. The fungus differs from *Laestadia melastomatum* in absence of paraphyses and from *physalospora multipunctata* which has long pedicilled asci.

Guignardia helicteres, sp. nov.

Spots tan colored, circular, dead, 3-5 mm. in diameter, definitely bordered by a thin purplish line. Perithecia immersed, dark, 125-160 μ in diameter, ostiole dark bordered. No paraphyses. Asci 8-spored, 68x14-17 μ. Spores oblong, obtuse, continuous, hyaline, 17x5 μ.

On *Helicteres jamaicensis,* Barceloneta, 9260.

Guignardia clusiae sp. nov.

Spot none. Perithecia numerous, scattered over the lower surface of fallen leaves, 110-160 μ, black, sub-epidermal. Asci cylindrical, 8-spored, 65-72x7 μ. Paraphyses none. Spores 17-20x7 μ, elliptical, continuous, hyaline.

On *Clusia grundlachii,* Maricao 809, (type), 4774.

Guignardia pipericola sp. nov.

Spots circular 3-8 mm. in diameter, tissue but slightly changed and the spot evident chiefly for its perithecia. Perithecia numerous, 150 μ in diameter or oblong and 150x280 μ, black, imbedded in a gall-like structure due to hypertrophy of a few surrounding cells. Asci aparaphysate, long pediceled 85x17μ, the long pedicel occupying about half of this length. Spores oval, hyaline, continuous, inordinate, 13-17x5 μ.

On *Piper medium,* Camuy, 4998 (type), Vega Baja, 370a Aguada, 5078, Trujillo Alto, 9401, Sta. Ana, 7615, Florida Adentro, 7648, Rio Tanama, 7949, 7869, 7872, Manati, 7701, Peñuelas 9148, 3592, *Piper marginatum,* Lajas, 7180, Cabo Rojo, 2244, 6472.

The fungus is widely distributed and is conspicuous on account of its perithecia which are quite regularly concentrically arranged.

Guignardia rhynchosporae sp. nov.

Perithecia spherical, opening hypophyllous, entirely invisible from above, located in the loose tissue below the epidermis, about 235 μ in diameter. Paraphyses none. Asci long, narrow, long stalked, 140-156x7 μ, 8-spored. Spores 1-celled, hyaline, 27x5 μ, thicker in the middle, tapering toward the ends.

On *Rhynchospora cyperoides,* Martin Peña, 9302 (type).

Guignardia cephalariae (Aud.) var. *alternantherae* Sacc.

On *Alternanthera sessilis,* Mayaguez 7554, 9360, 49, 834, 3933, Rio Piedras, 9464, Las Marias, 8188, 8193, 7031, Utuado, 4577, Guayanilla 5913.

Pleosporaceae

Physalospora Niessl

Physalospora caryophyllinicola sp. nov.

Hypophyllous. Spots abundant, especially upon the lower leaves, closely studded with the black perithecia. Perithecia sub-epidermal, globose, 60-110 μ in diameter, ostiole 20 μ. dark-bordered. Asci cylindrical, 25x8 μ, 8-spored. Paraphyses filamentous, guttulate, thin. Spores 20x5 μ, oval with one side slightly more convex than the other, guttulate.

On *Drymaria cordate* (L.) Willd. Jayuya, 5937.

Physalospora laguncularіae Rehm.

On *Laguncularia racemosa,* Guanica, 363, Boqueron, 367.

It causes characteristic spots and is especially abundant on seedlings and cotyledons. The spores are slightly smaller than indicated by Rehm's description and are not clearly fusiform as he describes and figures.

Physalospora andirae sp. nov.

Spots conspicuous both above and below, tan colored, irregular in shape, rather definitely bordered. Thickly set with perithecia which open below. Perithecia sub-epidermal, finally erumpent, tan-colored. Each perithecium surrounded by a delicate dark circle about 0.5 mm. in diameter. Asci thin-walled, 8-spored, 54-68x7 μ, spores uniseriate or inordinate, one-celled, oval, hyaline. Paraphyses many, filamentous.

On *Andira jamaicensis,* Camuy, 7277 (type). Mayaguez, 1037, 1479, 3939, 3950, Vega Baja, 461, 492, 465, San Sebastian, 5198, Maricao, 3628, Cabo Rojo, 6485, Coamo, 842, 8357, 8478, Quebradillas, 4999, Hormigueros, 218, San German, 5808, 842, Lajas, 7178, Tanama Rio, 7835, Arecibo-Lares Road, 7294, Martin Peña, 9315, Peñuelas 9163, Sta. Catalina, 2721.

This form is exceedingly common on Andira and has more the general aspect of insect than fungous injury. It is exceedingly well defined and easily recognizable.

Physalospora bambusae (Rab.) Sacc.

On *Lasiacis sorghoidea,* Luquillo Forest, 5427.

P. maculans, Sacc. & Troller, on Cyperus and *P. panici* on Panicum are close to the above.

Cucurbitariaceae

Nitzschkia Otth.

Nitzschkia nervincola Rehm.

On *Gesneria albiflora,* Maricao, 3670, 1002, 8917, 207, 735, 3498, 6718, Mayaguez, 7495, 7496, 6725.

Otthia Nits

Otthia panici sp. nov.

Stromata black, linear, 60 μ wide, 110-470 μ long or sometimes much longer, erumpent, crustose, bearing several perithecia. Perithecia imbedded in the stroma, ostiolate. Asci, long-cylindrical, monostichous, spores dark, 1-septate, 7-9x3 μ

On *Panicum maximum,* Jayuya, 5994, Preston's ranch, 6659 (type.)

Pleosporaceae

Metasphaeria Sacc.

Metasphaeria abortiva. sp. nov. Fig. 7.

Spots 3-5 mm. in diameter, circular, pale, conspicuous from both sides of the leaf, center black, bearing one perithecium or occasionally more than one. Perithecium black, 470-630x 40-50 μ, subcuticular, rupturing hyphophyllous, asci thin-walled, irregular in shape, 68x27 μ, 8-spored. Spores inordinate, 31x7 μ, 2-septate, hyaline or very faintly colored. Central cell smaller than terminal cells and apparently abortive.

On Varronia alba, Mayaguez, 304 (type), 6782, Maricao. 3457, 3465, Arecibo-Lares Road, 7315.

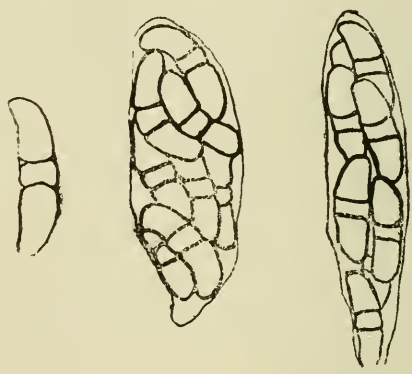


Fig. 7. *Metasphaeria abortiva.*
Asci with eight 3-septate spores and single spore, showing the smaller apparently abortive central cell. No. 7315 (type). Drawn by J. MacInnes.

Leptosphaeria Ces. and de Not.

Leptosphaeria sacchari V. Breda.

On cane, Añasco, 3555.

Ophiobolus Riess

Ophiobolus barbatus Pat. & Gaill.

On Vitex, 823. The ascigerous stages of this fungus were not seen but the very remarkably shaped conidia (text fig. 8) which agree precisely with those of Patouillard & Gaillard described from Venezuela (Bullt. Soc. Myc. de Fr. 4: 114, 1888 and T. IV Pl. XIX, F. 7b) indicate that the conidial form in the two instances are the same. In my specimens the terminal cells were hyaline, the other cells dark and the component parts of the spore were either 4 or 5-septate.

MELANCONIDIACEAE

Melanconis Tul.

Melanconis sacchari Mass.

On *Saccharum officinale.* Mayaguez (Fawcett.)

Fig. 8. *Ophiobolus barbatus*
A conidium showing pale end cells and dark central cells and the peculiar grouping in pairs in which they always occur, 823. Drawn by J. MacInnes.

DIATRYPACEAE

Diatrype Fries.

Diatrype stigma (Hoffm.) Fries.

On dead wood, Martin Peña (Johnston), 4974.

MELOGRAMMATACEAE

Endothia Fr.

Endothia parryi (Farl.) Cke.

On *Fourcroya hexapetala*, Indiera Fria Maricao, 216, 3494, Maricao 3496, 281, 2337, 8822, 7177, Trujillo Alto 9406.

Endothia longirostos, Earle. Santurce, 4340.

XYLARIACEAE

Nummularia Tul.

Nummularia bulliardi Tul.

On rotten wood, Rio Piedras, (Johnston), 4669.

Hypoxylon Bulliard

Hypoxylon annulatum (Schw.) Mont.

On dead wood, Palo Seco (Stevenson), 2989.

Ustulina Tul.

Ustulina vulgaris Tul.

On *Citrus aurantium,* Palo Seco (Stevenson,) 3429.

Daldinia de Not.

Daldinia concentrica (Bott.) Cet. and de Not.

On rotten wood, Palo Seco (Stevenson), 3381.

Xylaria Hill

Xylaria hypoxylon, (L.) Grev. Cabo Rojo, 2290.

Xylaria polymorpha, (Pers.) Grev. Mayaguez, 3017.

Xylaria sp. Monte Alegrillo, 1414.

Kretzschmaria Fries.

Kretzschmaria coenopus (Mont.) Karsten.

On rotten wood, Aibonito (Stevenson), 5020.

BASIDOMYCETES

HEMIBASIDII

USTILAGINALES

USTILAGINACEAE

Sphacelotheca de Bary

Sphacelotheca panici leucophasi (Bref.) Clint.

On *Valota insularis,* Aibonito, 40; Manati, 4297. Coamo Springs, 8568.

Cintractia Cornu

Cintractia axicola (Berk) Cornu.

On *Fimbristylis,* Quebradillas, 5033, Bayamon, 1881, Mayaguez 5821.

On *Fimbristylis diphylla,* Sta. Catalina, 668, 5818, San Juan, 4538, Santurce, 5729, 1798, 1874, Quebradillas, 5132, Lares 834, Rio Piedras (Stevenson), 2179.

Cintractia leucoderma, (Berk.) P. Henn. Cataño, 5782, Luquillo Forest, 5610, Manati, 5254, on Rhynchospora sp.

Mayaguez, 836, Cataño, 4090, Pueblo Viejo (Stevenson), 3985.

On *Rhynchospora corymbosa,* Mayaguez, 836, Cataño 5254, Rio Piedras, 9277.

Cintractia limitata, Clint. On *Mariscus ligularis,* Manati, 5309.

On *Cyperus ligularis,* Boqueron, 4854, Mayaguez, 1850, Santurce, 1852.

Cintractia utriculicola (P. Henn.) Clint. On *Rhynchospora corymbosa,* Mayaguez, 1061a. On *Rhynchospora aurea,* Mayaguez, 6783, 836a.

Ustilago Rouss

Ustilago affinis, E. and E. On *Stenotaphrum secundatum,* Arecibo, 1758, Bayamon, 1891, Ponte Santiago, 2458, *S. hermaphroditum,* Rio Piedras, 7604.

Ustilago zeae, (Beck.) Ung. On *Zea mays,* San German, 5812.

TILLETIACEAE

Burrillia Setch.

Burrillia echinodori, Clint., on *Echinodorus cordifolius.* Guanica, 335.

UREDINALES

PUCCINIACEAE

Puccinia Pers.

Puccinia hydrocotyles (Link) Cook.

On *Hydrocotyle australis* (Stevenson), 3979.

Puccinia huberi.

On *Panicum utowanaeum,* Mona Island, 6348.

Cerotelium Arth.

Cerotelium conavaliae.

On *Conavalia gladiata,* Rio Piedras, 9278, 9504.

Botryorhiza W. & O.

Botryorhiza hippocratae W. & O.

On *Hippocratea volubilis,* Rosario, 321, Ciales, 29, Mayaguez, 1714, 3915,, Vega Baja, 1195, 2504, 514, Monte Alegrillo, 4721a, Luquillo Forest 5560, Mayaguez, 284, 1195, 1198, 1010, 3915, 1205, 4721, 7033, San German, 7513, 7520, Mayaguez, 7470, 7590, Joyuda, 915, Maricao, 4721.

AURICULARIALES

Auricularia Bull.

Auricularia auricula (L.) Murrill, 113, 7004.

Auricularia delicata, Mayaguez 2960, Monte Alegrillo, 2321.

DACRYOMYCETALES

DACRYOMYCETACEAE

Guepinia (Fries)

Guepinia spathularia (Schw.) Fr. 1605. (Guepinia palmiceps) Luquillo Forest, 5564.

EUBASIDII

AGARICALES

HYPOCHNACEAE

Hypochnus Ehrenb.

Hypochnus rubrocinctus. Ehbg., 1619.

THELEPHORACEAE

Peniophora Cooke

Peniophora cinerea (Fr.) Cke.

On *Citrus decumana,* Espinosa (Stevenson), 5087.

Corticium Pers.

Corticium salmonicolor, B. & Br.

On *Citrus sinesis,* Pueblo Viejo (Stevenson), 5436.

Corticium lactescens, Berk.

On rotten wood, Rio Piedras (Stevenson) 3357.

Corticium partentosum, B. & C.

On rotten wood, Campo Alegre (Stevenson), 3597.

Stereum Pers.

Stereum tuberculosum Fr.

On rotten wood, Rio Piedras(Stevenson), 3360.

Stereum fasciatum Schw.

On rotten wood, Rio Piedras (Stevenson) 1937.

Stereum lobatum Kunze, 7000.

HYDNACEAE

Irpex Fries.

Irpex lacteus Fr.

On rotten post, Bayamon (Stevenson), 5360.

POLYPORACEAE

Daedalea Pers.

Daedalea amanatoides, Beauv. 1611, 1877, 2100, Monte Alegrillo, 2316, Cabo Rojo, 6460.

On rotten wood, Rio Piedras (Stevenson) 3359.

Trametes Fries

Trametes havannensis (Berk. & Curt.) Murrill, 449.

Hexagona Pollini

Hexagona daedalea (Link) Murrill, 2022, 2034, Monte Alegrillo, 625.

Hapalopius Karst.

Hapalopilus licnoides (Mont.) Murrill, 425. Indiera Fria. Maricao, 3401.

Hapalopilus gilvus (Schw.) Murrill, Maricao, 2118, 1566.

Inonotus Karst.

Inonotus corrosus Murrill, 1820.

On dead wood, Sardinera, Mona Island.

Irpiciporus Murrill

Irpiciporus lacteus (Fries) Murrill? No. 91.

Coriolus Quel

(Type *Polyporus zonatus* Fr.)

Coriolus hollickii, Murr. Monte Alegrillo, 4760.

Coriolus pinsitus, (Fr.) Pat. Utuado, 4400, 760, 405, Mona Island, 1715, 450, 2101, 1608, Monte Alegrillo, 2315, Vega Baja, 1847, Rio Piedras (Stevenson), 5426c.

Coriolus versicolor, (L.) Quel. Mayaguez, 2179.

Coriolus membranaceus (Sw.) Pat., 2171, Monte Alegrillo, 2304, 1219, 1242, 92.

Coriolus drummondii? (Klot.) Pat., 2051.

Coriolus ochrotinctellus, (?), Murrill, 2355.

Coriolus pavonius (Hook.) Murrill, 1217, 1239.

Coriolus maximus (Mont.) Murrill, Cabo Rojo, 2098, 2099, 1240.

Coriolopsis Murrill

(Type *Polyporus occidentalis* Klot.)

Coriolopsis rigida (Berk. & Mont.) Murrill. 1414, 1696.

Coriolopsis occidentalis (Klotzsch) Murrill, 1238.

Coriolopsis crocata (Fries) Murrill, 2011.

Microporellus Murrill

(Type *Polyporus dealbatus* B. & C.)

Microporellus dealbatus (Berk. & Curt.) Murrill, 570.

Rigidoporus Murrill

(Type *Polyporus micromegas* Mont.)

Rigidoporus surinamensis (Miq.) Murrill, El Alto de la Bandera, 1614, Monte Alegrillo, 2302, Rio Piedras (Stevenson) 5426b.

Gloeophyllum Karst.

(Type *Lenzites saepiaria* Fr.)

Gloeophyllum striatum (Sw.) Murrill, 2505, 2102.

On dead wood, La Ramona, (Johnston), 4879.

Favolus Beauv.

Favolus subpulverulentus Berk. & Curt. 1237, Monte Alegrillo, 2311, 2320.

Fomes Gill.

Fomes auberianus (Mont.) Murrill, 1816, Maricao, 1916, 1216.

Elfvingia Karst

(Type *Fomes applanatus* (P.) Gil.)

Elfvingia fasciata (Sw.) Murrill, 1558, Monte Alegrillo, 2318, 2307, 406, 1215, 1213, 2121, 2119.

Elfvingia tornata (Pers.) Murrill, 1610, 2130, 2120, 1607, 1622, 2124, 762.

Pyropolyporus Murrill

Pyropolyporus dependens Murrill.

On dead wood, Mona Island, 1819.

Pycnoporus Karst.

(Type *Boletus cinnabarinus* Jacq.)

Pycnoporus sanguineus (L.) Murrill.

On dead wood, Mona Isand, 1876, 1754, 3891, 446, Añasco, 3538. Rio Piedras (Stevenson), 319.

Pogonomyces Murrill

(Type *Boletus hydnoides* Sw.)

Pogonomyces hydnoides (Sw.) Murrill, 1305, 1235, 2117, 547, 2098, 7003, Monte Alegrillo, 1411. Mona Island, 1688.

On rotten wood, Espinosa, (Stevenson), 2749.

AGARICACEAE

Schizophyllus Fries

Schizophyllus alneus (L.) Schr. Maricao, 4909, Mona Island, 6417, Monte Alegrillo, 1359, 2309, Cataño, 1919, El Gigante, 1617, 195, 1567, 1846,, Mona Island, 1687, 1849.

On dead palm log, Bayamon, (Stevenson), 389.

Lentinus Fries

Lentinus crinitus (L.) Fr.

On rotten wood, Rio Piedras, (Stevenson), 367.

On dead wood, Mona Island, 1878, 111, Cayey, 2927, 1606, 1565.

Lentinus hirtus (Fries.) Murrill, 7002, 1338, Sierra de Luquillo, 2764, 1613, 2118, 1605.

Lentinus strigosus (Schw.) Fr. Cabo Rojo, 6466.

Lentodium Morg.

Lentodium squamosum (Schf.) Murrill. (*Lentinus lepideus*), 2020.

Lepiota Fries

Lepiota rubrotincta? Pk. 1306.

NIDULARIALES

NIDULARIACEAE

Cyathus Haller

Cyathus roeppigii Tulasne

On bamboo post. (Stevenson), 5150.

Cyathus sp. Cabo Rojo, 6488.

FUNGI IMPERFECTI

SPHAEROPSIDALES

SPHAERIOIDACEAE

Darluca Cast.

Darluca filum (Biv.) Cast.

On *Puccinia eleocharidis* on Eleocharis, Mayaguez 481; on *Puccinia rivinae* on *Rivina humulus,* Desecheo Island, 1590; on *Kuehneola gossypii* on *Gossypium barbadense,* 5226; on *Puc-*

cinia cannae on Canna, 4168, 3610, 6292. San German 4168. On *Uromyces leptodermus* on *Lasiacis divaricata,* 4608, 4677, 6089, 447, 4793; on *Panicum barbinode,* 3953; on *Uredo aeschynomenis on Aeschynomene americana,* 3945; on *Puccinia huberi* on *Panicum trichoides,* Jayuya, 5981; on *Puccinia substriata,* on *Eriochloa subglabra.* Mayaguez 481. On *Puccinia gouaniae,* Utuado. A paraphysate, 8-spored ascomycete was found associated with the Darluca but was in such condition that it could not be determined.

Phyllosticta Pers.

Phyllosticta lantanae sp. nov.

Spots small 1-3 mm. in diameter, white above, tan colored below. Pycnidia 140 μ in diameter, ostiole 15-17 μ. Spores oblong, 7x2 μ.

On *Lantana odorata* Desecheo Island, 168, (type), Mona Island, 6416, 6440, Utuado, 6592, Guanica, 332.

The spore size is in close agreement with that of *P. gei* Bres. but it does not agree with this in other regards.

Phyllosticta clusiae sp. nov.

Spot large, 5 cm. or more in diameter, pale, border definite. Pycnidia numerous, scattered profusely over the blanched area, epiphyllous, sub-cuticular, erumpent, 110-140 μ in diameter, black, ostiolate. Conidia oblong-elliptical, obtuse, continuous, hyaline, 10x5 μ.

On dead leaves of *Clusia rosea,* Maricao, 739a (type).

It differs essentially in characters of the spot from *P. arthrophylli* Koord., which is the only species with which it shows agreement in size of spores.

Phyllosticta superficiale sp. nov.

Pycnidia straw colored, 68x94 μ in diameter. Ostiole 7 μ in diameter, dark bordered. Pycnidia entirely superficial borne on the hyaline mycelium among the surface hairs of the host. Spores somewhat irregular, oblong, 4-5x1.5 μ, hyaline, continuous.

On *Passifora sexflora,* Ponce, 4337 (type), 4377. Monte de Oro. 5736. The following numbers of the same hosts were in a spot of the same general appearance, but no pycnidia were found. El Consumo, 885. Adjuntas, 5822, Utuado, 4383, 6611, Luquillo Forest, 5557, Monte de Oro, 5674, Jajome Alto, 5686, Maricao, 880, 3466, 198, 4765, Guayama, 848.

Phyllosticta hybiscina E. and E.

On *Abutilon umbellatum,* Mona Island, 6120.

Septoria Fries

Septoria fici-indicae Vogt.

On *Opuntia dilenii, Guanica,* 396. Sta. Isabela, 6825.

The spores are slightly larger (34-37 μ) than the description calls for (24-28μ), and are clearly septate.

Septoria petroselini var. *apii.*

On *Apium graveolens,* Maricao, 3416. El Gigante 8517, Aibonito 8454.

Septoria mikaniae Wint.

On Mikania sp. El Gigante, 8538.

Septoria lycopersici Speg.

On *Lycopersicum esculentum,* Rio Piedras (Stevenson), 3955.

Cicinnobolus Ehr.

Cicinnobolus cesatii D. By.

On *Erysiphe polygoni* (?) On *Cassia toro,* San German, 5802, on *Cassia occidentalis,* Guayama, 5330.

Phomopsis Sacc.

Phomopsis vexans Harter.

On egg plant, Rio Piedras (Stevenson), 3953.

Phomopsis citri Faw.

On *Citrus decumana,* Rio Piedras (Stevenson), 3615.

Cytospora Ehrenb.

NECTRIOIDACEAE

Aschersonia Mont.

Aschersonia aleyrodis Web.

On *Psidum guayava,* Mayaguez, 6643, 493, 6362, Jayuya, 3120a, Utuado, 6615, Rio Piedras (Johnston), 4360.

Aschersonia cubensis B. & C.

On *Zamia integrifolia,* Sta. Ana, 6674. On scale on Citrus (Stevenson), 2649.

Fungi which closely resemble the above but of which specific determination could not be made were found on:

Miconia, Vega Alta, 4155; Palicourea, Manati, 4279; Wedelia, Vega Baja, 1928; Rondeletia, Maricao, 870; Gesneria, Maricao, 1002, 4670; Paullinia, 1207; Pilocarpus, Mayaguez, 7080; Inga, Mayaguez, 7474; Ocotea, Jajome Alto 8428, Vega Baja, 509; Blechnium,—; *Pavonia typhalaea,* Mayaguez, 7400

Melasmia Lév.

Melasmia coccolobiae sp. nov.

Stromata hypophyllous, circular, about 2 mm. in diameter, black, each bearing several conidial cavities, strictly superficial but with the mycelium extending deep within the leaf. Pycnidia approximately circular, 60-90 μ in diameter, the base colorless and thin, resting on the cuticle, the pycnidial cavity covered by a thick, black, fungous cover. Conidiophores short. Conidia hyaline, continuous, acute at one end, rounded at the other, 8-10x2 μ.

On *Coccolobis,* Maricao, 3712 (type).

Melasmia ingae sp. nov.

Spots circular, visible above and below; from above 2-3 mm. in diameter, centers filled by a black stroma 1-2 mm. in diameter, border definite; from below black stroma surrounded by a pale zone 1-2 mm. broad. Stroma bearing several spore cavities mostly located at its margin. Mycelium permeating the leaf tissue in the diseased region. Stromata subcuticular forming first under the upper epidermis, less frequent under the lower epidermis. Rupturing irregularly, no ostiole. Conidiophores short, parallel. Conidia irregularly oblong, tapering slightly to each end, continuous, hyaline to very pale straw-colored. Maximum size 24x5 μ. Numerous small apparently immature spores, 3x7 μ, issue from the spore cavities.

On *Inga laurina*, Las Marias, 423.

These fungi are referred to the form genus Melasmia without intending to imply that they are ascigerous forms of Rhytizma.

Melanconiales

Melanconiaceae

Gloeosporium Desm. & Mont.

Gloeosporium manihot Earle.

On *Manihot manihot*, Rio Piedras (Stevenson), 5134.

Glocosporium violac B. & Br.

On Viola (cult), Mayaguez, 6305.

Colletotrichum Corda

Colletotrichum lobeliae sp. nov.

Spots numerous, scattered over the leaf, 2-3 mm. in diameter, or by coalescence large, dark to purplish above, below tan-colored and raised blister-like; border definite. Acervuli hypophyllous, scattered over the diseased tissue. Setae numerous, scattered, 136 μ long, 6 μ thick at base, several septate, tapering, obtuse, black. Spore cylindrical, somewhat irregular, obtuse, continuous, hyaline, 17-31x5-6 μ, mostly the larger size.

On *Lobelia assurgens* var. *portoricensis*, Maricao, 776 (type) 3513.

Colletotrichum lindemuthianum (Sacc. & Mag.) B. and Cav.

On cultivated beans, Rio Piedras (Stevenson), 3879.

Colletotrichum gloeosporioides Penz.

On grape fruit leaves, Pueblo Viejo (Stevenson), 5003.

Colletotrichum piperis sp. nov.

Spots circular, 1-3 cm. in diameter, older portion dark and strongly marked by a series of concentric lines about 1 mm. apart; this older portion surrounded by a zone several millimeters wide of pale, evidently diseased leaf tissue. The oldest parts of the spot crack and portions fall away. Acervuli amphigenous, numerous, scattered throughout the darker portion of the spot, small, mostly 45-80 μ in diameter, thickly set with setae. Setae in many cases growing solitary or in groups, but without conidiophores. Setae 70.85 μ long, black, tapering obtuse. Conidiophores rather long, hyaline. Conidia oblong, obtuse, 17-27x7 μ, continuous, hyaline.

On *Piper umbellatum*, Caguas, 288 (type), 291a.

This fungus is remarkable for the small size of its acervuli which in many cases consist merely of two or three setae and an equal number of conidiophores or indeed in many cases of solitary setae without conidiophores, though a sufficient number of larger acervuli occur to show relation to the genus Colletotrichum. The fungus appears to be aggressively parasitic.

Colletotrichum omnivorum Hals.

On Pandanus sp. (cult.), Caguas, 290a.

The setae are not universally present.

Colletotrichum curvisetum sp. nov.

Spots circular, ashen at center, dark bordered. Acervuli variable, 30-80 μ in diameter with from 1 to 20 setae, often sterile, setae black, septate, acute, gracefully curved. Conidia oblong, obtuse, 17x5 μ, slightly smoky.

On *Hura crepitans*, Añasco, 3594, Mayaguez 5830, associated with *Cercospora hurae* and with a pycnidial fungus.

The spots usually bear both the Colletotrichum and the Cercospora. The Colletotrichum is quite frequently sterile, the acervuli then consisting of merely setae or setae connected by a dark subiculum.

Colletotrichum erythrinae E. & E.

On *Pithecolobium unguis-cati*.

Coamo, 3973, 129, Boqueron, 4876, Guanica, 337a, 354a. Guanajibo, 8585, Mona Island 6137, 6094, Boqueron, 4876, Desecheo Island, 1576.

The fungus is evidently aggressively parasitic. The spots are quite characteristic and readily separable by the naked eye from the various other spots on this host.

Colletotrichum philodendri P. Henn.

On *Philodendron krebsii*, Arecibo-Lares Road 7226. Rio Tanama, 7849. I place this specimen under this name though there is not complete agreement with description. The acervuli are very large, 150-240 μ, much larger than description calls for, the setae, too, are obtuse, not acute.

Pestalozzia De Not.

Pestalozzia palmarum Cke.

On *Cocos nucifera*, Rio Piedras (Stevenson), 2220.

Pestalozzia coccolobae, Ell. and Ev.

On *Coccolobis uvifera*, Boqueron, 339b.

Pestalozzia funerea Desm.

On *Clusia rosea*, Maricao, 739.

On *Musa paradisica*, Rosario, 3796, Barros, 122, on Citrus (cult.) Utuado, 6869a, on *Acrista monticola*, Luquillo Forest, 5553, on *Poinciana pulcherrima*, Mayaguez, 3966, on *Pithecolobium unguis-cati*, Mona Island, 6137, on *Inga vera*, Maricao, 205, on *Chrysobalamus icaco*, Santurce 258.

Melanconium Link

Melanconium sacchari Mass.

Saccharium officinarum, Mayaguez, No. ?

MONILIALES

MONILIACEAE

Acrostalagmus Corda

Acrostalagmus albus Preuss.

On Aphis on pepper, Rio Piedras (Stevenson), 5608.

Verticillium Nees

Verticillium heterocladium Penz.

LaRamona (Johnston), 1018.

Pellicularia Cooke

Pellicularia koleroga Cke.

On *Coffea arabica*, Mayaguez, 9488.

Monosporium Bon.

Monosporium uredinicolum sp. nov.

Mycelium floccose, byssoid, forming white, moldy spots 1-2 mm. in diameter over each rust sorus. Hyphae hyaline, septate, very sparsely dichotomously branched. Conidiophores indistinguishable from the mycelium, simple or sparsely dichotomously branched. Spores acrogenous, solitary or rarely catenulate, 12-15 μ, hyaline, continuous, cylindrical, obtuse at each end.

On *Coleosporium ipomoeae* on *Ipomoea batatas*, No. 6668 (type).

Host determined by Dr. Arthur.

This fungus was very common at the place of collection. A large field of sweet potatoes was badly rusted. Apparently every leaf in the field bore numerous rust sori and apparently every sorus was overgrown with this fungus. Its hyaline mycelium is found covering the sorus and growing in and around each rust spore.

Trichothecium Link

Cephalothecium Corda.

Trichothecium fusarioides. Sp. nov.

Colonies cottony, white, 2-5 mm. in diameter, surrounding the parasitized Phyllachora. Mycelium hyaline, septate, serile, mainly creeping, 2 μ thick, mainly branching at right angles. Conidiophores erect or ascending, long, 100 μ, and extremely attenuate, 1 μ at tip, septate, unbranched. Spores borne solitary but accumulating in bunches of 10 to 50 on the tips of the conidiophores, hyaline, 1-septate, fusoid, acute at each end, 13-20x2½-3 μ.

On *Phyllachora peribebuyensis* Speg. on Miconia sp., Maricao, 3610.

While this fungus bears some resemblance to *C. macrosporium* Speg., it differs essentially from it in several characters, particularly in the shape of the spores.

Diplosporium Bon.

Diplosporium album Bon var. *fungicolum.*

On *Parodiella cayaponiae,* Garman.

On *Cayaponia,* Utuado, 4360.

Blastotrichum Corda

Blastotrichum miconiae sp. nov.

Mycelium hyaline, forming white spots on under sides of leaves. Spot circular, indefinite, 2-5 mm. in diameter, pale to yellow above. Aerial mycelium abundant, creeping and branching profusely and irregularly, 3-5 μ thick. Erect mycelium mainly branching dichotomously, sometimes geniculate. Conidia 0-3-septate, falcate, acute, 17-30x3-5 μ. Associated with and probably belonging to Borinquenia, on *Miconia laevigata,* Maricao, 4822, Utuado, 6871, 6862, Aguas Buenas 302. Separated from previously described species by its parasitic habit and its association with Borinquenia. (This is essentially a Fusarium without the sporodochium, i.e., having the conidiophores of the Moniliaceae.)

Monogrammia gen. nov.

Conidia on short, branched, hyaline conidiophores, one-celled, hyaline, with six lobes all in one plane.

Monogrammia miconiae. sp. nov. Fig. 9.

Mycelium hyaline, hypophyllous, in small, 1-5 mm., circular spots. Conidiophores short, usually simple; conidia adhering in clusters, hyaline, continuous, six-lobed, shaped like a monogram of the letters H. and I; attached to the conidiophores by

Fig. 9. *Monogrammia miconiae* typically formed spores. Drawn by J. MacInnes.

one central extremity. Spores 20-25x25-28 μ, extreme measurements; minimum median 10-12 μ, median longitudinal 12-15 μ.

On Miconia, associated with *Hyalosphaeria miconiae,* Yabucoa, 6705.

This most peculiar form was found on only one collection, but in that the monogram-formed spores were present in great abundance. This collection is also one that gave *Hyalosphaeria miconiae* and it is quite probable, since the two were intimately associated, that they are really connected though such a suggestion cannot be entertained as a certainty merely on circumstantial evidence.

Dematiaceae

Ellisiella, Sacc.

Ellisiella portoricensis sp. nov. Fig. 10.

Hypophyllous, forming large, 0.5-4 cm., black, velvety spots, densely covered with the fungus. Conidiophores oblong, rounded, pale, base, angular, inverse radiate; stalk 10 μ long, 5 μ thick, base 7 μ high, 10 μ in diameter.

Sterile setae, very numerous, forming a velvety coat to the spot; black, simple, stiff, straight, 360 μ long, 4 μ wide, cells about 14 μ long. Tip pale, acute; base dark, abruptly enlarged. Conidia hyaline or very lightly tinted, pyriform, 17x7 μ, rounded at one end, acute-attenuate at other.

On dead leaves of *Clusia rosea.*

Arecibo, 6809 (type), Desecheo Island 1595, Lajas, 7136a, Hormigueros, 7348.

Napicladium Thum.

Napicladium fumago Speg.

On *Miconia,* 6705, Arecibo, 6804.

In dark, sooty, epiphyllous blotches. The spores agree well with the figures and measurements of Spegazzini. (Fungi Chilenses p. 190), but the number of septa is often as much as eleven with 3 to 4 more close septa at each end. The mycelium which is associated with it is also more beaded than in the figure of Spegazzini.

Brachysporium Sacc.

Brachysporium stemphyliodes (Cd.) Sacc.

On *Anona montana,* Mayaguez, 7561.

The conidia measure only 20-24x14 μ, while the description of this species gives 35-37 μ. This perhaps is a distnct variety or species.

Alternaria Nees.

Alternaria solani (E. & M.) T. & G.

On Datura, Yauco, 3276.

On *Datura suaveolens,* Barros, 151. Coamo, 88, Aguas Buenas, 305a, on Solanaceae, Jajome Alto 5690.

Microclava gen nov.

A Dematiaceous fungus with simple conidiophores which broaden out at the distal end and bear two, oval, dark cells.

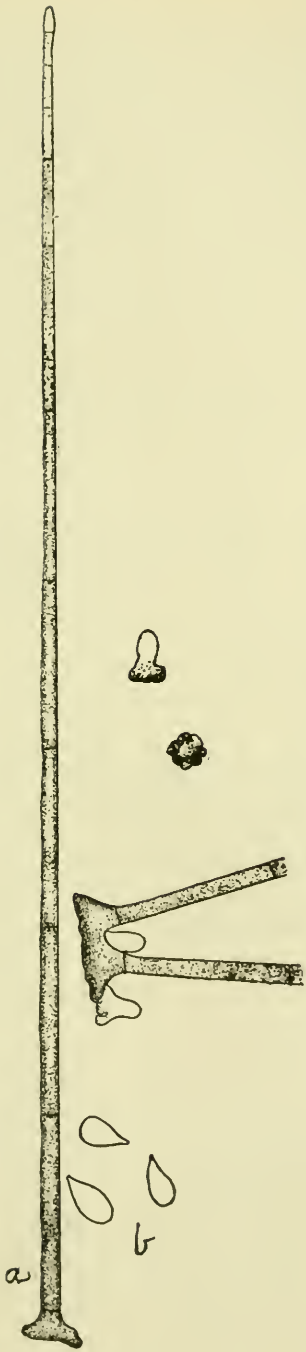


Fig. 10. *Ellisiella portoricensis*

(a) A setum, (b) 3 spores, (c) conidiophores, side and bottom view, (d) bases of two setae and of two conidiophores as borne. Drawn by J. MacInnes.

Type *M. miconia.*

Microclava miconia sp. nov. Fig. 11.

Mycelium internal, hyaline, 3 μ thick, septate, bearing many swellings, and small protuberances, branches arising at very obtuse angles. Conidiophores, simple, erect or ascending, straight, 30-100 μ, $2\frac{1}{2}$ μ thick near top, tapering gradually to base, 2 μ, stipe about 4-septate, apex bearing 2 basal, straw-colored cells and 2 oval dark cells.

On *Miconia laevigata.* Aguas Buenas 302 (type).

This fungus forms dense growths of conidiophores over the leaf surface, often associated with a Microthyriaceous fungus,

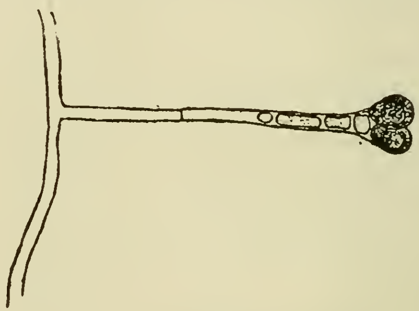


Fig. 11. *Microclava miconiae*
Hyaline mycelium with pale conidiophore and dark conidia. No. 302 type. Drawn by J. MacInnes.

though possibly not parasitic upon it. No close relative of this fungus seems to exist though it clearly belongs to the Dematiaceae. Its relationship is probably with some such form as Triposporium which if two-spored and with each spore reduced to one cell might simulate the condition here presented.

Microclava coccolobiae sp. nov.

Mycelium internal pale to brown. Conidiophores simple, about 70 μ high, 3 μ thick at base, stipe usually unicellular. Upper part broadening gradually to 8 μ in thickness, and consisting of three superimposed cells.

On *Coccoloba diversifolia,* Maricao, 8877.

Triposporium Corda

Triposporium stelligerum Speg.

On —— Aguas Buenas, 302, on *Rudolphia volubilis,* Maricao, 5439, Luquillo Forest, 5439a, on Piper, Maricao, 3371, on *Zamia integrifolia,* Monsallo, 9348, on *Chiococca alba,* Vega Baja, 7743, on *Winterana canella,* Guayanilla, 8548, on *Annona montana,* Mayaguez, 7561, on *Myrcia deflexa,* El Alto de la Bandera, 8268, on Didymopanax, 1246, on Miconia, 6705.

This peculiar fungus agrees very closely, even in minute details, with the South American form as described and figured by Spegazzini.

Passalora F. and Mont

Passalora cercropiae sp. nov.

Spots visible from above, below consisting of irregular, diffuse smoky blotches, 1-2 cm. in diameter. Conidiophores simple, smooth, black, over 600 μ long, slightly geniculate at the tip, 3 μ thick. Conidia pale to black, oblong to clavate, apex obtuse, base often pointed, 2-celled, 2-27x3.5 μ.

On *Cecropia peltata,* Arecibo, 7790.

Cladosporium Link

Cladosporium calotropidis sp. nov.

Spots circular, 1-5 cm. in diameter, indefinite border, grayish-black, equally visible above and below but more definitely bordered below. Conidiophores cespitose from the stomata, amphigenous but much more abundant above, occupying every stoma within the diseased area. Each conidiophore cluster consists of from 10-20 conidiophores. Conidiophores short, 20x35 μ thick, 7 μ, simple, obtuse, dark, crooked, 1 or more septate. Conidia oval to cylindrical, 1-2 or 3-celled, mostly 2-celled, brown, 20-34x7 μ.

On *Calotropis procera,* Guayanilla, 9130 (type), 291.

Cladosporium guanicensis sp. nov.

Spots 1-5 mm. in diameter, roughly circular, definite, pale above, dark below. Conidiophore clusters hypophyllous, numerous, dense, so close together as to nearly cover the leaf. Conidiophores about 75 μ long, yellow. Conidia yellow, 2-celled, oval, obtuse, 17-24x8 μ.

On *Argemone mexicana,* Guanica, 347a, (type), Coamo, 620.

Cladosporium herbarium (Pers.) Lk.

On *Canna coccinea,* Villa Alba, 107; on *Canna glauca,* Utuado, 6006; on Canna Sp. Mayaguez, 3964, Aibonito, 8441. Associated with *Puccinia cannae.* This fungus is very common forming a sooty coating upon the leaves. So far as I have observed it is not present except where the rust is and may be dependent upon the rust for its early sustenance.

On *Conavalia obtusifolia* Boqueron, 336a, forming a dense, sooty coating over the leaves.

Cladosporium fulvum Cke.

On tomato, Florida Adentro, 7660, Utuado, 8026, Tanama Rio, 7881, Cabo Rojo 3168, Caguas 289a, Rio Piedras (Stevenson), 3818.

Cladosporium mikaniae sp. nov.

Spots diffuse, indefinite, 1-2 cm. in diameter, tawny. Mycelium abundant within and on the trichomes. Conidiophores hypophyllous, tawny. Conidia 34-48x3-4 μ, tawny, one-septate or occasionally with more septa. On Mikania, Las Marias, 314 (type).

Cladosporium citri Mas.

On Citrus sp., Bayamon (Stevenson), 2481.

Helminthosporium Link

Helminthosporium ravenelia Curt. and Berk.

On *Sporobulus jacquemontia,* Rio Piedras (Johnston), 4205.

Helminthosporium stahlii sp. nov.

Spots small and irregular or large and diffuse, pale, above, dark below. Conidiophores numerous, lax, long, 155 μ, crooked, straw-colored to yellow, quite dark in mass, simple or branched. Conidia very uniform in size, 24x6-7 μ, and shape, long-elliptical to pyriform, rounded at the large end and with a slight apicule at the small end, when young continuous, later 1-septate and when mature usually 3-septate.

On *Passiflora foetida,* Luquillo 6 (type), Mayaguez, 1699, Preston's Ranch, 6670.

In general the fungus is close to *H. molle* but is distinguished from it by the great regularity of its spores and the apiculate small end.

Helminthosporium varroniae sp. nov.

Hypophyllous. Mycelium superficial, fine, 0.5-1 μ, pale. Conidiophores dark, crooked, 4 μ thick, 160x200 μ long, solitary and scattered or in small groups.

Conidia usually 3-septate, pale straw colored, acute at each end, slightly constricted at the septa, 27-44x6-7 μ.

On Varronia. Florida Adentro, 7663. This fungus is particularly interesting because it closely resembles those Helminthosporiums which are so common on Meliola. This one is sufficiently different from them to be considered a separate species but near enough to show that it belongs in the same sub-generic group with them.

Helminthosporium caladii sp. nov.

Spots circular or oval, often 1.5-2 cm. in diameter; centers ashen-white, borders tan-colored. Clusters of conidiophores numerous throughout the diseased area, each consisting of many, usually more than 20, conidiophores. Conidiophores very crooked, long, 85 μ, pale yellow. Conidia oblong to cylindrical, obtuse, pale straw colored, 3-septate when mature, 27-41x7 μ.

On *Caladium bicolor* Mayaguez, 3860 (type), 75, 252, 292, 7587, 7401, Manati 4327, Añasco 8691, 3220, Rio Piedras (Stevenson) 386.

The spot produced is quite characteristic and gives evidence of the aggressive character of the parasite. The fungus is distinctive owing to its numerous long, crooked conidiophores.

It differs from *Cercospora Caladii* Cke. in septation and size of spores.

Helminthosporium spiculiferum E. & E.

On *Thrinax*, near Utuado, 6616.

Helminthisporium ravenelii.

On *Sporobolis indicus* El Alto de la Bandera, 8663, Jajome Alto, 8404. This "smut grass" is very common throughout the island.

Helminthosporium glabroides Stev.

On *Perisporium portoricense;* on *Calophyllum calaba,* 7489.

Cercospora Fries.

Cercospora violae Sacc.

On Viola sp., Rio Piedras (Stevenson), 5125.

Cercospora rigospora Atks.

On *Solanum nigrum,* Rio Piedras, (Stevenson), 5316.

Cercospora personata (B. & E.) E.

On *Arachis hypogaea,* Rio Piedras (Stevenson), 5121.

Cercospora nicotiana E. & E.

On *Nicotianum tobaccum,* Bayamon (Stevenson), 5517.

Cercospora citrullina Cke.

On *Citrullus vulgaris,* Pueblo Viejo (Stevenson), 5446.

Cercospora hurae sp. nov.

Spots circular or sometimes angular by venous limitation, 2x0.5-1 cm. in diameter, ashen in center, purplish border, with numerous concentric lines marking the dead leaf tissue visible equally from both sides of the leaves. Conidiophores amphigenous but much more abundant below, emerging from the stomata in small or large clusters, straw-colored about 35 μ long, geniculate. Conidia linear, many-septate, 50-85x3-4 μ, straw colored, obtuse.

On *Hura crepitans,* Mayaguez, 478, 5830 (type), 70, Añasco 3594.

Cercospora ricinella S. & B.

On Ricinus sps. Jayuya, 5973, Yauco, 3238, Peñuelas, 4889, Utuado, 6553, Coamo, 125, 60, 84.

Cercospora biformis Petch.

On *Passifora sexflora,* Mayaguez, 1140.

Cercospora trichostigmae sp. nov.

Spots definite tan colored, angular, 3-10 mm. in diameter, Conidiophores hypophyllous, arising from small black tubercular masses, short, dark Conidia oblong, cylindrical, obtuse at each end, pale straw colored, 34x50x3 μ, many septate.

On *Trichostigma octandra,* Barceloneta, 9254 (type), Rio Piedras, 9470.

The conidiophores are so closely compacted as to make this a transition form between the Moniliales and Tuberculariales.

Cercosporia cucurbiticola P. Henn.

On Cayaponia Maricao, 4815. Rosario, 3777. The species of the two hosts which were not the same were not determined.

Cercospora achyranthis Syd.

On *Achyranthis aspera,* Guanica, 333, Hormigueros, 459a, Bayamon, 459. The type of this species was described from Japan and in some respects differs from the Porto Rican material, particularly in the length of the conidiophores and shape and character of the spot.

Cercospora alternantherae E. & L.

On *Alternanthera portoricensis,* Yauco, 3273, Coamo, 3976, 820, 8479.

Cercospora gilbertii Speg.

On *Iresine paniculata,* El Alto de la Bandera, 8286. This specimen differs from Spegazzini's description in that the spots are not pellucid, the spores too, are a trifle thicker.

Cercospora bixae, A. & N.

On *Bixa orellana,* Mayaguez, 56, Lares, 4845, Rosario, 3795. The last number also bears spots of entirely different character, small, with white center and purple border. In these is a Cercospora which appears quite different from *C. bixae.* On account of sparcity of material it is not described.

Cercospora biformis Petch.

On *Passiflora sexflora*, Mayaguez, 1140.

Cercospora trichophila sp. nov.

Spots circular, dead, 3-5 mm. in diameter. Conidiophores hypophyllous, yellow, very long, lax creeping and twining among the leaf hairs of the host. Conodia long, many septate. 44-68x5 μ.

On *Helicteres jamaicensis*, Peñuelas, 4888.

On *Solanum torvum*, Mayaguez, 361, 1144, 1266, Utuado, 4691, 7982, Vega Baja, 486, Rio Tanama, 9205, 7832, Monacillo, 9339, Arecibo-Lares Road, 7227, 7296, Mayaguez, 7036, Lajas, 7156, Manati, 7693, Mona Island, 6431.

On *Solanum verbascifolium*, El Gigante, 8499, El Alto de la Bandera, 8260.

The fungus has much the habit of a Cladosporium but the spores of a Cercospora.

Cercospora flagellaris E. & M.

On Phytolacca icosandra, Maricao, 2323.

Cercospora portoricensis E.

On *Piper aductum*, Mayaguez, 45a, 315, 1166, 7501, 7035, Peñuelas, 9143, Juana Diaz, 9131, Martin Peña, 9308, Coamo Springs, 8358, Tanama Rio, 7833, Jajome Alto, 8420, 1088, Arecibo-Lares Road, 7319, 7015, Añasco, 8735, Trujillo Alto, 9399, Peñuelas, 9132, Adjuntas 463, Corozal 412, Ciales 22.

On *Piper umbellatum*, Maricao, 8854, 7903, Rio Arecibo, 7771.

Cercospora caseariae sp. nov.

Spots ashen white, irregularly circular, definite, 2-4 mm. in diameter, surrounded by a purplish area a centimeter or more in diameter. Conidiophores in loose clusters. Conidiophores short, reaching but little above the epidermis. Conidia linear to clavate, straw colored, many septate, 50x4 μ, obtuse.

On *Casearia ramiflora*, Villa Alba, 99, Caguas, 292a, Luquillo Forest, 5556, Quebradillas, 5171, Utuado, 4691, 4675, 8051, San German, 4865, 5839, Cataño, 4190, Martin Peña, 9306, Mayaguez, 3940, 211, Aguada, 5086, Aguadilla, 4858, Maricao, 370, Martin Peña, 9330, Vega Baja, 9268, Rio Tanama, 7925, Jayuya, x, Bayamon, 387, Preston's Ranch, 6698, Sta. Catalina 2720.

On *Casearia sylvestris,* Mayaguez, 524, 3900, 76, 3895, Coamo, 7275, Rio Tanama, 7884, 7855, Hormigueros, 7364, Lajas, 7177, Corozal, 406, Quebradillas, 5010, 5004, 7273, Ponce, 8682, Luquillo Forest, 5431, Monte de Oro, 5714.

On *Casearia guianensis,* Rosario, 3801, Corozal, 420, Mayaguez, 1386.

The spots produced on *C. sylvestris* are much smaller than on *C. ramiflora,* usually only 1-2 mm. in diameter. These on *C. guianensis* are intermediate in size.

Cercospora thouiniae sp. nov.

Spot indefinite diffuse, the diseased area showing above merely slightly discolored, below marked only by the ferruginous fungus. Conidiophores hypophyllous, abundant, long, lax, ferruginous smooth, crooked, slightly darker than the spores. Conidia, long, narrow, 58-72x5-7 μ, usually clavate, many-septate.

On *Thouinia striata,* Maricao, 751.

Cercospora bernardiae sp. nov.

Spots small, circular, 1-3 mm. in diameter. Yellow above, pale below, definite. Conidiophores epiphyllous in dense clusters, almost tubercular, short, about 35 μ long, pale yellow. Conidia linear 51-68x7 μ, obtuse, 3-many septate; very faintly straw tinted.

On *Bernardia bernardia,* Guanica, 355a.

The fungus is especially interesting since its general aspect is not that of a Cercospora and on account of its almost tubercular habit.

Cercospora mikaniacola sp.

Spot circular, small, 1-2 mm. in diameter, or by concentric enlargement, 5-10 mm. in diameter, sordid white in center, dark bordered, definite. Conidiophores hypophyllous, cespitose, fascicles of many conidiophores, or often solitary. Conidiophores pale brown, 6 μ thick, 50-100 μ long, or in old spots 160 μ long, geniculate. Conidia, linear to whip shaped, pale, 34-78x3.5 μ.

On Mikonia sp. Utuado, 7923, (type), Aguado, 5083, Maricao, 4700.

Cercospora beticola Sacc.

On *Beta vulgaris,* Rio Piedras (Stevenson), 5550.

Cercospora henningsii Allesch.

On Cassava, Bayamon (Stevenson), 3932.

Cercospora atricincta.

On Zinnia sp. Espinosa (Stevenson), 3130.

Cercosporidium Earle

Cercosporidium helleri E.

Passalora helleri E.

On *Sphenoclea zeylandica* Mayaguez 3757.

STILBACEAE

Stilbella, Lindau

Stilbella flavida (Cke.) Kohl.

On coffee, Dos Bocas, 6565; Jayuya, 5975; Ponce, 4269; Monte de Oro, 5720; Rio Maricao above Maricao, 3637; El Gigante, 8488; Arecibo Lares Road, 7245.

On *Bryophyllum pinnatum,* Maricao, 385.

On *Psychotria uliginosa,* El Alto de la Bandera, 9047, on *Elephantopus mollis,* Jayuya, 467, Monte de Oro, 5740.

On *Piper macrophyllum* Monte de Oro, 5734, 5722; on *Synedrella nodiflora,* Ponce, 4268.

TUBERCULARIACEAE

Microcera Desm.

Microcera fujikuroi.

On grapefruit, Pueblo Viejo (Stevenson), 5008.

Epicoccum Link

Epiccoccum neglectum, Desm.

On Cestrum, Cabo Rojo, 6451.

The fungus is apparently parasitic. The sporodochia are large, 750 μ in diameter, 320 μ high. The conidia are about 10 μ in diameter, slightly smaller than the description calls for.

Pucciniopsis Speg.

Pucciniopsis caricae Earle.

On *Carica papaya*, Rio Piedras (Johnston), 1472.

Illosporium Mart.

Illosporium commelinae sp. nov.

Spot circular 1-2 cm. in diameter, discolored border indefinite. Sporodochia hypophyllous, one in nearly every stoma in the diseased area. Mycelium substomatal, very fine, about 1 μ, hyaline, branched and crooked. Sporodochia nearly spherical but slightly flattened on the top and slightly wedge-shaped below as they contract to the stomata, waxy, pale, about 95 μ in diameter. Conidiophores at first parallel, simple, about 35x1 μ, later growing out into long mycelium-like structures. Spores few, oblong, continuous, hyaline, obtuse, 10x3 μ.

On *Commelina elegans*, Aguada, 5109, Mt. Gigante 8485, on *Commelina longicaules*, 5081, Caguas, 287a, Hormigueros, 224; Rosario, 480; Guayanilla, 5923; Las Marias, 8248.

This fungus is very common on its widespread host and is conspicuous in its effects and vigorously parasitic. Although the sporodochia are numerous, spores are produced very sparingly. The sporodochia are distinctly waxy in texture, and when old have numerous long mycelial threads growing out from their upper surface.

Mycelia sterilia

Sclerotium Tode

Sclerotium portoricense, sp. nov.

Mycelium scant, hyaline, crooked, septate. Sclerotia superficial on leaves, culms, or leaf sheaths or more often under the

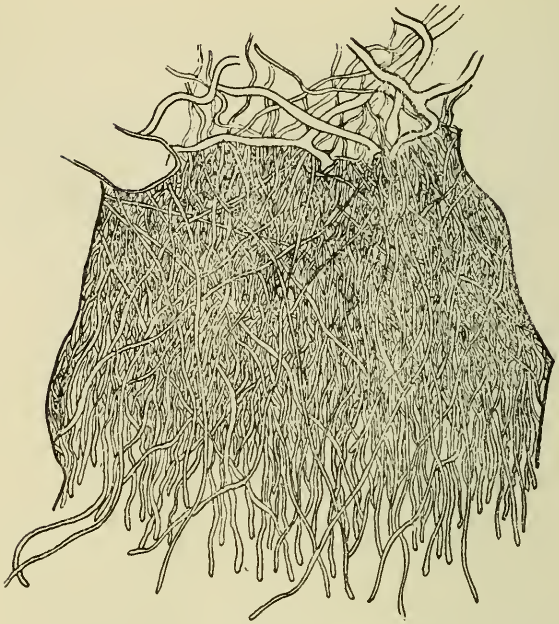


Fig. 12. Sporodochium of *Illosporium commelinae.* Drawn by J. MacInnes.

leaf sheaths, 280 μ in diameter, flattened. Thickly set with long, 800-1000 μ, fine, 3 μ, brown, septate hairs which arise as outgrowths from the surface layer of the sclerotium. Surface layer of cells dark, firmly adhering. Internal cells hyaline, angular, 10-14 μ in diameter, consisting of a thick wall, 3-4 μ, and a central granular protoplasmic area.

On *Cynodon dactylon.*

Santurce 378 (type), also a specimen by Stevenson Dec. 1916.

This structure is very remarkable and it is regrettable that more of the life history is not known.

FUNGI OF UNKNOWN AFFINITY.

Graphiola Poit.

Graphiola phoenicis (Mong.) Poit.

On *Phoenix dactylifera*, Mayaguez, 896, 3503, Coamo Springs, 8337; on *Inodes causiarum*, Jayuya 6731a, 3756; on Phoenix (?) Guanica (Smythe) 2563; on *Thrinax preceps*, Utuado, 8017.

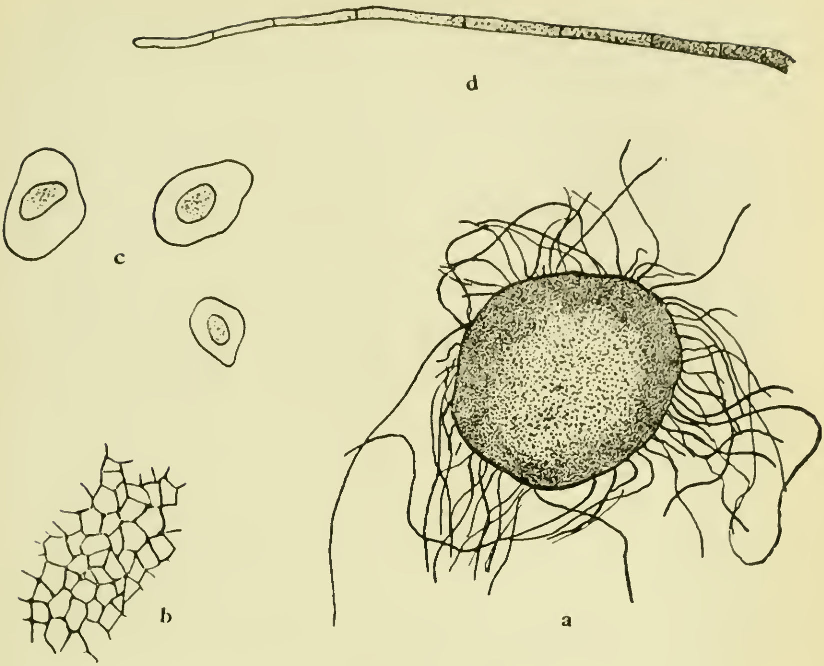


Fig. 13. *Sclerotium portoricense* sp. nov.

a. Sclerotium showing general appearance of sclerotium and the hairs.
b. A bit of the surface layer showing reticulations.
c. The hyaline internal cells showing thick wall and granular interior.
d. Detail of one of the perithecial hairs.

PARASITIC ALGAE

Cephaleuros virescens Ktz.

On *Psidium guajava,* Mayaguez, 155, 5819; on *Myrcia deflexa,* Mayaguez Mesa, 7436, Maricao, 5056; on *Cupania americana,* 9144; on *Nectandra patens,* 1750; on *Miconia laevigata,* Mayaguez, 7373; on *Inga laurina,* Willd., Jajome Alto, 7023, Mayaguez, 7038, 7049; on *Jambosa vulgaris,* Añasco, 8743; on *Artocarpus incisa,* 196, 1222; on *Coccolobis diversifolia,* Maricao, 8877; on *Ocotea leucoxylon,* Mayaguez, 7393; on Myrcia, Rosario, 4815; on *Cestrum laurifolium,* Mayaguez, 8158, 7088; on *Dendropanax arboreum,* Tanama Rio, 7955; on *Somidesia lindeniana,* Jajome Alto 8380; on *Lasiacis swartziana.* Jajome Alto, 5657, on Citrus sp. Mayaguez, 1017;

on *Citrus decumana,* Rio Piedras (Stevenson), 2327; on *Achras zapota,* Rio Piedras (Stevenson), 3244. On *Acrodictidium salicifolium,* Hormigueros 7360.

Crustose lichens on leaves.

Heterothecium phyllocharis.

Renealmia antillarum, Maricao, 743.

THE OCCURRENCE OF *ALTERNARIA* IN A CHARTERISTIC APPLE SPOT, AND AN APPLE ROT CAUSED BY *GLIOCLADIUM VIRIDE*

By Frances Jean MacInnes

The twenty-five apples on which this work is based came from Harristown, Illinois, early in July, and were not nearly mature. The spots were in various stages of development, making it possible to study the probable progress of the disease. Nothing is known of the conditions under which they grew, nor of the time the infection started.

THE DISEASE ON THE FRUIT

The spot on the fruit is striking in its early stages, due to the decided color change and in the later stages to the distinct margin as well as the darkened skin and tissue. The outer skin of the diseased portion is tough and leathery, and difficult to cut. Only a few millimeters beneath the skin are injured. The disease does not destroy a large part of the fruit, but it is unsightly, and would largely decrease salability.

The earliest stage of the disease showed no softening of the tissue or change in the size or shape of the fruit. A spot about 2 cm. in diameter was changed from green to a delicate yellow mottled with red. A later stage showed a spot slightly darker and mottled with both red and brown. What was considered a still more developed spot possessed the same characteristics as those above but in the center was a slightly sunken irregular brown spot with a distinct border. This spot was shiny, hard, and from 2 to 4 mm. in diameter.

In the more advanced stages the red color usually increased and the size of the hard brown spots became larger. The surface was in many cases slightly depressed and the round of the apple would be changed showing that there had been a stoppage of the growth of the cells on that side.

The outline of the spots in the later stages became definite, usually round (Plate II.) The color was then almost black with a brilliant red surrounding it. This was brightest at the border and radiated out over a large part of the apple, sometimes covering half of it, becoming less and less bright, and usually ending in a mottling or striping.

The size of the spot varied from 2 millimeters to about 3 centimeters in diameter. The progress of the fungus is very slow. Two apples were marked on the twelfth of November, and on the twelfth of March there was not more than 2 mm. of growth on the blackened portion of one, the reddened part apparently remaining the same, and no change at all in the other. The growth probably takes place in the orchard, as the fruit develops.

STRUCTURE IN CROSS SECTION

The fungus in the deepest spots observed penetrated only about 3 mm. deep. The average was from 1 to 2 mm.. Plate I. Figs. 1, 2, 3, 4, 5,, give an idea of the appearance of the spot in cross section.

The growth of the mycelium into the tissue caused the flesh to turn brown, the cells becoming corky and hard, and they were filled with a large quantity of starch (Plate I, Fig. 6). Starch was not present in the healthy cells, (Plate I, Fig. 7). The fungus appeared to be present only in the brown areas. In the very early stages no infected cells were seen but from such spots *Alternaria* was isolated. The depth of the diseased tissue varied with the degree of darkness of the epidermis. The tissue was slightly bitter to the taste, and hard to chew as compared with the healthy flesh.

The mycelium of the fungus can plainly be seen in the cells of the infected tissue (Plate I, Fig. 6). Under the very dark portions of the skin the mycelium was abundant, while under the lighter colored areas it was more difficult to find. Under the reddened portion of the skin radiating from the spot, none was apparent, and no culture was produced from this region.

METHODS OF CULTURE

In isolating the fungus from the apples all possible precautions were taken in order to avoid contaminations. Except where otherwise specified the medium used for all cultures was cornmeal agar made according to Shears' formula.

Before any cultures were made from the tissue of the apples the surface, which had been washed in water and dried with a clean towel, was wiped with sterilized cotton saturated with absolute alcohol.

THE FUNGUS

From all but two of the spots *Alternaria* was isolated. The cultures were all alike and originated from the point where the needle was put into the agar. From the number of isolations and the uniformity of the results there would seem to be little doubt but that this is the organism which causes the spot, although inoculations on healthy apples did not produce the same spot. It is probable that in the orchard the fungus gains entrance while the fruit is still young, and develops more or less with it. In the laboratory no results were obtained without breaking the skin, and when the inoculations were made under the surface a soft rot was produced without any darkening of the skin of the fruit.

The *Alternaria* found in this spot is not morphologically different from many other Alternarias which grow on a great many hosts. Dr. Elliott, then of this laboratory, now at the Arkansas Experiment Station, determined it as *Alternaria tenuis*, variety X. Two other varieties of Alternaria were isolated by me, one rotting the core of an apple, and one growing on the surface of the seed and not rotting the fruit. While these are like the Alternaria referred to above, under the microscope, and in culture the colonies look the same, they do not behave the same when inoculated on fruit. The one characteristic of this spot produces a rapid rot, the one from the core a slower growing rot, and the one from the seed no rot at all. Several cultures obtained from Dr. Elliott indistinguishable from these, produced no rot on the apple. One, however, caused a spot not unlike the one above described. It developed very slowly and make the skin dark, hard, and sunken. This was *A. fasciculata*, a variety of *A. tenuis*.

CULTURES

In culture the fungus produces a colony which grows very rapidly. There is generally abundant, white or greyish, cottony, aerial mycelium (Plate III, Fig. 2) which covers a very large number of spores which are produced from the internal mycelium. The under side of the culture is dark, with numerous more or less distinct concentric rings. The colony is indistinguishable from those of a large number of Alternarias.

Considerable variation is found when the fungus is grown on different media. Cornmeal gave a darker colored colony than bean (Plate III, Figs. 2, 3), and a rather more abundant growth. Unfavorable conditions caused the fungus to spread over a greater area but was much lighter in color and less abundant in growth and formation of spores.

THE CONIDIA

The conidia vary in length from 31 to 57 microns, the average being 43. These measurements do not include the beak. The end beak in a chain may be very long, while the spores within the chain may have almost none. The width of the spores was from 9 to 22 microns, the average being 3. Thus the spores are about three times as long as wide, not including the beak. They are almost always pointed and regular in shape when just mature (Plate I, Figs. 3, 8, 9), but when they are old they become wider, misshapen, the beak disappears, and the cells become constricted (Plate I, Fig. 11). The normal spores are dark in color and have from four to eight transverse septae. In the young or just mature spores there are a few longitudinal septae, but when they become old and constricted there are many. The spores are borne in great numbers and are almost without exception in chains, the number in the chain averaging about twelve. From one or more of these spores a side chain may be produced, having as many more (Plate 1, Fig. 8).

CONIDIOPHORES

The conidiophores vary in length from 100 microns or more to less than 10. They are invariably dark colored and in most cases the cell next the first spore is enlarged slightly

(Plate I, Fig. 8): The width is about the same as that of the mycelium. The septations are often more numerous than in the mycelium.

MYCELIUM

The mycelium is dark colored when well developed, but light when young. It varies from 3 to 9 microns in width. The mycelium is light colored, much finer, the septations are further apart, and little nodules often appear at various intervals.

LITERATURE

There are only a few references in literature to Alternaria as an enemy of the apple. Morse[1] mentions the leaves as being attacked. Stakman and Rose[2] of Minnesota describe an Alternaria on the fruit of the Wealthy apple. It causes a small brown spot in some ways resembling those above described. Personal communication with these authors, however, proved it to be different. The spot they describe is much smaller, different color, and has a more regular outline. They were able to produce typical spots when the organism was inoculated on the fruit, which I have not been able to accomplish.

Longyear[3] of Colorado has found Alternaria causing a blossom and core rot which enters in the stamens and stigmas and usually occurs in storage. These are both soft rots. Cook and Martin[4] found Alternaria in the Jonathan spot, and consider it to be the cause. They produced typical spots with the organism. However, Scott[5] considers that the Jonathan spot is due possibly to arsenical poisons, and Norton[6] ascribes it to gases from the cooling plants. Brooks, Fisher and Cooley[7] found Alternaria in apples in storage.

There is a marked resemblance between this spot as here described and that attributed to Lime Sulphur as described by the Illinois Experiment Station (Bulletin 185). Communication with the man from whose orchard the fruit came proved that no spray had been used later than two weeks after the petals fell. According to the Illinois Bulletin, no injury is done to the fruit by Lime Sulphur before July. This would indicate that this spot is not caused by Lime Sulphur.

It is possible that all these diseases, including the one described, are caused by the same organism, a variety of *A.*

tenuis which has under different environmental conditions become changed. It is a question whether their behaving differently when inoculated on apples is sufficient reason for their being considered as distinct species.

CONCLUSIONS

More work will have to be done before it can be determined definitely how this spot is formed. Although Alternaria has been found in every case, it may or may not be the direct cause. The time and method of entering the fruit will have to be determined in the orchard. Nothing certain can be said with regard to it until a typical spot has been reproduced by inoculation, but the presence of the Alternaria in the spots seems significant.

REFERENCES

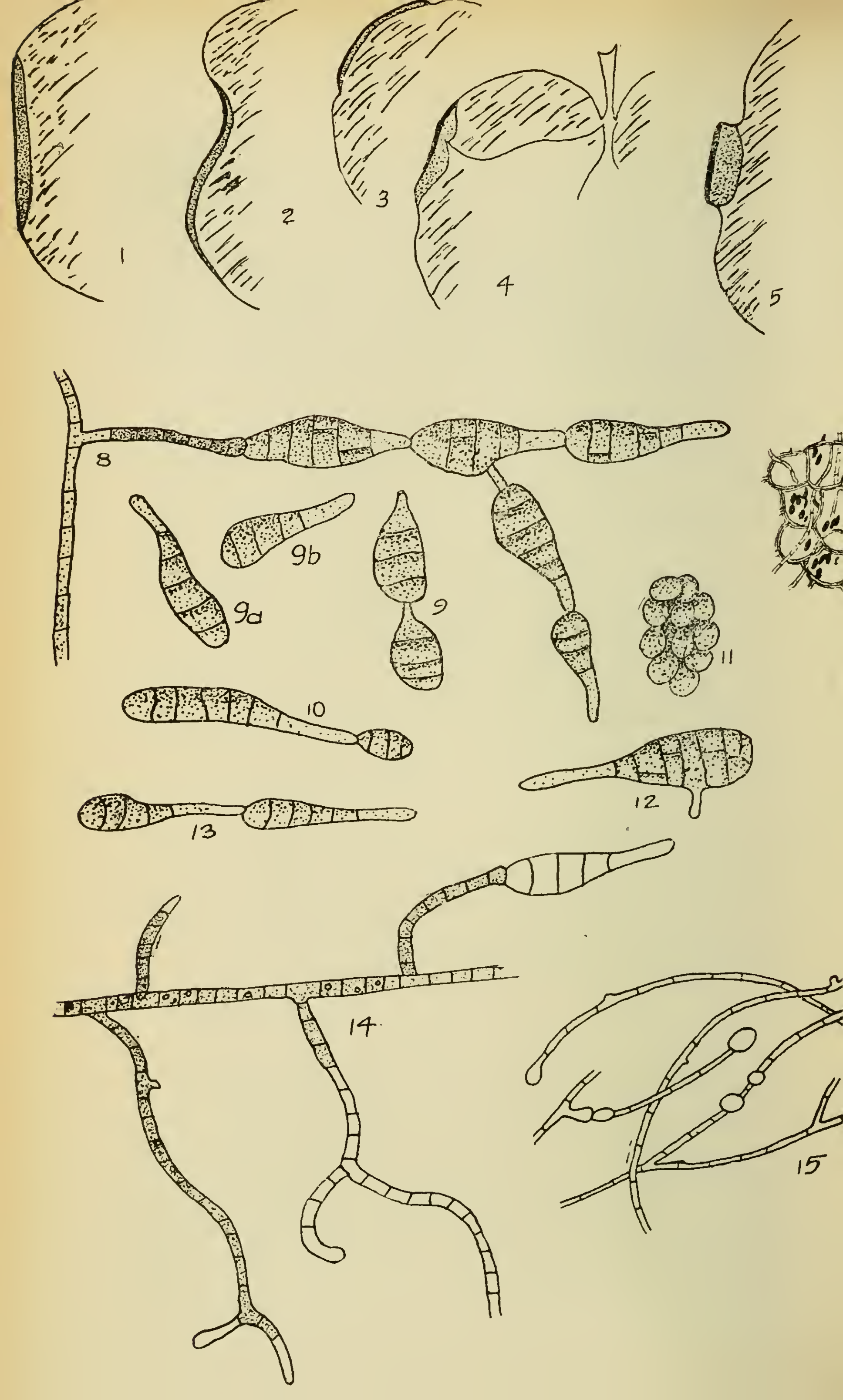
1. Morse, W., Maine Ag. Exp. Sta., Bul. 164, 1908.
2. Stakman, L. C. and Rose, R. C., Phyto. 4:333, 1914.
3. Longyear, B. O., Col. Agr. Exp. Sta. Bul. 105: 12, 1905.
4. Cook, M. T., and Martin, G. W., Phyto. 3:119, 1913.
5. Scott, W. M., Phyto. 1:32, 1911.
6. Norton, J. B. S., Phyto., 3:99, 1913.
7. Brooks, Fisher, Cooley Exp. Sta. Rec. 33, 1914.

AN APPLE ROT CAUSED BY *GLIOCLADIUM VIRIDE*

The fungus upon which this paper is based was found on several petri dishes in which cultures were made while isolating fungi from diseased apples. When inoculated on healthy fruit it produced a typical, dry, brown rot.

THE FUNGUS

The mycelium of the fungus is hyaline, septate, branching, and varies from 1.8 to 3.6 microns in width (Plate IV. Fig. 1). The conidiophores are formed as in Penicillium. They grow erect from the internal mycelium, branching once to many times (Plate IV. Figs. 7, 8, 9). They are hyaline, septate, and can be differentiated from the aerial mycelium only by the profuse branching. These branches become brush-like as in Penicillium (Plate IV., Fig. 13.)



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EXPLANATION OF PLATE II

No. I. Apples showing three sizes of spots—natural size. Upper right hand apple with two marks, one around the dark part, the other around the reddened part. No progress of the disease was apparent in four months.

No. II. Apple at left with one irregularly shaped spot. At right an apple showing a depression around edge of the spot.

EXPLANATION OF PLATE 1

Figs. 1, 2, 3, 4, 5. Diagrams of cross sections of apples showing the depth to which the fungus penetrates the tissue.

Fig. 6. Tissue of diseased portion, showing mycelium and starch grains.

Fig. 7. Tissue of healthy portion showing cells—no starch grains.

Fig. 8. Chain of conidia from conidiophores; also a chain developing laterally from a spore.

Figs. 9, 9a, 9b. Spore with different lengths of beak.

Fig. 10. Spore with small spore developing from end of a long beak.

Fig. 11. Old spore showing round instead of angular cells.

Fig. 12. Mature spore beginning to germinate.

Fig. 13. Typical long beaked spores.

Fig. 14. Mycelium from corn meal agar, showing the mature part and conidiophores dark and younger part light.

Fig. 15. Aerial mycelium, showing size as compared with internal mycelium. Note enlarged cells.

The conidia are borne in great numbers on the end of the conidiophores. It is difficult to determine how they are borne, as there is a sticky substance which holds them together in large masses which vary greatly in size and shape. These masses are at first greenish, but later almost invariably become black.

The individual spores are elliptical to ovate and may or may not be pointed at the ends (Plate IV., Fig. 3). In size they vary from 5.4 by 2.7 microns to 9 by 3.6 microns. Spores in a hanging drop of distilled water showed a germination of about 50 per cent in 9 hours (Plate IV. Fig. 4). In a hanging drop of cornmeal agar there was considerable growth in 12 hours. (Fig. 5).

CULTURES

On cornmeal agar this fungus produced a very characteristic colony. As the colony developed there was an abundance of white flocculent, aerial mycelium. This partially disappeared when the spores began to form. The spore masses were generally produced in concentric distinct rings. These rings were at first white but they later darkened, sometimes becoming green, and then black. There seemed to be some variation in color even when the fungus was grown on the same medium and under the same conditions. The spore clusters were very irregular in size and shape depending upon the number held together by the gelatinous substance. The older the colony the larger the clusters were; a tube four months old showed a cluster 1 cm. long and 2 cm. wide.

No difference could be noticed in the size or shape of the spores or the mycelium on the different media used; but the number of spores produced, the size of the spore clusters, and the abundance of the mycelium varied. When double the amount of asparagin was in the synthetic medium used the spores and mycelium were abundant. In media with double the usual amount of glucose the growth of mycelium was large but the number of spores produced was few. On synthetic media without asparagin the culture was weak and spread over a large surface. The same was true when no glucose was present. On plain agar, the development was weak and growth ceased entirely after the colony reached the size of 2 cm.

INOCULATIONS

When inoculated on healthy apples the fungus produced a characteristic spot. The development was slow, about two weeks being required to develop a distinct spot. In many cases no infection took place. The spot, when produced, was light brown with a distinct margin, which was slightly darker than the rest of the diseased portion. After about a month the spot was sunken and had not developed over 1 cm. in diameter. The surface was slightly hardened.

In cross-section the spot showed, in many cases, a diseased portion of much larger area than could be seen superficially. The fungus had, in one case for example, penetrated almost into the core of the apple in three weeks. It made a rather soft spongy rot—not as soft, however, as that of Penicillium. While the surface spot in this case was only .5 cm. in diameter, the tissue below was rotted 2 cm. deep and 1 cm. in either direction from the spot. In other cases the rot was not so rapid—penetrating only about .5 to 1 cm. with a surface spot of .5 cm. after two weeks. No observations have been made on fruit which had been inoculated more than a month.

EXPLANATION OF PLATE III

No. I. Cross sections of two infected fruits. On the upper side of the fruit at the left may be seen the infected portion—about 2 mm. in depth and 10 mm. wide. On the lower part of the fruit at the right may be seen the darkened tissue, about 3 mm. deep and 2 cm. wide, and the depressed edges.

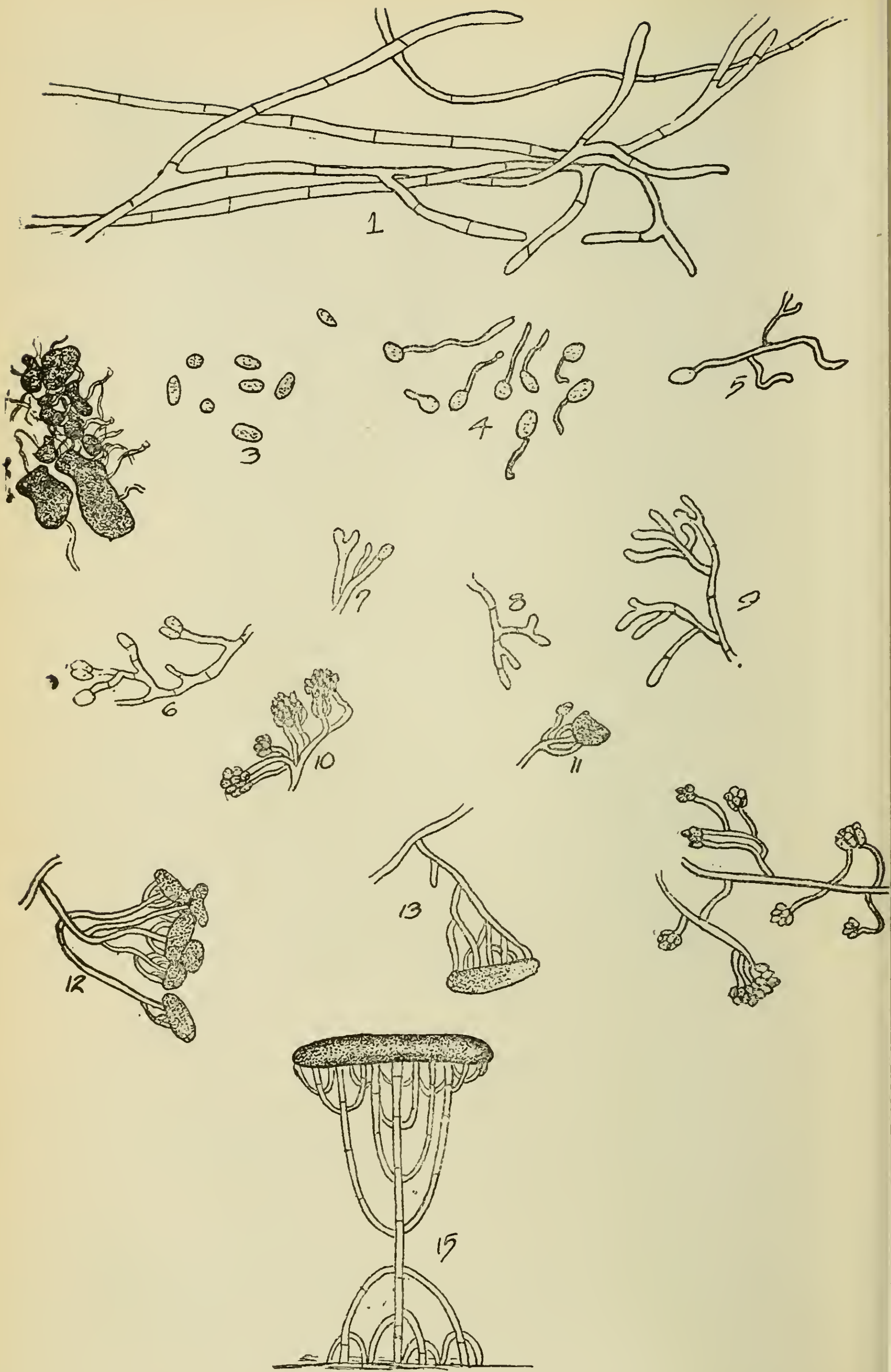
THE GENUS

The genus Gliocladium was described by Corda, the type species being *G. penicillioides*[2]. According to Saccardo the genus may be described as having the sterile hyphae creeping, the fertile hyphae growing erect, simple, septate, and forming upon branching a brush-like structure upon which the conidia are borne. The conidia are at first catenulate but later are enveloped by a mucilaginous substance into a little head. It is only in the presence of this sticky coat on the spores of Gliocladium that Gliocladium and Penicillium differ essentially. There are fourteen species given in the "Sylloge Fungorum" most of which occur on decaying fungi or other dead organic matter. None of them seems to be of any economic importance except *G. agaricinum* Corda and Mass., which arrests growth and breaks the pilei of mushrooms.

THE SPECIES

The fungus was submitted to Dr. Chas. Thom, who said, "I examined the culture and find a form which I have studied several times during the last ten years. Thus far I have called it '*Gliocladium viride* Matr.' The lot to which this belongs needs someone's time and attention, but this one runs close enough to the form named above to forbid separate nomenclature, unless for reasons based on a larger volume of study than I have thus far been able to give it." An article by Matruchot[1] gives fully the development of the species. There seem to be some differences between the fungus as described by him and the material at hand. Further study may justify describing it as a new species. Neither the variation in spore measurement, nor difference in the shape of the spores alone would be sufficient grounds for separating it. But *G. viride* is described as having at first catenulate spores. Examination of a large number of conidiophores of my species with spores varying in number from 1 to 3 or 4, has never shown any to be so. They seem rather to form on the ends of a hyphal thread, a new spore developing at the same point and pushing the old one aside. (Fig. 6).

Another difference seems to be in the development of the mycelium. *G. viride* forms a branch just below a septa which grows up parallel to the main axis, this in turn branching in


1
3
4
5
6
7
8
9
10
11
12
13
15

EXPLANATION OF PLATE IV.

Fig. 1. Mycelium showing method of branching.

Fig. 2. Spore masses showing irregularity in size and shape (low power.)

Fig. 3. Spores.

Fig. 4, 5. Germinating spores.

Figs. 6, 7. Conidiophores with developing conidia.

Figs. 8, 9. Conidiophores.

Figs. 10, 11, 12, 13. Spore masses held together by the gelatinous substance.

Fig. 14. Conidiophores with spores before agglutination.

Fig. 15. Diagrammatic representation of growth of mycelium as described by Matruchot.

the same manner. From just above a septa at the same time another branch or series of branches is formed which grows down to the medium parallel to the main axis but having positive geotropism (Fig. 15). This structure has not been observed in my material. In all sections studied the main hyphal thread came directly from the medium and produced the conidiophore unsupported by aerial branches.

TABLE

COMPARISON OF *G. VIRIDE* WITH THE SPECIES UNDER DISCUSSION

	Gliocladium viride	*Gliocladium sp.*
Spore Measurement	3-6x2-3	5.4-9x2.7-3.6
Spore Shape	Oval and pointed	Elliptical to ovate, sometimes pointed.
Spore Catenulation	Catenulate at first	Never catenulate in large number observed.
Development of Mycelium	Brush-like structure of mycelium grows both up and down.	Brush-like mycelium grows only up.

But a still more noticeable difference is in the color of the masses of the conidia. *G. viride* Matr. is described as green. In most cases the specimens in my cultures are black when mature, though some variation was observed in the young colonies.

REFERENCES

1. Matruchot, L., Bul. Soc. Myc. pp. 246, 1893.
2. Corda, A. J. C., Ic. Fung. IV., pp. 30.
3. Saccardo, P. A., Syll. 11, pp. 594.

PHYLLACHORA AS THE CAUSE OF A DISEASE OF CORN, AND A GENERAL CONSIDERATION OF THE GENUS PHYLLACHORA

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During the summer of 1915, F. L. Stevens noted in Porto Rico, the occurrence of an apparently undescribed disease of corn, which was widespread and was found in almost every field examined. To what extent crops are damaged by the disease is not known, but since the fungus attacks the leaves of corn before the grain is mature, and since the leaf may be infected to such extent that ten per cent of its area is destroyed, considerable damage must result from the presence of the the fungus. The present study is based entirely on herbarium material collected in 1915, and all efforts to culture the fungus have given negative results.

THE DISEASED SPOTS

The disease appears as well defined, conspicuous, sub-carbonaceous spots, averaging about 1.2 mm. in diameter, and slightly roughened on the surface. A sharp line of demarcation separates the healthy from the diseased tissue. The infection is local and so far as observed is confined to the leaf and the leaf sheaths. The spots, due to the formation of fungous stromata in the infected tissue, are scattered irregularly over the entire leaf and are visible from both upper and lower surfaces. They usually are larger and more conspicuous on the upper surface. In form they are round or elongated and have an irregular margin. The stromata tend to grow along a vein, sometimes to a distance of a cm. or more, although the more characteristic spot is round to ovate. The spots are small and numerous or comparatively large and sparsely distributed, and in either case are usually surrounded by a narrow yellowish-brown halo which is more evident on the under side of the leaf.

A fungus which appeared to be *Scolecotrichum graminis* was commonly present on the Porto Rican specimens. This fungus causes dark spots due to dense mycelium and olive brown conidia and is surrounded by a conspicuous light brown halo. When spots due to the disease which is the subject of this paper are in the centers of light brown apparently sunburnt areas the two diseases are very similar in appearance.

STROMATA

The first indication of the disease is a slight discoloration at the point of infection. The mycelium, which is at first hyaline, very soon develops an amber-yellow color, the contents of the invaded cells disorganize and the infection becomes evident through the color changes, even when a very few cells are involved. The fungus enters the epidermal cells and shows a tendency to grow close to the inside of the walls of these cells. From the epidermal region it proceeds into the mesophyll where it reaches its greatest development. Here the mycelium becomes dense and the host cells broken down. Perithecial cavities form in this region, and a dense mass of mycelium fills the epidermal cells which were not at first destroyed by the fungus, thus forming an incrustation over the stroma. In the development of the stromata the perithecia form earlier than this covering, and at one stage of the development the perithecia are conspicuous under low magnification with transmitted light. The perithecia which in the specimens examined, varied in number from two to thirty in a single stroma, occur either loosely scattered or so closely compacted that the walls coalesce, forming a dense stromatic mass which encloses the perithecia. In a transverse section of the leaf the perithecia occupy a medial position and the stromata usually fill the leaf tissue from one surface to the other before perithecia are formed.

There is considerable variation in size, form, and distribution of the stromata. Mature perithecia were seen in stroma as small as 0.2 mm. in diameter. An area of one hundred and ninety-five square centimeters contained nine large stromata with irregular margins, while a similar area contained eighty-one that were small, round, and regular in outline. The stromata are surrounded by yellowish-brown infected areas forming halos which are usually very narrow but may reach a width of one-third the diameter of the stromata and are generally a little more conspicuous on the under than on the upper side of the leaf.

MYCELIUM

The mycelium in newly invaded tissue is slender and hyaline. In the course of development it becomes amber-yellow and later dark-brown, filling the leaf tissue with a net-work of hyphae, which encloses in its meshes what remains of the broken down host cells. The mycelium is septate and branched, although not profusely so. It varies in thickness from 1.5 μ to 4.5 μ and in a later stage of development sometimes forms short and comparatively thick, irregularly shaped cells.

PERITHECIA

The perithecia are embedded in the stromata and consist of immersed cavities, subglobose or angled by mutual pressure. They are scattered in the stromata or closely aggregated, thirty being the maximum number in a single stroma. An apparent wall surrounds the loculus made up of dark brown mycelium and bearing at the tip a small ostiole. The ostiole is usually concealed by the epidermis. The perithecia open on both upper and lower surfaces of the leaf, contiguous ones in the same stroma sometimes have the ostiole on opposite surfaces of the leaf. The diameter of the perithecia parallel with the surface of the leaf varied from 171 μ to 352 μ. The vertical diameter of the perithecia is much greater than the length of the asci, since they reach up into the perithecial cavity only to about one-third of its height. Long paraphyses extend from the base toward the center of the cavity.

ASCI

The asci are numerous. They are cylindrical and vary in length from 64.8 μ to 91.8 μ, and in thickness from 7.2 μ to 10.8 μ, with a stipe 9 μ to 20 μ in length.

PARAPHYSES

Copious paraphyses are present extending far beyond the asci as they sometimes reach a length of 125 μ. They are filiform or attenuate from a somewhat thickened base.

SPORES

In each ascus are produced eight unicellular, hyaline, thin-walled spores. They are ovate in form with round ends and vary in length from 7.2 μ to 12 μ and in thickness from 4.5 μ to 7.2 μ. Usually they are uniseriate but there are occasional exceptions to this arrangement when the ascus is relatively short and the spores biseriate. Stained microtome sections show a very prominent nucleus.

The fungus is obviously of the Dothidiaceae and has been identified by the writer as *Phyllachora graminis* (Pers.) Fuck. which is found on many grasses in this country but has not been reported on corn. It conforms with the description of *Phyllacora graminis* in Saccardo's "Sylloge Fungorum,"[12] and with the description by Winter[15], Lindau[10], Ellis and Everhart[4], and Sydow and Theissen[13]. Boltshauser[9] describes *P. graminis* as having numerous, small stromata in living tissue and a few relatively large stromata in brown, dead leaves. This variation in the appearance of the stroma, from small and numerous to large and relatively few in number, is not considered by Sydow and Theissen of any importance in classification.

In my specimens the position of the asci in the perithecia does not conform to the description of *P. graminis* by Fuckel[7] or by Müller [11], the former claims that the asci grow from the base of the perithecia, the latter that they form an equatorial ring in the shape of a girdling band around the center of the perithecia. My specimens have the asci developing from the base and from the inner basal circular surface, up to about half the interior of the perithecia with the free ends extending toward the center. Microtome sections were made for comparison from available exsiccata. Nine specimens, from different hosts, identified as *Phyllachora graminis* were sectioned and examined. Each one had the asci developing similarly to those of the fungus on corn, and this mode of development seems to be constant. Sydow and Theissen[13] consider the position of the asci in the perithecia to be of specific import and my specimens agree with their description of *P. graminis* in this regard.

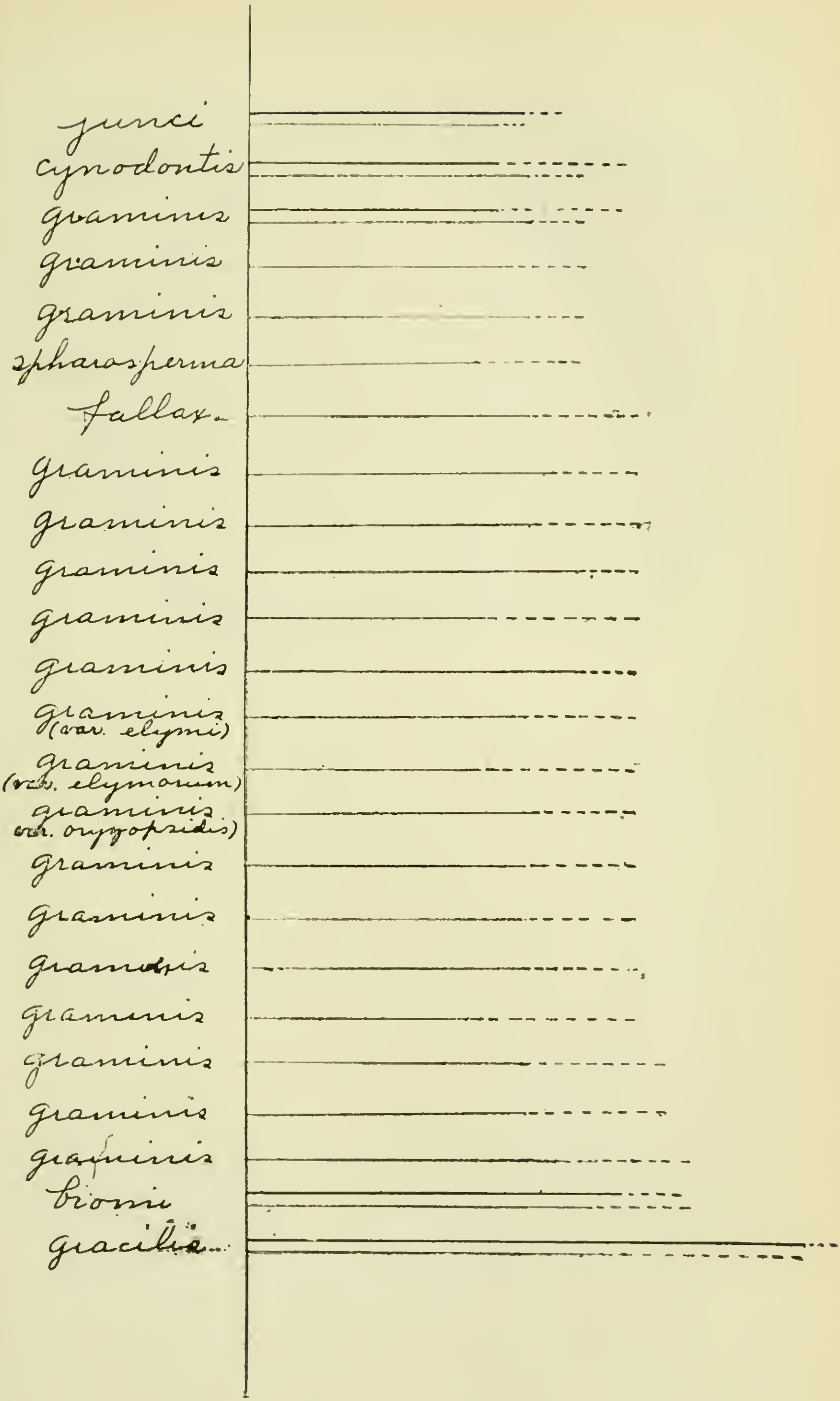
A peculiar distention of the basal centers of the perithecia is sometimes described but was not observed in the material examined. Sydow and Theissen think that this character is evident only in mature material and only at a definite stage of ripening.

The specimens examined have apparently a conspicuous perithecial wall. The Dothidiaceae are generally characterized by perithecia reduced to mere cells in the stromata, but Brefeld[1] says, "Phyllachora is unusual in that it has a definite perithecial wall." Ellis and Everhart[4] call the perithecia in *Phyllachora graminis* "ascigerous cells." Jaczewski[8] illustrates *P. graminis* by a drawing in which no perithecial wall is shown but in the descriptions of *P. graminis* by Winter[15], Lindau[10], Frank[6], Brefeld[1], and by Kirchner-Boltshauser[9], a definite perithecial wall is mentioned. Sydow and Theissen[31] explain the apparent presence of a perithecial wall by the fact that the function of the lacking wall is taken over by the inner stromatic surface surrounding the loculi. For this purpose the stromatic elements undergo special orientation which in *P. graminis* takes the form of a thickening and by reason of a darker color due to this thickening an actual perithecial wall is simulated.

The form of the perithecia varies from oval to angular, being modified by pressure during development. Young and old perithecia grow together in the same stroma, and the number in a single stroma has been considered as a specific character only in extreme cases in the Phyllachoraceae, although it is regarded as a distinguishing character in the Polystomellaceae.

Spore measurements, of use in systematic diagnosis, vary considerably in the species. The following tabulation gives graphically the spore length of measurements made from exsiccati of *P. graminis* on different hosts. A few other species of *Phyllachora* are included for comparison. The solid line represents the minimum and the entire line the maximum spore strength. Where there are double lines, the upper one represents spore measurements taken from Saccardo's "Sylloge Fungorum."

It is noteworthy that *P. cynodontis* and *P. graminis* have identical spore measurements in the "Sylloge Fungorum." The same spore measurements for these species were obtained from herbarium material. *P. sphaerosperma* has the same maxi-


junci
cynodontis
graminis
graminis
graminis
sphaerosperma
fallax
graminis
graminis
graminis
graminis
graminis
graminis (var. elymi)
graminis (var. elymorum)
graminis var. oryzopsidis)
graminis
graminis
graminis
graminis
graminis
graminis
graminis
bromi
gracilis

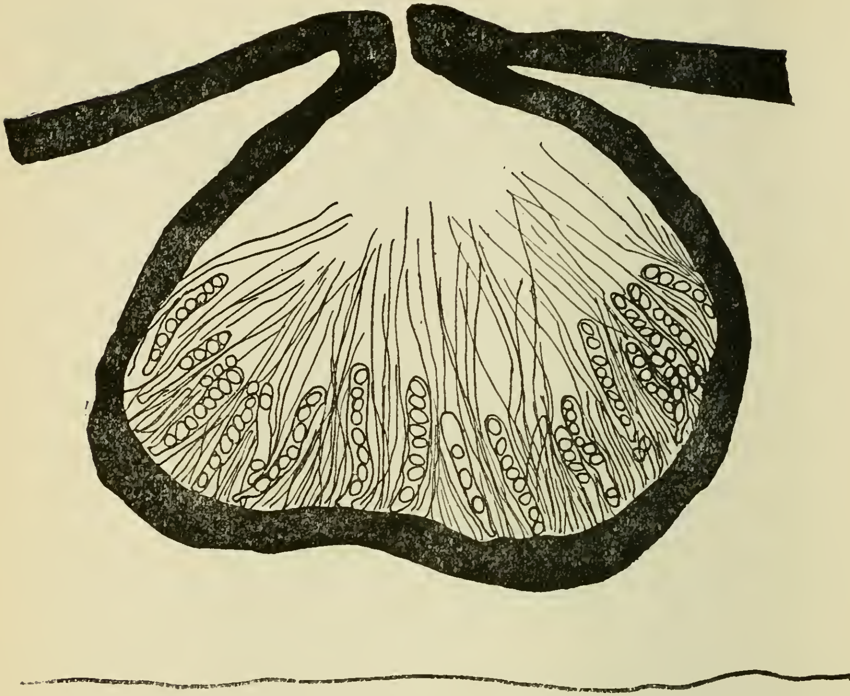


Fig. 3. Perithecia showing position of asci, apparent wall, and clypeus.

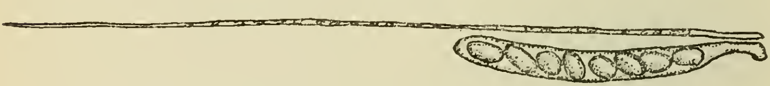


Fig. 4. Ascus and paraphyses

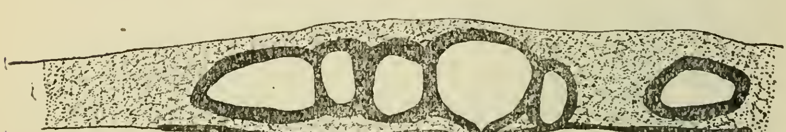


Fig. 5. Perithecia covered by clypeus

mum spore length as *P. graminis.* The measurements for spore length of different specimens of *P. graminis* show as great a variation among themselves as the spore length of *P. graminis* shows when compared with the other five species.

THE SPECIES OF THE GENUS PHYLLACHORA

The determination of the species of this fungus has raised the question of the validity of various of the species now regarded as distinct in the genus Phyllachora. For a satisfactory comparison of the species a tabulation was made from Saccardo's "Sylloge Fungorum." The arrangement of this tabulation is in the order of maximum spore length, and the table includes specific name, volume, and specific number of the "Sylloge Fungorum," spore measurements, ascus measurements, the host family indicated by number taken from De Dalla Torro and Harms "Genera Siphonogamarum." The species that are excluded in the revision by Sydow and Theissen are also indicated.

Saccardo lists four hundred and sixty-nine species on eighty-three different host families. A large majority of these are from the tropics. An indication of the very large number given on single families is afforded by the fact that sixty-three species are found on the Gramineae, forty-five on the Leguminosae, twenty-seven on the Moraceae, and twenty on the Compositae. The three species *P. bromi, P. maydis,* and *P. graminis* occur on the same host family and are similar in all of the most significant specific characters. It is doubtful if there are sufficient differences here to give these three distinct specific rank.

Of the species listed by Saccardo one hundred and thirty-three were described from immature material without spores and of these nine species were on Gramineae, five on Moraceae, nine on Leguminosae, and nine on Compositae. Such descriptions are, of course worse than valueless.

The presence or absence of paraphyses is regarded as of specific value. Sydow and Theissen even consider this of sufficient systematic importance to be a generic sign. The list by Saccardo, however, contains eighteen species said to be without paraphyses and in the description of two hundred and fifty-nine species the presence or absence of paraphyses is not mentioned. The stroma does not present sufficient variation to render it of much use for classification. The basis for specific differentiation thus lies chiefly in the character of the asci and spores. There is great variation in size and form of spores. The minimum spore length is 6 μ in the species *P. poae,* and the maximum 40 μ in *P. dasylirii.* There is also great diversity in spore form since in *P. dolenchogena* the spores are globular, in *P. dentritica* ovate and in *P. lonchotheca* the length of the spore is about six times its width. *P. bumbusina, P. stenostoma,* and *P. oxalina* have 1-septate spores, which is an exception to the generic character of continuous spores.

In as many as twenty-five instances two to six species have identical spore measurements. (e. g. *P. astrocaryi, P. tropicalis, P. bromi, P. lagerheimiana*). In some cases species having the same spore measurements are found on the same host family (e.g. *P. asprellae, P. pazschkeana.*) In one species only (*P. ficicola*Q is there variation from the usual spore number of eight. In this species there are asci having four spores.

In the revision of the genus by Sydow and Theissen[13] the number of species has been reduced to three hundred and twenty-nine. Form classification based upon the position of the perithecia in the host, fifty-two species have been removed to the genus Catacauma, eleven to the Genus Trabutia and four to the genus Bagnisiopsis, while a large number have been removed to other genera.

Fig. 6. Perithecia angled by growth pressure.

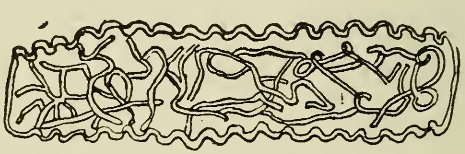


Fig. 7. Mycelium in newly invaded cell.

Fig. 9. Upper surface of leaf showing large and small stromata

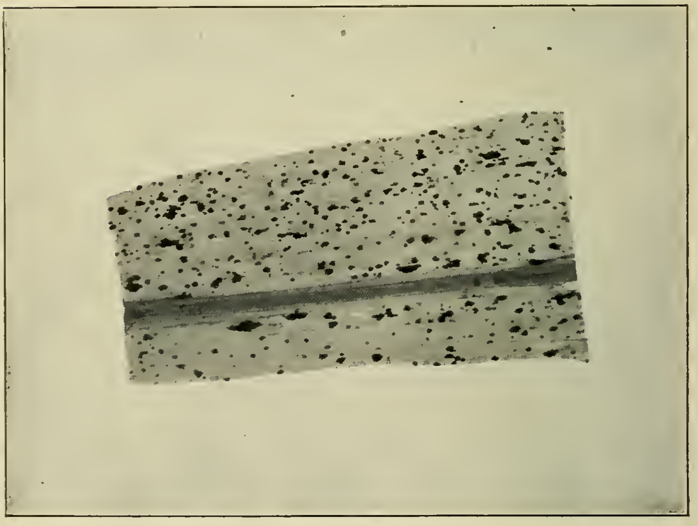


Fig. 8. Upper and lower surface of leaf showing stromata.

TABULATION OF SPECIES OF PHYLLACHORA FOUND IN "SYLLOGE FUNGORUM" ARRANGED IN THE ORDER OF SPORE LENGTH

The following tabulation is presented with the hope that it may be of service to those who study the genus, or have need to classify species within the genus.

NOTE: Column 1 contains vol. of the "Sylloge Fungorum" in which the species is described, and species number.

Column 2: specific name.

Column 3: spore length and breadth in microns.

Column 4: ascus length and breadth in microns.

Column 5: host family given by number taken from De Dalla Torre and Harm's "Genera Siphonogamarum."

The sign (*) indicates that the species is excluded from the genus Phyllachora by Sydow and Theissen[13].

Vol. & specie number	Specific Name	Spore length & breadth	Ascus length & breadth	Host family
* 2:5122	euglypta	5=	50=	
2:5136	poae	6=3		19
*17:2910	macrosiphoniae	6-8=5-6	55-65=9-11	270
1 9:4064	japonica	7-8=4		233
* 2:5120	nitidissima	7-8=2-5		
* 9:4104	leptostromoidea	8=3		.1
22:4718	corallina	8=4	70-80=5-6	137
17:2879	manaosensis	7-9=5-6	45-60=12-18	128
*14:2532	pestis-nigra (var. caracaensis)	8-9=5-6	75-90=8	141
14:2555	topographica	7-10=7-8.5	41-50=12	64
22:4733	parkiae	7-10=5-6	45-70=8-12	128
				19
22:4781	eleusines	8-10=6-7	65-80=6-7	126
17:2885	lungusaensis	8-10=3.5-4	35-40=10-18	128
* 2:5099	millepunctala	8-10=	70=	233
				.1
* 2:5153	pteridis	8-10=5-6	640=14	91
9:4041	balansae	8-10=67	55-60=10-12	140
				145
9:4058	pestis-nigra	8-10=3.5	40-50=10-12	141
				128
*11:2264	frigida	9-10=2.5-3.5	25=20	20
14:2535	desmodii	9-10=6-7	43-46=6-7	128
14:2571	olyrae	9-10=4.5	50=7	19
* 2:5112	ficuum	9-10=7-9	45-60=13-18	64
* 2:5144	junci	9-10=3-3.5	60-85=6-7	36
22:4750	globispora	10=10	75-100=10-12	147
9:4103	sphaerospora	10=10	80-100=15	19
9:4090	luzulae	10=5		36
9:4052	melianthi	10=6	60=20	167
9:4047	opaca	10=4-4.5	80-85=6-8	222
9:4033	michelii	10=8-9	90-100=9-10	128
2:5128	tragiae	10=		147
2:5126	dolichogena	10=10		128
* 2:5094	demersa	10=		95
11:2277	triumfettae	10=6-7	60-80=10-15	174
11:2289	dendritica	10=7	70=9	145

Vol. & species number	Specific Name	Spore length & breadth	Ascus length & breadth	Host family
14:2546	psychotriae	10=5	90=6-7 ..	270
14:2553	euphorbiaceae	10=5	60-75=10-12	147
14:2570	boutelouae	10=7	90=9	19
				147
17:2899	crotonis	7-11=5.5-7	42-55=7-9.5	61
:	(var. parvula)			19
17:2923	arthraxonis	8-11=4-5	35-45=8-12	117
22:4732	luzonensis	8-11=3:5-4	60-80=5-6	128
14:2575	cynodontis	3-11=5-6	40-50=7-10	
:	(var. chlorides)			
16:2204	millettiae	8-11=5-6	30-45=10-15	128
22:4778	oplismeni	9-11=4.5-6	38-45=6-11	
17:2921	chionachnes	9-11=6.5-7.5	45-48=10-11	19
17:2918	vossiae	9-11=4.5-5.5	55-66=9-11	19
*16:2192	cudrani	9-11=7-8	45-65= ..	64
* 2:5091	ulmi	10-11=5	60-70=8	63
16:2206	marmorata	10-11=10	70=12	64
22:4754	fici fulvae	10-11.5=8-11	60-80=8-11	64
9:4069	ruprechtiae	11=6-6.5	60-65=8-12	
*22:4783	grammica	8-12=6-7	60-70=8-10	
*22:4758	merrilli	8-12=4-6		64
22:4745	ardisiae	8-12=5-6	65-80=8-10	236
*17:2902	caseariae		60-90=10-12	199
17:2900	sunabae-cedronis	8-12=5-6	50-80=15-26	138
2:5132	graminis	8-12=4-5	78-80=7-8	19
2:5134	cynodontis	8-12=5-6	65-75=12-15	19
*11:2294	karnbachii	9-12=7-8	50-62=10-15	64
17:2898	maprouneae	9-12=7-9	60-100=12-20	147
22:4756	devriesei	10-12=7.8-5	60-80=10-12	64
22:4737	vernicosa	10-12=5-6	60-70=12-14	102
*22:4735	paulensis	10-12=7-8	70-80=15	128
*22:4729	biguttulata	10-12=5-5.5	50-65=8-10	
17:2916	serialis	10-12=5-6	75-80=12-15	19
9:4076	lucida	10-12=7	55-65=10-14	128
* 9:	trifolii	10-12=5		
9:4039	nitidula	10-12=4-6	80-100=12	258
* 9:	musae	10-12=7		
* 9:4093	graminis	10-12=5-6	60-75=8-12	19
	(var. tupi)			
*16:2191	ulcerata	10-12=5	65-70=10	
9:4065	sinik-lagaraik	11-12=7-8	65-72=11-13	236
14:2568	cordobensis	12=5-6	70=1[illegible]	19
14:2567	scanica	12=6		19
*14:2565	caricis	12=4.5	50=12	20
	(var. brasiliensis)			247
14:2549	aspidospermatis	12=6	75=15	153
*14:2547	randiae	12=5	50-60=10-12	270
14:2545	physalosporoides	12=7	70=10	280
14:2530	anonaceae	12=6	90=12	98
*11:2284	leviuscula	12=6	45-50=12	270
9:4094	brachypodii	12=6-7	24=6-7	19
9:4082	biareolata	12=5	90-95=6-9	
* 9:4059	dispersa	12=5	90-110=10-14	
* 9:4055	ficuum	12=6-8	45-65=10-20	64
	(var. spinifera)			
* 9:4054	infectoria	12=5		64
* 9:4050	intermedia	12=5	50=10	165
				222

Vol. & species number	Specific Name	Spore length & breadth	Ascus length & breadth	Host family
9:4046	guavira	12=5	100-110=6-8	270
* 2:5154	flabella	12=5	90=9	.1
* 2:5143	epitypha	12=4		8
2:5139	fuscescens	12=6-7	60-65=10-12	19
*16:2205	irregularis	12=7		64
9:4038	tenuis	10-13=4-4.5	70-75=10	258
9:4085	engleri	10-13=3-4	50-60=6-7	
11:2281	subtropica	10-13=3-5	100=10-11	147
11:2290	fructigena	10-13=7-9	30-35=18-24	
22:4734	pongamiae	10-13=3.5-4	60-70=8-10	128
14:2551	henningsii	11-13=7-9	80-100=12-14	147
* 9:4072	pirifera	12-13=6-8	70-80=7-12	280
*22 4737	papuloso	12-13=8-9	50-60=16	
	(var. vernicosa)			
22:4739	litseae	12-13=6-8	100-110=	
			10-11	102
*22:4748	randiae	12-13=7 8	40-60=15-20	270
•	(sub. sp. aculeatae)			
*22:4749	phyllanthophila	12-13=7-9	50-60=20	147
	var. egregia			
22:4771	bouteIouicola	12-13=6	80-90=12-15	19
9:	xanthoxyli	13=3		
11:2276	gratissima	13=9-10	100-110=21	102
11:2299	philodendri	13=6	130=6-7	23
17:2877	monninae	13=6.5-8	75-110=11-13	145
17:2880	schizolobiicola	8-14=4-4.5	50-70=10-14	128
11:2305	asprellae	10-14=6-8	80-110=8-9	19
16:2196	rudgeae	10-14=5-7	80-120=8-10	270
16:2214	pazschkeana	10-14=6-8	60-96=12-18	19
*17:2897	phyllanthophila	10-14=5-7	35-45=12-15	147
17:2915	maydis	10-14=5.5-6.5	80-100=7-8	19
22:4724	peribebuyensis	10-14=5-7		223
:	(var. brachycarpa)			
*22:4725	aggregatula	10-14=5-7	40-55=14-18	223
22:4751	blanguillo	10-14=7-8	60-75=10-15	147
*22:4752	fici-obscurae	10-14=10-11	80-90=10-12	64
22:4757	amaniensis	10-14=6-7	100-130=7-10	64
22:4766	cyperina	10-14=3.5-4.5	60-80=6	20
*11:2287	sellowii	10-14=5-6	100-120=7-9	128
* 9:4083	alpiniae	11-14=5-6		46
17:2904	melaleucae	11-14=4.5-6.5	66-84=8-11	222
*16:2201	acaenae	11-14=6-7	35-42=11-13	126
14:2573	graminis	11-14=7-8	86-100=10-12	19
	(var. panicicola)			
14:2570	tricholaenae	11-14=6-8	46-65=14-18	19
*14:2534	dalbergiicola	11-14=7-9	45-55=18-26	128
				247
11:2292	quebrachii	12-14=6-7	80-90=10-12	153
*14:2540	subopaca	12-14=7	75=10-15	222
*14:2560	flavo-cincta	12-14=5-6	100-110=	
			12-15	
14:2563	viridulocincta	12-14=6	75=9	23
17:2881	schizolobii	12-14=5	65-75=12	128
17:2906	vernoniicola	12-14=6-8	70-80=13-15	280
17:2912	astrocaryi	12-14=7-8	80-140=13-16	21
22:4736	goeppertiae	12-14=10	80-100=15-20	
22:4746	ambrosicola	12-14=8-9	80-120=10-16	280

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2:5095	tetrantherae	12-14=		102 222
2:5105	tropicalis	12-14=7-8	70-75=10-14	186
2:5135	bromi	12-14=7-8	80-98=8-11	19
9:4060	sororcula	12-14=5-7	100-120= 10-14	
9:4061	taruma	12-14=6-7	65-75=10	
9:4070	astronii	12-14=8-9	50=20	153
*11:2269	goyazensis	12-14=8-12	70-90=17-18	222
*11:2274	lagerheimiana	12-14=7-8	90=15	50
11:2273	marginalis	13-14=6-7	18-20=15	
22:4762	coccolobae	13-14=6	70-80=10-18	77
9:4044	applanata	14=4.5	90-106= 10.5-14	137
9:4048	annuliformis	14=8		102
17:2892	ocoteae	10-15=7-8	60-80=12-20	102
17:2922	graminis (var. panici sulcati)	10-15=7-8	60-80=10-14	19
22:4722	canarii	10-15=3.5-4		
22:4747	macarangae	10-15=5-6	50-70=10-14	147
9:4035	paraguaya	11-15=6-8	50-75=14-18	
*17:2888	mexicana	11-15=6.5-8	80-110=12-15	169
*14:2557	tonkinensis	12-15=9	75=9	
*16:2199	perforans	12-15=5	80=1^	128
17:2896	huallagensis	12-15=5-6	50-80=12-15	102
17:2905	cinerea	12-15=5-7	80-100=12-15	258
22:4721	leeae	12-15=7-8	100-140= 10-15	170
2:5124	dalibardae	12-15=		126
11:2263	acaciae	12-15=4-5	45-52=14-17	128
*11:2265	machaerii	12-15=4.5-6	88-105=7-9	128
*11:2297	amenti	12-15=5-6	50-60=12-14	
*14:2537	peribebuyensis var. bullosa	12-15=6-7	120=10	
22:4742	noackii	12-15=8-10	85=10	280 66
16:2193	hakeae	13-15=5-6	90-110=8-10	222
9:4092	setariaecola	13-15=6-6.5	90-95=10-12	19
*11:2291	arrabidaeae	13-15=4.5-5.5	65-87=13-18	169
22:4770	eriochloae	14-15=7	70-80=10-12	19
22:4744	jacquiniae	14-15=8-9	100=14-18	137
9:4079	apiahyna	14-17=7	90-110=12-14	
* 2:5152	aloetica	14-15=9.5		280
*17:2925	filicina	14-15=5-6	70=10-11.5	50
16:2197	rubefaciens	15=8	90=15	
14:2544	nidulans	15=8-10	70-80=9-12	280
16:2213	minutissima	15=		19
17:2920	eleusines	15=7	130=12	19
22:4741	nectandricola	15=7-9	100=15-13	
* 2:5096	simillima	15=		128
2:5115	crotonis	15=10		147
2:5133	stenospora	15=		19
11:2279	durantae	15=8	90=21	253
22:4772	cenchricola	15=10	80-90=12-16	19
*11:2295	abyssinica	10-16=7-10	80-120=14-22	64
*17:2874	miryensis	11-16=7-9	60-70=10-18	98
* 9:4067	gibbosa	12-16=8-9	90-100=	

Vol. & species number	Specific Name	Spore length & breadth	Ascus length & breadth	Host family
			9.5-10-5	223
*22:4730	myrrhinii	12-16=5-6.5	55-72=12-16	222
17:2895	madeirensis	12-16=5-6	50-60=8-12	102
*17:2878	hammari	13-16=7-9	45-75=20-30	128
*22:4753	fici minahassae	13-16=5-6.5	45-60=10-16	64
14:2550	alyxiae	13-16=6-7	80-100=10	247
9:4034	enterolobii	14-16=6	60-70=10-12	128
				222
9:4045	brasiliensis	14-16=10	80-18	137
11:2293	crotonicola	14-16=10	100-120=	
			13-15	147
14:2536	amphidyma	14-16=6	100-125=7-8	159
				140
22:4769	melicicola	14-16=8	120-130=10	198
22:4773	chloridicola	14-16=7-8	85-100=8-10	19
*11:2270	subcircinans	14-16=8-10	80-90=10-16	222
11:2275	xanthoxyli	14-16=7	84-100=12-14	137
17:2882	derridis	14-16=4-6	55-70=12-15	128
14:2552	julocrotonis	14-16=8-10	100-120=	
			10-12	147
22:4728	ipirangae	15-16=8	80-90=10-12	222
* 9:	Ph.(?) gracillima	15-16=5	50-60=10	
16:2203	laurinearum	16=8	140=12	102
* 9:4063	Ph. (?) menispermi	16=8	60-90=18-20	
17:2889	pusilla	11.5-17=7-10	70-105=11-21	
16:2198	centrolobii	14-17=8-10.5	82-100=14-16	128
22:4777	acuminata	14-17.7=5-6.5	100-140=9-10	19
14:2574	cornispora	14-17=5-7	50-70=10-15	19
17:2893	opposita	14-17=5	80-100=10-12	102
2:5118	brasiliensis	15-17=9-11	70-80=25-30	
*11:2306	dactylidis	7-18=9	108=12	
22:4776	heterospora	10-18=6-8	50-80=10-15	19
17:2917	sacchari	12-18=9-12	80-120=15-18	19
17:2890	minuta	13-18=7-8	80-110=15-18	175
17:2911	effigurata	13-18=5-6	70-100=6-11	64
* 9:4078	exanthematica	13-18=6		
				147
*16:2202	huberi	14-18=8-10	50-65=16-20	145
*22:4760	circinata	14-18=5-6	42-60=12-15	64
*11:2271	pittospori	14-18=10-13	110-150=	
			15-25	118
2:5101	incarcerata	14-18=		98
9:4081	Ph.(?)arechavaletae	15-18=5-6	100-110=	
			10-14	
* 9:4066	peribebuyensis	15-18=6-8	80-90=9-11	223
*11:2298	cocoicola	15-18=7-9	100-130=	
			13-16	
11:2304	acutispora	15-18=5-6	90=8	19
14:2556	valsispora	15-18=4.5	110=12	
14:2559	timbo	15-18=5-6		
2:5156	episphaeria	15-18=		
9:4032	Dalbergiae (var. macrosca)	15-18=8	100-120=27	128
9:4042	copaiferae	15-18=6-8	70-80=10-12	128
17:2876	securidacoae	15-18=5-7	60-80=10-18	
17:2903	baumii	15-18=5-7	90-150=8-10	239
*17:2913	scirpi	15-18=4-5	65-85=10-12	20
9:4068	pulchra	16-18=8	75-80=12-16	239

Vol. & species number	Specific Name	Spores length & breadth	Ascus length & breadth	Host family
9:4051	subrepens	16-18=8-9	85-90=12-16	165
* 9.4049	laurina	16-18=5		102 128
9:4031	puiggarii	16-18=8-9	80-100=15-26	280
9:4040	guatteriae	16-18=8		98
2:5093	rhytismoides	16-18=		128
* 2:5108	repens	16-18=		
22:4738	parvula	16-18=5-6	85-100=10-14	102
* 9:4089	fimbristylidis	17-18=2-3		20
2:5137	sylvatica	17-18=8	90-95=15	19
9:4056	vinosa	18=8-9	90-100=15-25	64
2:5121	lucens	18=6		
14:2531	hibisci	18=7	90=15	175
14:2533	collaeae	18=5	70=15	126
*14:2539	feijoae	18=10	60=25	
14:2566	silvatica brasiliensis	16=6-7		19
22:4720	duplex	18=10	120=15	165
*11:2296	schweinfurthii	15-19=9-11		64
14:2569	chusqueae	15-19=7-8	65-90=14-20	19
11:2285	symploci	16-19=8	80-90=2	242
9:4037	amphigena	16-19=6-8	50-60=12-16	256
17:2875	vochysiae	12-20=8-10	70-85=12-22	143
2:5130	wittrockii	12-20=4-7	70-80=6-10	271
*17:2887	centrolobiicola	12-20=8-10	80-90=14-20	128
16:2195	physocarpi	12-20=6	70=16	
*22:4767	fimbristylicola	14-20=4-6	55-60=8-10	20
*11:2286	miconiae	14-20=9-10	35-55=21-24	
22:4775	bokensis	15-20=9-13	80-110=16-20	19
2:5142	bonarienis	15-20=7-9	65-70=12-18	19
9:4057	trivialis	16-20=5-7	140=150	248
9:4095	andropogonis	16-20=6-8	100=20	19
9:4043	selenospora	16-20=6	90-100=14-20	137
14:2554	ficicola	16-20=6-8		64
*14:2564	renealmiae	18-20=7-8		19
22:4774	urvilleana	18-20=4	60-70=7-8	165
*11:2272	gentilis	18-20=8-9	120=12-14	222
9:4036	sordida	18-20=7-9	120-130= 10-12	258
* 2:5150	kniphofiae	18-20=5-6		36
16:2210	shiraiana	18-20=7-8	90=8	19
* 9:4062	Ph. (?) piperacearum	18-20=6	80=12-14	
9:4080	ulei	18-20=5.5	90-106=12.5	
*14:2542	distinguenda	18-20=4.5	60-70=18	222
*22:4763	vilis	18-20=5	50-64=10-12	
9:4087	Ph. (?) palmicola	18-20=9	52=15-20	21
9:4098	gracilis	18-20=7-8	80-90=14-18	19
9:4100	Ph. (?) tricuspidis	18-20=6-9	90-120=10-14	
11:2283	nidulans	19-20=10-12	180-200=20	280
*22:4768	sacchariaegyptiaci	19-20=7.5-9.5	145-155= 12-14	19
9:4053	aspideoides	20=10	100-110= 12-14	64
* 2:5110	aspidea	20=		64
* 2:5140	muhlenbergiae	20=6.5-7.5	60-64=17-18	19
16:2209	scleriae	20=4	60=10	20
* 2:5147	acrocomiae	20=9-10	80-120=15-20	21
9:	lespedezae	20=10		

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11:2280	cestri	20 = 6-7	80-100 = 23-25	256
9:4088	nervisequia	19-21 = 7-7.5	87-110 = 16	
*16:2194	roupalae	21 = 9-10		66
				43
*11:2300	glaziovii	15-22 = 6-9	48-58 = 10-15	128
11:2303	coicis	16-22 = 11-14	50-70 = 15-20	19
14:2543	lehmanniana	17-22 = 5-6	95-120 = 12-16	143
14:2538	negeriana	18-22 = 10-14	100-120 =	
			20-33	126
17:2886	diocleae	18-22 = 4-5	50-60 = 10-12	128
				.1
*17:2924	pteridiicola	18-22 = 7-8	90-100 = 10-15	91
*11:2301	perisporioides	19-22 = 9-11	40 = 35	21
22:4743	conspicua	19-22 = 6.5-8	80-115 = 15-18	
2:5092	dalbergiae	19-22 = 5	65-75 = 14-16	128
* 9 4091	anceps	20-22 = 6	195 = 8	20
22:4717	erythroxyli	20-22 = 4	50-60 = 12-14	134
22:4765	pappiana	22 = 9	90 = 10	
17:2908	viticicola	15-23 = 8-10	65-80 = 13-20	253
16:2212	cyperi	19-23 = 6-9	100-107 = 15	19
17:2919	sporoboli	20-23 = 10	100 = 20	19
17:2883	copeyensis	20-23 = 8-10	65-70 = 15-17	128
*11:2288	pululahuensis	23 = 12	100 = 30	223
22:4779	sorghi	18-24 = 12	90-130 = 13-20	19
2:5145	cyperi	21-24 = 5-6		20
9:4101	cyperi	22-24 = 5-6	75-80 = 12-15	19
:	(var. donacis)			
* 9:4075	nyctaginearum	22-24 = 9	90-110 = 18-20	80
* 2:5141	gangraena	16-25 = 3.5-4.5	40-50 = 10-12	
*22:4727	lindmani	16.5-25 = 6.5-9		222
				.1
* 9:4105	rhopographoides	19-25 = 7	106-124 = 12-5	91
22:4761	simplex	19-25 = 7	90-115 = 19-24	77
16:2211	oxyspora	20-25 = 5-6	96-115 = 9-10	19
* 2:5125	viventis	20-25 = 7		128
14:2561	costaricensis	21-25 = 10-14		
11:2268	maculata	22-25 = 8		222
			120-130 =	
11:2267	begoniae	22-25 = 5	15-20	208
*11:2278	escalloniae	23-25 = 6-7	110-120 = 20	117
14:2577	hieronymi	18-26 = 5-7	50-75 = 15-21	
17:2884	juruensis	20-26 = 5-6	60-65 = 10-17	128
16:2215	apiculata	22-26 = 8-10	100 = 10-11	19
* 9:4086	mucosa	22-26 = 10-12	90-95 = 20-28	
9:4097	infuscans	22-27 =	124-142 =	
			18-26	19
14:2558	tonduzii	25-27 = 7-10	72-108 = 20-28	
16:2208	tjangkorreh	24-28 = 8	180 = 20	19
17:2914	eximia	25-28 = 8-12	125-200 =	
			18-25	19
* 9:4084	atroiquinans	25-28.5 =		
		10-10.5	62-66 = 26-27	132
17:2894	socia	20-30 = 13-15	140-200 =	
			18-30	102
22:4782	usteriana	25-30 = 5-6	60 = 12-15	
22:4740	lepida	24-32 = 7-9	110-140 =	
			14-24	102
22:4726	petitmenginii	26-33 = 7-8	80-110 = 20-25	222

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2:5119	fatiscens	30-33=		
17:2901	tonduz'i	25-35=5-6	75-80=15-20	236
* 2:5104	lonchotheca	35-6=	90-100=15-20	
* 2:5148	calamigena	35		
* 2:5146	dasylirii	30-40=16-18		132
17:2891	macrospora	35-40=8	140=	177
16:2207	Ph. (?) megalospora	65-70=8-10	220=20	20
* 2:5097	rhopalina			
* 2:5098	microcenta			64
* 2:5100	depazeoides			
2:5102	granulosa			143
2:5103	explanata			140
* 2:5106	mycrocae			222
2:5107	grevilleae			66
2:5109	catervaria			64
2:5111	thwaitesii			64
* 2:5113	decaismeana			64
2:5114	tenuis			128
2:5116	inclusa			
2:5117	phylloplaca			
* 2:5123	heraclei			128
2:5127	ambrosiae			280
* 2:5129	picea			170
2:5131	melaena			128
2:5138	tritici-gracilis		27=3	19
* 2:5149	strelitziae			45
* 2 5151	melanophaca		50=	38
* 2:5155	anomala			165
2:5137	rhytismoides			
* 2:5158	asteromorpha			61
* 2:5159	impressa			126
* 2:5160	colensoi			
* 2:5161	orbiculata			240
* 2:5162	acervulata			
* 2:5163	rhois			
* 2:5164	latitans			233
* 2:5165	annulata			170
* 2:5166	abortiva			216
* 2:5167	lauri-borboniae			102
* 2:5168	juglandicola			60
* 2:5169	sassafras			102
* 2:5170	melastomatis			223
* 2:5171	subcuticularis			271
* 2:5172	rosae			126
* 2:5173	maculans			
* 2:5174	castaneae			62
* 2:5175	lauricola			102
* 2:5176	polygalae			145
* 2:5177	glycineos			128
				20
* 2:5178	conspurcata			222
2:5179	permeans			
* 2 5180	xylostei			271
* 2:5181	exculpta			147
				50
* 2:5182	barringtoniae			219
* 2:5183	musae			45
* 2:5184	trifolii			128

Vol. & species number	Specific Name	Spore length & breadth	Ascus length & breadth	Host family
* 2:5185	brachystemonis			
5:5186	lespedezae			
* 2:5187	bullata			280
				280
* 2:5188	xanthii			257
* 2:5189	solidaginum			
* 2:5190	exasperans			
* 2:5191	tragacanthae			128
* 2:5192	morthieri			228
* 2:5193	angelicae			228
* 2:5194	podagrariae			228
* 2:5195	companulae			276
* 2:5196	punctiformis			
* 2:5197	gentianae			
* 2:5198	eupatorii			280
* 2:5199	stipata			228
* 2:5200	deusta			175
* 2:5201	phlogis			21
* 2:5202	cinerascens			248
* 2:5203	asclepiadis			248
* 2:5204	impatientis			168
* 2:5205	silphii			280
* 2:5206	dispersa			
* 2:5207	conferta			
* 2:5208	chenopodii			78
* 2:5209	ornans			248
* 2:5210	hibiscicola			175
* 2:5211	phytolaccae			83
* 2:5212	inelegans			83
* 2:5213	elegans			83
* 2:5214	crustacea			83
* 2:5215	ramosa			78
* 2:5216	polygonati			38
* 2:5217	nodicola			227
* 2:5218	elliptica			254
2:5219	ambrosiae			280
* 2:5220	viticola			170
* 2:5221	hyssopi			254
* 2:5222	effusa			280
* 2:5223	frigoris			271
* 2:5224	chalybaea			233
* 2:5225	demigrans			233
* 2:5226	missouriensis			
* 2:5227	pomigena			
* 2:5228	fructigena			
* 2:5229	culmicola			19
* 2:5230	aristidae			19
* 2:5231	delicatula			19
* 2:5232	setariae			19
* 2:5233	nigrescens			19
* 2:5234	canaliculata			19
* 2:5235	penicillata			20
* 2:5236	cepae			38
* 2:5237	dioscoreae			
* 2:5238	panici			43
* 2:5239	lineola			19
* 2:5240	scapincola			38
* 2:5241	thanatophora			38
				205

Vol. & specie number	Specific Name	Spore length & breadth	Ascus length & breadth	Host family
				205
* 2:5242	caricis			280
* 2:5243	musae			45
* 2:5244	filicum			165
* 9:4071	Ph. (?) populi			56
				250
* 9:4073	polemonii			61
* 9:4077	interstilialis			
* 9:	caricis			
				19
9:4096	sphaerosperma		84-90=10-10.5	84
11:2262	cassiae		10-100=11-15	128
11:2302	luzulae			36
*14:2548	plantaginis			280
*14:2562	Pt. (?) yuccae		50-60=7-8	38
*14:2576	diplocarpa			128
*14:2578	fructicola			
*14:	tenuissima			
14:	spegazzinii			
14:	rhytismoides			
14:	winteri			
14:	ambrosiae			165
*22:4719	intermedia			
:	(var. luxurians)			
22:4723	Ph. (?) aberiae		80-100=10-12	
22:4759	dendroidea			64
22:4731	bakeriana			128
22:4764	melanoplaca veratri			38
22:4780	paspalicola			19
16:2200	Ph. (?) tipae			128

BIBLIOGRAPHY

1. Brefeld, Oscar. Mykologie 9: 265.
2. Clevenger, Jour. of Mycol., 11:163. 1905.
3. Currey, Frederick. Trans. Linn. Soc. 22: 1858.
4. Ellis and Everhart, North American Pyrenomycetes.
5. Engler and Prantl, Naturlichen Pflantzenfamilien. 1: 381.
6. Frank, A. B., Frankheiten der Pflanzen. 2: 630.
7. Fuckel, L., Symbolae Mycologicae.
8. Jaczewski, M. A., Bul. Soc. Mycol. de France. 10: 1894.
9. Kirchner, D. O., and Boltshauser, H., Atlas ser. 2 tab. 15 fig. 4-7.
10. Lindau, In Ingler's Pflanzenfamilien 1:281.
11. Müller, In Pringshenis Jahrbucher. 25.
12. Saccardo, P. A., Sylloge Fungorum. 2:594.
13. Sydow, H. and van F. Theissen S. J., Annal. Mycol. 13: 149. 1915.
14. Sorauer, Atlas Pflanzenkr. tab. 17. fig. 2C.
15. Winter, George, Rabenhorst's Kryptogamen Flora 2:894-898.

SOME NEW PORTO RICAN FUNGI

L. E. MILES, UNIVERSITY OF ILLINOIS

The material studied was collected by Dr. F. L. Stevens in the years 1912 and 1913, and the specimens are deposited as described by Miss Esther Young (1). Expressions of appreciation are due to Dr. N. L. Britton and Mr. Percy Wilson, of the New York Botanical Garden, and also to Mrs. Agnes Chase of the Bureau of Plant Industry, for assistance by determining host-plants.

I.—MYCOSPHAERELLA TABEBUIAE sp. nov.

Spots amphigenous, becoming white and transparent, small, 1-5 millimeters in diameter, surrounded by a dark, brown-purple blotch which gradually shades off into the normal leaf tissue. Perithecia numerous, epiphyllous, black, quite evident on the light background of the center of the spot, 80-130 microns in diameter, ostiolate. No paraphyses. Asci cylindrical, sometimes slightly ovate, double-walled, straight or somewhat curved, 50-60x10 microns. Spores narrowly clavate, hyaline, straight or slightly curved, 1-septate in the middle, scarcely if at all constricted, lower cell narrower and somewhat pointed, 17-20x3.5 microns.

On living leaves of *Tabebuia haemantha* (Bertero.) DC. in Porto Rico: Vega Baja, 2021 (type); Mona Island, 6187.

This species differs from *Mycosphaerella capreolata* on *Bignonia capreolata* in its narrower spores, and from *M. erysiphoides* on *Tecoma radicans* and *M. passiflorae* on Bignonia in its much larger spores.

II.—MYCOSPHAERELLA DIDYMOPANACIS sp. nov.

Spots amphigenous, mostly circular, sometimes confluent, but the individual spots remaining distinct, very light-brown or gray in color, one or two centimeters in diameter, surrounded by a narrow orange-brown line, on the lower side thickly studded to within a millimeter of the edge of the spot by the small black perithecia. Perithecia amphigenous, much more abundant on the lower side of the leaf, erumpent, numerous, small, dark, 70-130 microns. Ostiole 12-20 microns in diameter. No paraphyses. Asci short-stalked, oblong, slightly ovate, 40-50x10-12 microns. Spores hyaline, 1-septate, somewhat constricted, elongate-elliptical, cells slightly pointed at ends, 17-20 by 3-3.5 microns.

On living leaves of *Didymopanax mortoni,* Dcne. in Porto Rico; Añasco, 35; 39; 297; 2962; 3591 (type); 3780; 5716; 5748; 6829; 8140; Utuado, 4681.

This species differs from *Mycosphaerella araliae* and *M. panacis* in that its spores are much larger, and from *M. papyrifera* and *M. longispora* in its much smaller spore measurements.

III.—MYCOSPHAERELLA DUBIA sp. nov.

Spots amphigenous, round or somewhat irregular, becoming two or three centimeters in diameter, often confluent, dry, pale-brown, surrounded by a darker brown border which gradually shades off into the normal leaf tissue, many on a leaf. Perithecia epiphyllous, erumpent, scattered, minute, 45-60 microns, ostiolate. Ostiole 10-12 microns in diameter. No paraphyses. Asci ovate, curved, 24-27x10 microns, Spores inordinate, hyaline, uniseptate, not constricted, straight, fusoid, 10x3-3.5 microns.

On living leaves of Solanum (?) sp. in Porto Rico: Maricao 750 (type.)

This species differs from *Mycosphaerella solani* on *Solanum dulcamara* in having smaller perithecia and asci, and from *M. asterinoides* on members of the Solanaceae, *M. lycii* on *Lycium vulgaris,* and *M. nicotianae* and *M. tabaca* on *Nicotiana tabacum* in having all its measurements smaller.

IV.—MYCOSPHAERELLA GUTTIFERAE sp. nov.

Spots epiphyllous, somewhat irregular, when young salmon-colored, when old covered by a cinereous, papery membrane, bounded by a raised border, composed of very narrow bands of alternate light and dark brown. Spots reaching a diameter of one and one-half or two centimeters. Perithecia epiphyllous, numerous, black, erumpent, scattered over the entire spot, plainly visible 80-110 microns, with an ostiole 20-25 microns in diameter. Asci ovate or broadly clavate, 55-65x17 microns Spores slightly fusoid, uniseptate, inordinate, hyaline, the lower cell a little narrower, 24x4-5 microns.

1. Mycologia, 7 (1915) 143.

On living leaves of *Clusia gundlachii,* (Stahl) in Porto Rico; Maricao, 286 (type); 809, 7136, 7482, 8829, 8849, 8906.

This species differs from *Mycosphaerella clusiae* on *Clusia rosea* in the appearance of the spots and in the larger spore measurements.

V.—MYCOSPHAERELLA MAXIMA sp. nov.

Spots amphigenous, irregular, pale-salmon in color, conspicuous, bounded by a narrow dark brown line,, several on a leaf, often becoming three or more centimeters in diameter, sometimes confluent. Perithecia epiphyllous, subepidermal, minute, thickly scattered over spot, ostiolate, 80-90 microns. No paraphyses. Asci oblong or slightly narrowed above, 55-60x15-17 microns. Spores inordinate, hyaline, narrowly oblong, uniseptate in the middle. 28-35x3.5-4 microns.

On living leaves of an undetermined host, probably a member of the Rubiaceae in Porto Rico: Maricao, 754 (type.)

VI.—MYCOSPHAERELLA PERSIAE sp. nov.

Spots amphigenous, on upper side of leaf covered by a cinereous, papery membrane, without a limiting border, on the lower side brown, bordered by a narrow line of darker brown, very irregular, both in size and outline, a single spot often covering several square centimeters of the leaf surface; the thin membrane finally flaking off and leaving a spot on the upper surface which closely resembles the one on the lower side. Perithecia epiphyllous, somewhat flattened, black, scattered, rather numerous, 70x80-100 microns, ostiolate. Ostiole very slightly raised, 15-25 microns in diameter. No paraphyses. Asci oblanciolate or narrowly clavate, 45-55x 7-9 microns. Spores hyaline, uniseptate, cylindrical, scarcely constricted at the middle, mono or subdistichous, slightly pointed at the ends, 12-13x3-4 microns.

On living leaves of *Persea americana,* Mill., in Porto Rico: Maricao, 753, 4486 (type); 4809; Rio Piedras, 2176; 2501; San German, 5797; Dos Bocas below Utuado, 6601.

This species differs from *Mycosphaerella exutans* on *Persea carolinensis* which has minute spots with unequally uniseptate spores.

VII.—MYCOSPHAERELLA PALMAE sp. nov.

Spots amphigenous, from small and oval to quite long and narrow, with the long axis parallel to that of the leaf, light-brown, surrounded by a narrow, dark-brown line. Perithecia amphigenous, small, dark, immersed often closely aggregated, 80-90 microns in diameter, ostiolate. No paraphyses. Asci oblong or broadly clavate, straight, 45-50x17 microns. Spores hyaline, uniseptate, not constricted, fusoid, straight or curved, usually curved, pointed at both ends, 30-35x4-5 microns.

On leaves of palms in Porto Rico; Guanica, 2107 (type).

VIII.—MYCOSPHAERELLA CHRYSOBALANI sp. nov.

Spots amphigenous, irregular, both in size and outline, usually becoming confluent so as to cover a large part of the upper leaf surface; on upper side covered by a white, cinereous membrane, which makes the spots very conspicuous. Perithecia epiphyllous, numerous, black, erumpent, scattered, 100 microns in diameter, ostiolate. No paraphyses. Asci ovate or oblong, 40-50x15 microns. Spores inordinate, hyaline, uniseptate in the middle, not constricted, fusoid, somewhat pointed at ends, straight or curved, 24x3.5 microns.

On leaves of *Chysobalanus icaco*, in Porto Rico; Rio Piedras, 5699 (type).

IX.—MYCOSPHAERELLA ANTHURII sp. nov.

Spots very large, sometimes 10 centimeters in diameter, amphigenous, somewhat irregular in outline, dry and becoming practically transparent, thickly studded with black perithecia, bounded by a narrow, dark-brown line, portions falling out and leaving merely a network of veins. Perithecia epiphyllous, subepidermal, very numerous, scattered over the entire spot, dark, ostiolate, 100-150 microns in diameter. Asci ovate, oblong, or broadly clavate, 45x15-18 microns. Spores ovoid or oval, light-green, septum usually indistinct, guttulate, inordinate, 15-20x6 microns.

On leaves of *Anthurium acaule* (Jacq.) Schott Melet., in Porto Rico: Aguas Buenas 299; Monte Aleguillo, 1420; Yabucoa, 2184 (type); Trujillo Alto, 2407; Rosario, 3788; Catario, 4150; Bayamon, 4162; Cabo Rojo, 6456; Tanama River, 7850; Dos Bocas, 8095.

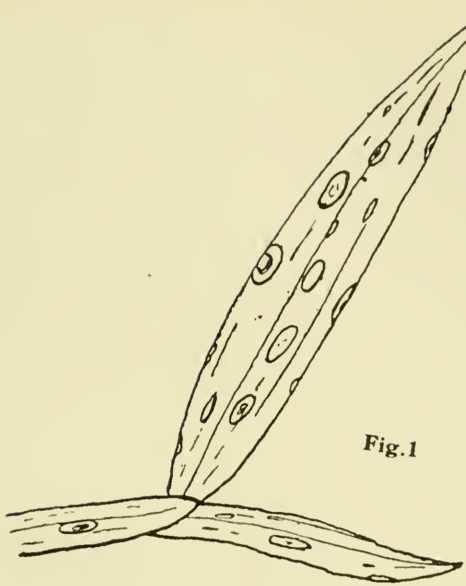


Fig. 1

X.—HELMINTHOSPORIUM MAYAGUEZENSE sp. nov.

Spots amphigenous, distinct, conspicuous, very light-brown, cinereous toward the center, surrounded by a narrow, dark-brown line. Spots oval in outline, varying in size from quite small to a centimeter in length, approximately one-half as wide as long. Conidiophores large, numerous, single or very rarely in pairs, unbranched, hollow, straight or slightly curved, rising usually from a point where two or more mycelial hyphae come together, as a rule, through a stoma, often constricted at the point of passage through the epidermis, expanding into a more or less pronounced swelling immediately above it, dark-brown in color, 300-500x18-22 microns. Mycelium composed of short irregularly shaped cells, branching quite frequently, intercellular, light-yellow in color. Spores fusiform or clavate, 3-4-septate, dilute-brown, borne singly, short-pedicillate, thin-walled, collapsing readily, 135-155x35-45 microns at the broadest point.

On culms and leaves of *Paspalum conjugatum*, Bergius, in Porto Rico, Mayaguez, 970; 1066; 7124 (type); 8232, 8279; 8941; Dos Bocas, 1093; San German, 5803; Añasco, 4904; Maricao, 8776.

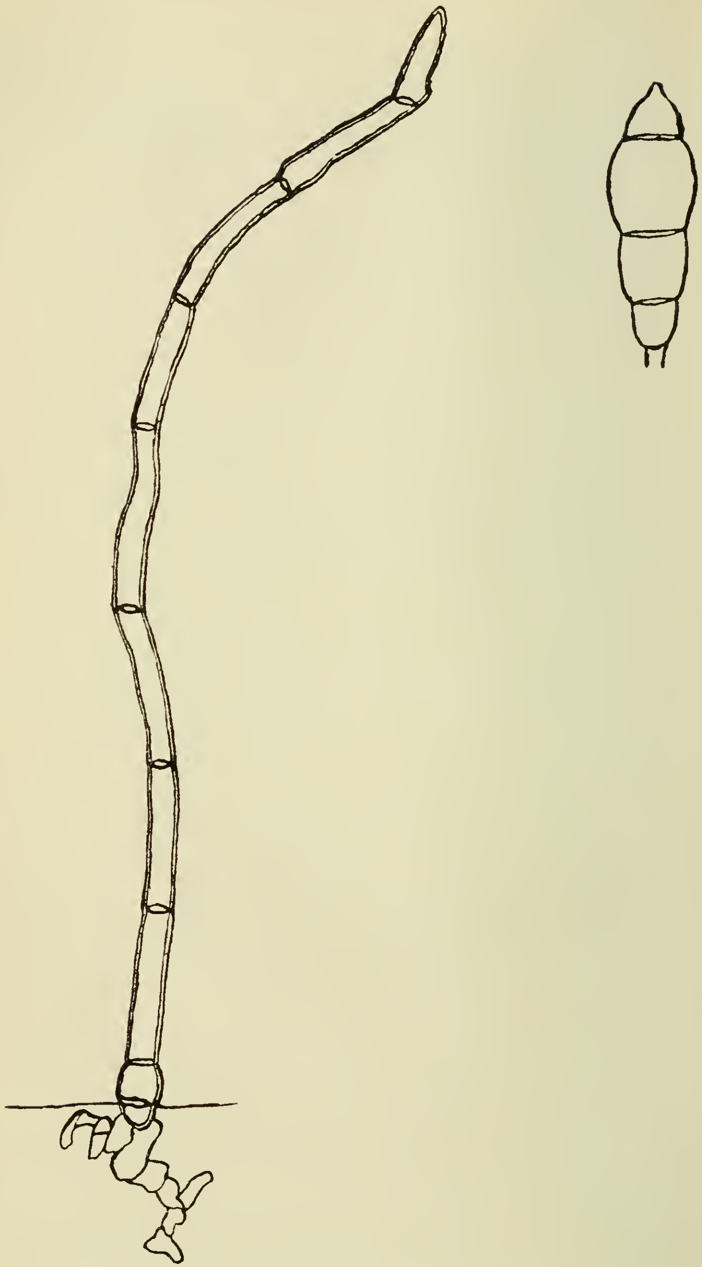


Fig. 2

XI.—CERCOSPORA CARBONACEA sp. nov.

Spots amphigenous, very conspicuous on upper side of leaf, burned or charred in appearance, usually angular, limited by veins or veinlets, somewhat elevated, becoming one or one and one-half centimeters in diameter; on the lower side of leaf, brown, becoming darker with age. Conidiophores fasciculate, 10-20 in a cluster, arising from a stoma, erect, 1-2-septate, dark, simple, unbranched, smooth or somewhat geniculate toward the apex, 50-80x4-5 microns. Conidia single, cylindrical always curved near one end, cane-shaped, 4-8-septate, slightly narrower at the straight end, very dilutely colored, 70-100x6 microns. (Fig. III.)

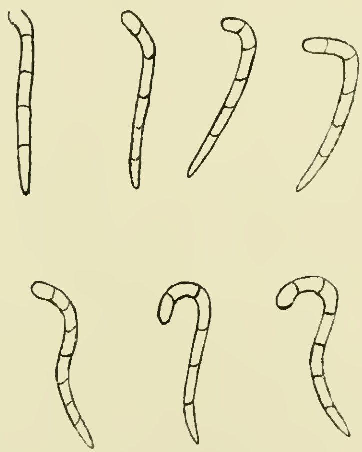


Fig. 3

On living leaves of *Dioscorea alata*, L. in Porto Rico: Vega Alta, 4178; (type); Vega Baja, 4234; Cabo Rojo, 6469; Añasco, 3563; St. Ana. 6687.

EXPLANATION OF FIGURES

Fig. I—Helminthosporium leaf-spot on *Paspalum conjugatum*.

Fig. II—*Helminthosporium mayaguezense;* (a) conidiophore; (b) spore.

Fig. III—Spores of *Cercospora carbonacea*.

NOTES ON CEPHALEUROS VIRESCENS

RUTH HIGLEY, UNIVERSITY OF ILLINOIS

Cephaleuros virescens, an alga belonging to the family, Chrolepideae, is rare as a parasite, occurring only in a few rather restricted regions. It has hitherto been recorded on very small number of hosts, and the literature on the subject is very scant. The more important papers dealing with the genus Cephaleuros, are those by D. D. Cunningham[1], H. Marshall Ward[2], and N. Thomas[3]. The last paper deals with specimens of the alga on plants in Ceylon, The Barbados, and the Dutch East Indies, where it causes much damage, on account of its weakening effect on young tea plants.

In view of the meager data available in regard to a form of economic importance it seems wise to list and briefly describe material found on the Porto Rican collection made by Prof. F. L. Stevens during the summer of 1915. This collection was described by Miss Esther Young[4]. A specimen of the alga in question, growing on Psidium, was determined by Dr. W. G. Farlow[5], and his letter, giving a brief discussion of the species, is quoted in full below. The other determinations were made by me. The Cephaleuros appears on some ten different hosts, superficial characters making it possible to divide the form into four distinct groups. It is with these gross details that this paper is concerned.

In group one, the alga is hypophyllous, forming a spot 8-10 mm. in diameter. The fruiting stalks are large and very green even when dry, are more or less diffuse, but occur only in the central portion of the spot. The outside uncovered zone is dark, a little discolored, and shows through to the upper side as a dull brownish-green. There are not more than three or four spots on a single leaf. To this group belong specimens on *Lomidesia lindiniana* Berg., 8380, Jajome Alto, and *Cupania americana.* L., 9144.

In group two, the fruiting spots are epiphyllous, 1-6 mm. in diameter, and very numerous. They are solid, very compact with definite margins, greenish-gray in color, and appear as a dark spot on the under side of the leaf. This is the condition on *Miconia laevigata* (L) P. 7373, Mayaguez.

In group three, the spots of alga are epiphyllous, 4-8 mm. in diameter, the brownish-green color. They are compact with regular margins and have a feathery appearance due to the very long fruiting stalks. There are from one to ten spots on nearly every one of the three hundred leaves in the collection. To this group belongs specimens on *Ocotea leucoxylon* (Sw.) 7393, Mayaguez, *Inga laurania* (Sw.), Willd., 7023, Jajome Alto and *Coccolobis diversifolia* 8877, Maricao.

Group four shows the alga forming spots which are epiphyllous, averaging 4 mm. in diameter, and very scattered. These spots are flat and smooth with very few fruiting stalks. They are light in color, and are more or less regular in outline. Of this type are specimens on *Acrodilidium salicifolium,* 7360 Hormigueros, *Nectandra patens,* (Sw.) Griseb. 1750, *Jambosa vulgaris* P. 8743, Añasco, *Artocarpus incisa* L., 7196. To this group also belongs the alga on *Sergania* 2242, Cabo Rajo, except that the spots in this case are only 1-2 mm. in diameter and are very irregular in outline.

In general it may be said that the algal spots are composed almost entirely of fruiting stalks. The differences in the resisting power of the several hosts are the causes of the variations in luxuriance and gross details.

1. D. D. Cunningham, Trans. Linn. Soc., 2nd. ser., Bot., 1: 301-318, 1879.

2. H. Marshall Ward, Trans. Linn., Soc., 2nd. ser., Bot., 11: 87-115, 1883.

3. N. Thomas, Ann. Bot., 27: 781-793, 1913.

4. Esther Young, Myc., 7:143-150, 1915.

5. Dr. W. G. Farlow, Copy of letter under date May 14, 1916. "The growth which you send on guava is a Cephaleuros, a genus of alga which is often associated with lichens of the genus Strigula. Your material is the pure algal form without admixture of lichen hyphae. It seems to be the same as the *Cephaleuros mycoidea* G. Karsten, on guava leaves distributed in Wittroch & Nordstedt's Algae Aquae Dulcis, No. 413, from Jamaica. I have also the same species from Jamaica, from another source. Although the specimens in Wittroch & Nordstedt were named by W. Schmidle, he stated in Hedwigia XXXVII, 62, 1819, that he considered it uncertain whether the form on guava really belonged to *C. mycoidea,* but at the same time did not refer it to any other species.

"The *C. mycoidea* Karsten, is the same as *Mycoidea parasitica* D. Cunningham, which is considered by Marshall Ward and Harriot to be identical with the older *Cephaleuros virescens* Kunze. The Jamaica alga on guava may be kept under the latter name for the time being. The species of Cephaleuros which have been described, although not numerous, are by no means clearly defined and the Jamaica alga corresponds better with the forms of *C. virescens* than with any other species. How far the base of *C. virescens* may be changed by the substratum is not at present sufficiently known. In this connection may be mentioned No. 47 of C. L. Smith's Central American Fungi which was issued under the name of *Caemansiella nicaraguensis,* Ell. & Ever., which is not a fungus, but a species of Cephaleuros. In the second century of the above named work, a new label for No. 47, was issued with the name changed to *Cephaleuros virescens.* It seems to me that it should be referred rather to *C. candelabrum* Lageih. & Schm., which was later (Allg. Bot. Zeit. V 3, 1899) made by Schmidle the type of a new genus, *Phylloplax.* Possibly further study might show the form on guava, so far as its basal portion is concerned, is the structure of Phylloplax, but present available material is not in condition to determine that point. The sporangia of the guava form, Normener, are more like those of *C. virescens* than those of ***Phylloplax candelabrum,*** and lack the verticillate arrangement which seems to be characteristic of the latter when well developed." (Signed by W. G. Farlow.)

Papers on Geology

THE THEBES SANDSTONE AND ORCHARD CREEK SHALE AND THEIR FAUNAS IN ILLINOIS

T. E. Savage, University of Illinois

The Thebes sandstone was named by Worthen[1] in 1866 from the town of Thebes, in Alexander County, Illinois, near which the formation is well exposed. This sandstone is known in Illinois over only a relatively narrow area bordering Mississippi River in the southwest part of the State. West of this the strata extend into adjacent portions of Missouri, and outcrop in several places in the vicinity of Cape Girardeau. The total thickness of the formation in this region is about 75 feet.

The basal portion of the Thebes sandstone is exposed along a small stream in the south part of the town of Thebes, where it rests unconformably upon the Fernvale (early Richmond) limestone. This lower sandstone is here fine grained, yellowish brown, and micaceous, with a thickness of 6 or 8 feet, and grades upward into a coarser grained, bluish sandstone with few fossils.

The following species of fossils are common in the fine grained basal phase of the Thebes sandstone:

Climacograptus putillus Hall.

Lingula ovoides n. sp.

Conularia ornata n. sp.

Isotelus brevicaudatus n sp.

Endymionia bellatula, n. sp.

The lower horizon of the Thebes sandstones containing *Endymionia bellatula* is exposed again farther north in the south bank of Madison Creek, in the S. E. quarter section 8, T. 11, S. R. 2 W., in Calhoun County. The sandstone here is yellow to buff, and thin bedded. It rests unconformably upon the Kimmswick limestone, and passes upward into a bed of sandy shale.

Still farther north, in Pike county, Missouri, a sandstone that corresponds to the basal portion of the Thebes formation is exposed along a stream one-half mile west of Dover Church.

1. Worthen, A. H., Geol. Survey of Illinois, Vol. I, p. 139, 1866.

This sandstone is bluish gray, and also contains numerous more or less complete tests of *Endymionia bellatula.* This species of *Endymionia* is not known to occur at any other horizon and hence furnishes a reliable guide to the basal portion of the Thebes sandstone.

The middle part of the Thebes sandstone formation can be studied in good outcrops in the bank of Mississippi River a short distance north of the railroad bridge in the town of Thebes, and also in the bank of the river about three miles north of the latter place. Corresponding strata are also well exposed in the railroad cut a short distance east of Thebes, and along the Chicago and Eastern Illinois railroad within a distance of one mile both north and south of the village of Gale, in Alexander County. At the above mentioned localities the sandstone is bluish where unweathered, and is coarser grained and thicker bedded than the material in the basal part of the Thebes formation. The fossils *Climacograptus putillus* and *Lingula ovoides* are present throughout this formation.

The upper part of the Thebes standstone outcrops in the east bank of Mississippi River, and in a cut along the Chicago and Eastern Illinois railroad one-half mile south of Gale, where the contact of this sandstone with the overlying Orchard Creek shale is well exposed. The material in the upper part of the Thebes formation is bluish, rather coarse grained, and occurs in layers 4 to 10 inches thick. The fossils are similar to those present in the middle part of the sandstone.

AGE OF THE THEBES SANDSTONE

Although the Thebes sandstone in this region contains none of the species of fossils characteristic of the normal Richmond or Maquoketa strata, the stratigraphic position of the formation lying above the Fernvale (early Richmond) limestone as it does at Thebes, Illinois, and Cape Girardeau, Missouri, and below the Orchard Creek (early Silurian) shale, as south of Gale, fixes its age as somewhere in the Richmond stage. It cannot be very early Richmond inasmuch as the Thebes sandstone not only overlies the Fernvale (early Richmond) limestone, but is separated from this limestone by a sedimentary break of considerable length. Judging from the numerous, widely separated areas in which the Fernvale limestone is known, and where it is only a few feet in thickness, it seems probable that a period of general peneplanation in this region intervened between the deposition of the latest of the Fernvale limestone and the earliest of the Thebes sandstone. The latter formation could thus not be older than about middle Richmond, and possibly is late Richmond in age.

The unconformable relations of the Thebes sandstone with the underlying Fernvale limestone or older rocks in this region indicates that the remarkable succession of oscillatory movements of advance and retreat of the sea that occurred in the lower Mississippi embayment during the Alexandrian epoch of the Silurian period began here during the early part of Richmond time.

THE ORCHARD CREEK SHALE

The Orchard Creek shale occupies the distinguished position of being the oldest fossiliferous marine formation of Silurian age known in the United States. It is even more restricted in its distribution than the Thebes sandstone, being known in Illinois in only a few places in Alexander county in a distance of 4 or 5 miles north and south of Thebes. The formation was named from Orchard Creek which joins the river south of Thebes in Alexander county, near the mouth of which stream this shale is exposed in the bank of Mississippi River.

The best known exposures of shale of this formation is along the Chicago and Eastern Illinois railroad about one-half mile south of Gale, and in the river bank near this place. The strata consist of bands of blue or bluish-gray calcareous shale, 4 to 6 inches thick, alternating with layers of impure, argillaceous limestone which in the lower and middle parts are 2 to 4 inches thick. The calcareous layers become thicker and closer together in the upper part where the bed grades upward without any distinguishable sedimentary break into the overlying Girardeau limestone. The total known thickness of the formation is about 22 feet.

The calcareous layers of this formation furnished the following species of fossils:

Fossils from the Orchard Creek Shale:

Strophostylus ornatus n. sp.

Cyclocystoides ornatus n. sp.

Prasopora sp.

Chasmatopora granistriata (Ulrich).

Plectambonites aff. sericeus (Sowerby).

Rafinesquina near alternata (Emmons).

*Rafinesquina mesicosta (Shumard).

*Leptaena rhomboidalis (Wilckens).

Strophomena aff. planumbona (Hall.)

*Protozeuga sulcocarinata Savage.

*Homoeospira immatura Savage.

Dalmanella meeki (Miller).

*Dalmanella modesta Savage.

*Rhynchotrema (?) illinoisensis Savage.

Pterinea thebesensis Meek and Worthen.

Pterinea oblonga n. sp.

Cf. Byssonychia tenuistriata Ulrich.

Lyrodesma sp.

*Phragmolites imbricatus (Meek and Worthen).

Strophostylus ornatus n. sp.

*Cornulites incurvus (Shumard).

*Cornulites tenuistriatus (Meek and Worthen).

Isotelus convexus n. sp.

*Acidaspis halli Shumard.

*Calymene dubia Savage.

*Cyphaspis girardeauensis Shumard.

*Encrinurus deltoideus Shumard.

Ceratopsis robusta, Ulrich.

In the foregoing list of fossils, those species that continue upward into the overlying Girardeau limestone are indicated by a star in front of the name.

In a former paper the Orchard Creek shale was recognized as closely allied to the Girardeau limestone, but on account of the presence in this fauna of certain species with strong Richmond aspect, the formation was provisionally referred to late Richmond time. More recent study of the fauna of the Girardeau limestone[1] and of the Orchard Creek shale, has convinced the writer that the affinities of the Orchard Creek shale fauna are much closer with the Girardeau limestone fauna than with that of any Richmond. The large proportion of species occurring in both formations may be seen in the above list of fossils. The significance of the similarity of the fauna of the Orchard Creek shale to that of the Girardeau limestone is also much more important than the persistence of a few Richmond species in the Orchard Creek beds. Hence the Orchard Creek shale is now considered as representing the initial deposits in the early Silurian sea that advanced northward in this area from the Gulf of Mexico region.

Description of New Species of Fossils from the Thebes Sandstone and Orchard Creek Shale in Illinois

ECHINODERMATA

Cystoidea

Cyclocystoides ornatus n. sp.

Plate II, Fig. 1.

Description: In some respects this species resembles *Cyclocystoides illinoisensis* described by Miller and Gurley from the Girardeau limestone, but it may be distinguished from that species in having only 20 plates in the submarginal ring (Miller and Gurley assume that *C. illinoisensis* would have from 24 to 30 plates), and the upper and outer side of each of these plates is marked by 4 transverse grooves while in *C. illinoisensis* there is no indication of such markings.

In the species here described the submarginal ring is subcircular to subovate in outline, two specimens measured 22 mm. in the greater diameter and 19 mm. in the smaller, while a

1. Savage, T. E., Ill. State Geol. Surv. Bull. No. 23.

smaller individual was 16 mm. in larger diameter and 14 in the smaller. In the 4 good specimens at hand the submarginal ring is made up of 20 plates which are nearly equal in size, and much longer than wide. The upper and outer surface of the more elevated portion of each of these plates is grooved by 4 main transverse furrows which divide this part of the surface of each plate into 5 subequal transverse ridges. Besides these stronger transverse ridges and furrows, the surface of the plates is granulose when unworn. The spoon shaped excavations in the outer part of the submarginal plates, described by Raymond, are not well exposed, being covered by a series of small curved plates lying outside the more elevated portion of the submarginal plates of which in some places more than two are contiguous to a single one of the latter.

The disk within the submarginal ring is covered with small, convex, granulose plates of irregular shape, except in one place where the disk may be broken. In one of the specimens a narrow ridge extends from between adjacent submarginal plates for a short distance towards the center, but these are not thought to belong to the normal structure of the disk.

This species is rather common in the Orchard Creek shale, both north and south of Thebes, Illinois.

MOLLUSCOIDEA

Brachiopoda

Lingula ovoides n. sp.

Plate I, Fig 9.

Description: Shell subovate in outline; the lateral margins gently convex in the central portion, antero-lateral margins regularly convex, anterior margin broadly rounded, postero-lateral margins nearly straight, diverging at an angle of about 78 degrees.

Ventral valve moderately convex, the greatest convexity in a transverse direction, highest posterior to the middle from which the surface slopes rather regularly to the margins, but is less convex over the anterior portion; beak rather gradually tapering to the subacute apex. Surface marked by rather broad, low, concentric lines of growth which in places appear slightly lamellose.

Dorsal valve about equal in convexity to the ventral, the posterior margin more obtuse and the posterior lateral margins more convex than those of the ventral valve; a rather prominent internal median ridge is indicated by a depression in the surface of the impression of the interior extending from near the apex anteriorly to near the mid-length of the valve. Surface marked by concentric lines similar in character to those on the ventral valve.

The dimensions of the type specimen are: length 14 mm., width 8 mm., thickness about 2 mm. Shells of this species are sparingly present throughout the Thebes sandstone in Illinois.

In size and general appearance this species resembles *Lingula covingtonensis* from the Trenton limestone, but may be distinguished from that form by the less acuminate posterior portion, the narrower width of the shell in proportion to its length, and the more flattened character of the concentric ridges.

Hebertella lineolata n. sp

Plate I, Figs. 1 and 2.

Description: Shell subquadrate in outline, wider than long, the hinge line equaling, or a little shorter than the greatest width, the cardinal extremities obtusely angular to subrectangular.

Ventral valve moderately convex, the greatest depth near the middle on each side of the sinus, the surface sloping rather steeply from the beak and borders of the sinus to the front and lateral margins, but becoming gently convex towards the cardinal extremities; beak moderately prominent, arched; cardinal area of moderate width, gently concave, mesial sinus beginning in the umbonal region, and becoming wider and deeper to the front where it is somewhat produced, the bottom of the sinus flat or gently concave.

Dorsal valve strongly convex, the greatest depth in front of the umbonal region, the medial portion elevated into a flattened mesial fold which begins near the beak and becomes broader and increasingly prominent to the front where the valve is emarginate; bordering each side of the fold in the anterior portion of the shell the surface is flattened or slightly concave from which depression the curvature is rather steep to the lateral margins and from the umbonal region to the cardinal area, the slope in less abrupt over the cardino-lateral margins, beak moderately prominent, strongly incurved.

The surface of both valves on each side of the fold and sinus is marked by 5 to 7 low, bifurcating plications which are progressively weaker toward the cardinal extremities; the bottom and sides of the mesial sinus are occupied by 3 to 5 similar plications, and a prominent furrow extends along the medial portion of the fold. Besides these stronger radiating markings, the surface of the plications and intervening depressions over the entire valves is ornamented by fine radiating lines; a few concentric lines of growth are often prominent near the anterior and lateral margins of the valves. The dimensions of the type specimens are: length 32 mm., width 39 mm., thickness 18 mm.

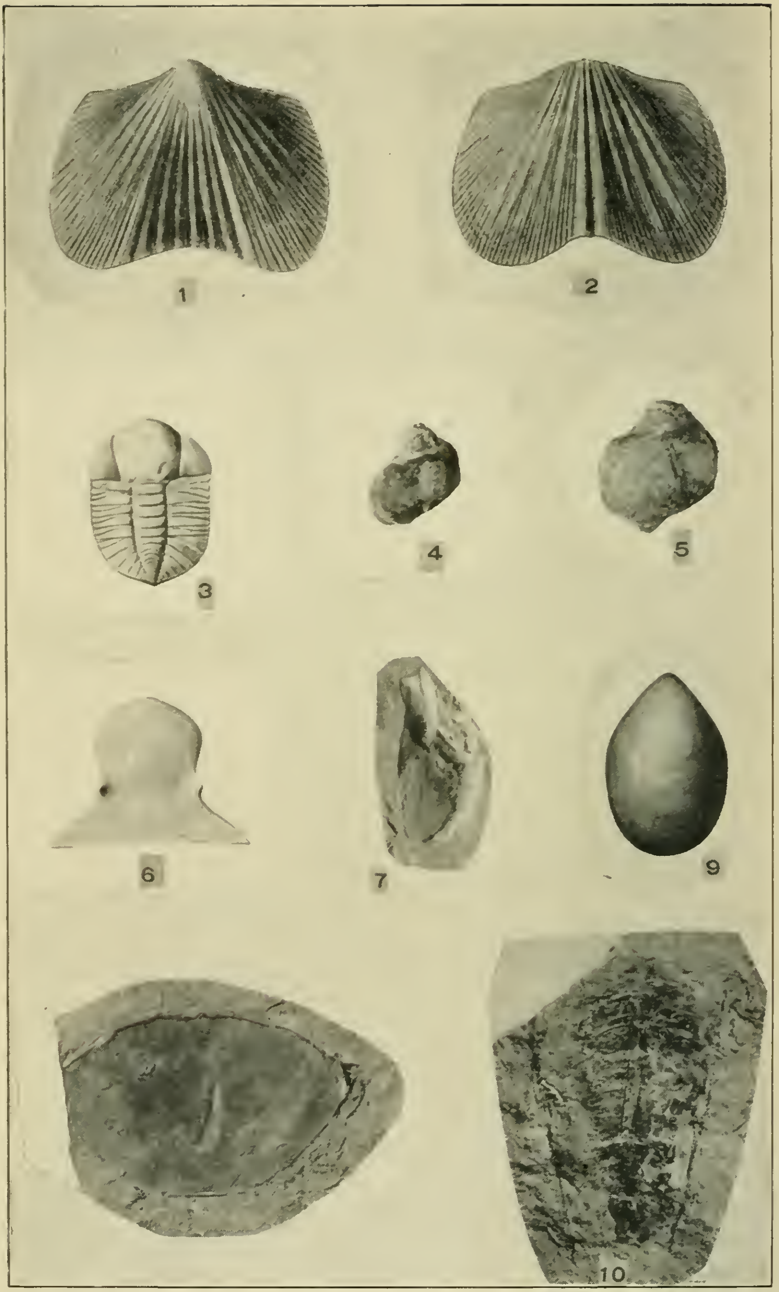
This species may be easily distinguished by its large size, the well defined fold and sinus extending nearly to the beaks, and the fine radiating striae that cover the coarser radiating markings. Shells of this species occur in the Fernvale limestone near Thebes, Illinois, and at Cape Girardeau, Missouri.

Pelecypoda

Pterinea oblonga n. sp.

Plate II, Fig. 2.

Description: In size and general outline this species more nearly resembles *Pterinea demissa* Conrad of the Richmond and Mayville beds than any other known species of the genus. It differs from Conrad's species in the longer and less obtuse anterior auriculation, and in the much shorter and less acute extension at the posterior extremity of the hinge line. Our shell is semielliptical in outline, exclusive of the auriculations; the right valve is oblique, longer than high, the greatest length along the hinge line, moderately convex over the umbonal region, antero-lateral and postero-lateral regions flat or nearly so, ventral half of the valve flat or slightly concave. Beak situated about one-fourth of the length of the cardinal margin from the anterior extremity. The anterior auriculation is slightly larger than the posterior one, depressed or flat, not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sharply defined from the body of the shell, the anterior margin meets the hinge line at an angle of about 50 degrees; is slightly sinuate below the auriculation below which it curves with gentle convexity to the broadly rounded ventral margin; posterior auriculation nearly flat, not sharply defined, the posterior margin forming an angle of about 45 degrees with the hinge line, below the auriculation the posterior border is nearly straight to near the lower part, where it blends with a broad curve into the ventral margin. Entire surface marked by numerous rather fine concentric lines of growth which are most conspicuous over the auriculations. A few indistinct radiating lines may also be present.

The dimensions of the type are: length along the hinge line 45 mm., greatest length below the auriculations, 37.5 mm., height 37.5 mm., convexity of right valve, 3 mm.

Shells of this species are rather rare in the Orchard Creek shale south of Thebes, Illinois.

Gastropoda

Strophostylus ornatus n. sp.

Plate I, Figs. 4 and 5

1913 cf. Cyclomema cancellata Hall, Ill., State Geol. Survey, Extract Bulletin No. 23, p. 55, pl. 4, fig. 4.

Description: Shells resembling those of *S. cancellatus* Hall, to which species they were referred in a former report. However, the species here described may be distinguished from *S. cancellatus* by the more shallow suture, and the marked difference in surface ornamentation; in our species the revolving lines are much more numerous, and continue in full strength up to the suture, and into the umbilicus. The shell is turbinate, height and width about equal, volutions about 4; apex small, upper volutions increasing rather rapidly in size to the body whorl which enlarges more rapidly forming from two-thirds to three-fourths of the height of the shell; the whorls are subovate in cross section, umbilicus shallow, inner lip slightly reflexed, outer lip not expanded, sutures not deeply impressed.

The height of different shells varies from 19 to 22 mm. and the width from 16.5 to 22 mm. The entire surface is ornamented with elevated revolving lines which are alternating in size, a weaker line occurring between two adjacent stronger ones. About ten of these lines occur in a space of 2 mm. The revolving lines do not become weaker near the suture, nor do they become obsolescent in the umbilicus; the raised lines are separated by depressed interspaces about equal in width to the lines. Numerous fine transverse lines and occasional coarser lines of growth cross the revolving ridges and furrows in a direction obliquely backward from the suture, and give to the surface a finely cancellated appearance.

Shells of this species are common in the Orchard Creek shale both north and south of Thebes. They occur also, though less abundantly, in the overlying Girardeau limestone in the same region.

CONULARIDA

Conularia delicatula, n. sp.

Plate I, Fig. 10

Description: Shell moderately large, pyramidal in form, quadrangular in transverse section, the sides gradually diverging from the apex to the aperture. The sides of the shell seem to have been somewhat convex and the angles apparently furrowed. The surface on each side is marked by a series of fine, close, transverse lines of which there are about 20 in a distance of 1 mm. These are directed slightly upward toward the aperture as they approach the angles.

Besides the numerous fine transverse raised lines and furrows, and occasional stronger transverse ridges or wrinkles, the fine transverse furrows are set at close intervals by minute tubercles or interruptions in the depressions, which under a lens are in places seen to be arranged in vertical rows in such a way as to resemble very fine longitudinal striae, and give to the entire surface an extremely delicately ornamented appearance.

This species occurs sparingly in the lower part of the Thebes sandstone in the vicinity of Thebes, Illinois. It is readily distinguished from other late Ordovician species of this genus by the very delicate character of its surface ornamentation.

ARTHROPODA

Trilobita

Isotelus brevicaudatus n. sp.

Plate I, Fig. 6, 7 and 8

Description: Cephalon transversely semi-elliptical in outline, length along the median line about 22 mm. which is a little less than half the width, genal angles rounded; occipital groove well defined. Glabella not distinctly defined, moderately convex in the median portion, slightly angular at its anterior extremity, width between the eyes slightly more than 12.5 mm., or a little more than half the greatest length of cephalon; eyes situated at or slightly posterior to the mid length of the glabella. Greatest width of glabella anterior to the eyes 23.5 mm. The facial sutures anterior to the eyes curve outward rather strongly to near the margin whence they continue around the anterior portion of the cephalon. Posterior to the eyes the facial sutures are directed backward and outward, cutting the posterior border of the cephalon more than half the distance between the points directly behind the inner margins of the eyes and the genal angles. Free cheeks about 9 mm. broad at the widest part, nearly twice as long as wide, the widest part opposite the posterior border of the eyes, the outer margin gently curved or nearly straight, and the genal angles rounded. Thorax not known.

Pygidium transversely subelliptical, a little longer than the cephalon, length 26.5 mm., width a little less than twice the length, ratio of length to width as 7 to 11; axis poorly defined, not extending to the posterior extremity, no segments visible on the axis or on the pleura, anterior border convex, antero-lateral margin rounded, posterior border broadly rounded. Marginal border slightly exfoliated, 6 mm. wide, and marked by fine lines sub-parallel with the lateral margins.

Fragments of the test of this species are very numerous in a narrow zone in the basal part of the Thebes sandstone where they are associated with *Endymionia bellatula*.

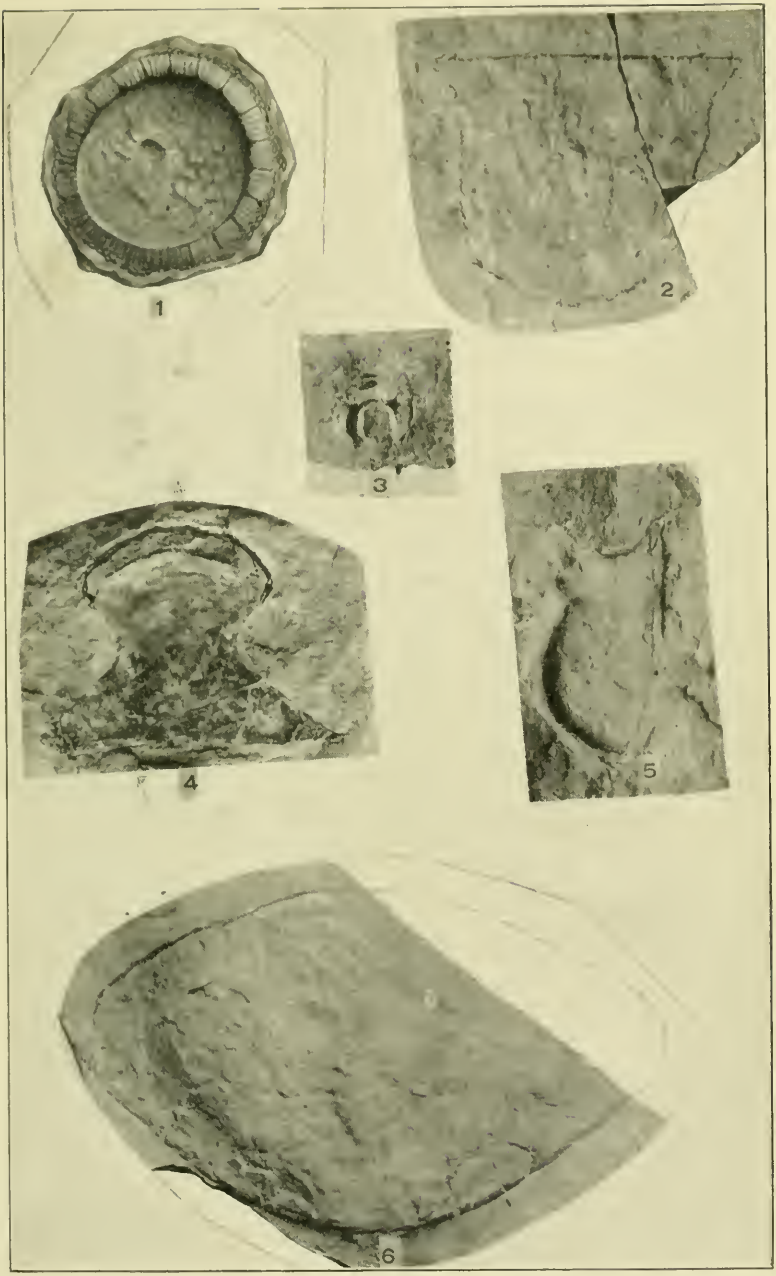
The species above described somewhat resembles *Isotelus susae* Whitefield in general outline of cephalon and pygidium, but differs from that form in the much greater constriction of the glabella between the eyes which are situated much farther anteriorly than in Whitfield's species. These characters give to the cephalon of the two species quite a different appearance. From *Isotelus longaevus* of the Edgewood formation this species is distinguished by its much larger size, by the greater length of cephalon in proportion to the width, and by the narrower and relatively smaller free cheeks.

Isotelus convexa n. sp.

Plate II, Figs. 3, 4, 5 and 6

Description: This species is closely allied to *Isotelus brevicaudatus,* described on a former page from the Thebes sandstone in Illinois. It differs from that form in having the lateral margins of the expansion of the glabella anterior to the eyes more angular; in the shorter, more elevated and more rounded palpebral lobes, and in the relatively greater width and convexity of the free cheeks, and in the greater convexity of the cephalon and pygidium.

The cephalon is smooth, semi-elliptical in transverse direction, gently convex, about 31 mm. long on the median line, which is about one-half the width. The eyes are situated more than one-third of the distance to the front from the posterior border; genal angles rounded. Glabella not defined by distinct axial furrows, moderately convex in the median portion and anterior to the eyes; width at the constriction between the eyes 18 mm. which is slightly less than one-half the length of the glabella, and three-fifths of its greatest width in front of the eyes. The facial sutures anterior to the eyes curve rather abruptly outward to near the margin of the cephalon whence they continue forward near the anterior margin. Posterior to the eyes the sutures trend obliquely backward and outward to the posterior border of the cephalon which they reach about 26 mm. from the median line. Free cheeks large, rather convex, about 15 mm. wide and 30 mm. long, behind the posterior margin of the eye; genal angles rounded, without spines; palpebral lobe subcircular, elevated, and prominent. Hypostome short, narrowest in front of the branches, with relatively short lobes. Thorax not seen.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Pygidium transversely sub-elliptical in outline, moderately convex, length 52 mm, width slightly less than twice the length, without apparent concave border, although when only partially exfoliated undulating lines sub-parallel with margin are present near the border. Axial lobe poorly defined, much the widest anteriorly, the posterior end usually more prominent than the other portions, without annulations. Fragments of the test this species are common in the Orchard Creek shale north of Thebes, Illinois.

Endymionia bellatula n. sp.

Plate I, Fig. 3.

Description: The species here described is so unlike any other known trilobite that a comparison with other forms is unnecessary. The genus was described by Billings to receive the only species previously known in North America (*Endymionia meeki* Billings), which was found in rocks of early Ordovician (Canadian) age in eastern Quebec.

In the species here described the entire test is sub-elliptical in outline, the ratio of length and width as 7 to 5; lateral margins nearly straight, anterior and posterior borders rounded.

Cranidium transversely semi-elliptical to broadly sub-triangular in outline, length slightly more than one-third the entire length of the test, anterior portion broadly rounded, Glabella convex, nearly as wide as long, reaching the anterior margin, widest in the anterior portion, bordered laterally by well defined dorsal furrows, without lateral furrows, occipital furrow not prominent. The greatest width of the glabella is equal to or slightly greater than one-half the width of the cephalon. Outside the dorsal furrows the cheeks are sub-triangular in outline, smooth, gently convex, the outer margin gently rounded, and genal angles rounded, without spines. The position of the eyes and of the facial suture cannot be distinguished.

Thorax a little shorter than the cephalon, less than half as long as wide, composed of 5 segments; axial lobe defined by distinct dorsal furrows, slightly narrower than the pleural lobes, the extremities of the segments truncated bluntly, pleural portions of the segments marked on the dorsal surface by an undulating furrow.

Pygidium depressed convex, broadly triangular in outline, with entire margin, length a little less than that of the thorax, antero-lateral portions sub-angular, lateral and posterior margins rounded. The axis but slightly more elevated than the lateral lobes, a little less than one-third the width of the pygidium anteriorly, narrowing gradually to the posterior extremity. Segments of axis 7 to 9, well defined except in the posterior portion, lateral lobes with 7 visible segments which arch backwards and reach the margin, without furrows, the proximal portion of the anterior segment concealed by the posterior thoracic segment. The surface of the test without visible tubercles or other ornamentation.

The length of an average specimen is 11.5 mm., width 8 mm., length of cephalon 5 mm., length of thorax 3.5 mm., length of pygidium 3 mm. Fragments of the test of this species are numerous in the fine grained sandstone near the base of the Thebes formation, near Thebes, where it is associated with *Isotelus brevicaudatus.* It also occurs along Madiison Creek in Calhoun County, Illinois and near Dover Church, in Pike County, Missouri.

EXPLANATION OF PLATE I.

Hebertella lineolata n. sp.

Fig. 1. View of ventral valve of type specimen.
Fig. 2. View of dorsal valve.
Natural size, Fernvale limestone.

Endymionia bellatula n. sp.

Fig. 3. Dorsal view of nearly complete test of type specimen. X 2. Thebes sandstone.

Strophostylus ornatus n. sp.

Fig. 4. View of nearly perfect specimen.
Fig. 5. Lateral view of a larger shell.
Natural size, Orchard Creek shale.

Isotelus convexa n. sp.

Fig. 6. Dorsal view of cranidium of type specimen lacking the free cheeks.
Fig. 7. A single free cheek of small individual.
Fig. 8. Dorsal view of pygidium of about average size. Natural size, Thebes sandstone.

Lingula ovoides n. sp.

Fig. 9. View of ventral valve of type specimen. X2, Thebes sandstone

Conularia ornata n. sp.

Fig. 10. Lateral view of an incomplete specimen, natural size, Thebes sandstone.

EXPLANATION OF PLATE II.

Cyclocystoides ornatus n. sp.

Fig. 1. View showing ring of submarginal plates of type specimen, X $1\frac{2}{3}$. Orchard Creek Shale.

Pterinea oblonga n. sp.

Fig. 2. View of right valve of type specimen, natural size, Orchard Creek shale.

Isotelus convexa n. sp.

Fig. 4. View of cranidium lacking free cheeks.
Fig. 5. Free cheek of a large individual.
Fig. 6. Dorsal view of pygidium.
Fig. 3. Hypostome thought to belong to this species. Natural size, Orchard Creek shale.

THE CLIMATIC HISTORY OF ALASKA FROM A NEW VIEWPOINT

Eliot Blackwelder, University of Illinois

In the earlier days of geologic study, inferences regarding the climates of bygone periods were drawn chiefly from fossils. Palm leaves in Greenland and musk-ox bones in Kentucky gave their obvious testimony. Even in those days, however, the climatic significance of certain kinds of sediments was well recognized. But at first, it was only the peculiar and extreme sedimentary types, such as glacial till and beds of rock salt or gypsum, that were interpreted in this manner. Ordinary sandstones, shales and conglomerates were hardly suspected of containing a hidden record of ancient climates to which the key had not yet been found.

Within the last few years, however, we have come to understand that the formation of sedimentary rocks is controlled by several factors and that one of the most important—in many cases the dominant—factor is climate. As the influence of the climatic factor comes to be understood, we find ourselves able, with increasing confidence, to read from the sediments the climatic conditions under which they originated. In this respect we owe much to Professor Joseph Barrell of Yale.

At present the climatic significance of the continental sediments is much better understood than that of the marine deposits. There is however, good reason to hope that we may soon understand the latter as well as the others. The value of the sedimentary deposits to the student of ancient climates depends upon the fact that the climatic conditions either directly or indirectly control most of the physiographic processes, and particularly the highly important process of weathering. Thus, in very dry regions chemical decay cannot have much effect—because moisture is the medium upon which it depends. Such sediments as are produced, are, therefore, the products of abrasion and isolation rather than of chemical dissolution. On the other hand, in a hot moist climate under the dense vegetation which inevitably prevails, chemical decay becomes dominant and it normally results in ferruginous clays which have but little resemblance to the rocks from which they were derived. It is, of course, evident that climatic conditions also influence the immediate deposition of sediments, as well as their derivation through the process of weathering. Thus a sedimentary layer which is deposited under water and in contact with much decaying organic matter, will necessarily be kept in a reduced or unoxygenated condition, whereas if it comes to rest on an exposed dry surface where aerated waters circulate down through it, the materials are likely to become thoroughly oxidized.

These are merely illustrations of a series of such influences of climate on sediments. Of course, there is still a large amount of work to be done by way of putting this branch of the science of geology on a firm basis. We are still far short of the point where we shall be able to interpret the climatic conditions from every kind of sedimentary deposit.

Let us now apply this principle to the detrital formations of Alaska. Neglecting the obvious local variations, the sedimentary deposits of Alaska possess important characteristics in common, but as a group they are contrasted with the sediments of, say, Southern California or Brazil. In some of the present mountain valleys the glaciers are forming till. In others the products of frost action and of glacial or fluviatil abrasion are being swept down by the streams and deposited as gravel, sand, and silt. In all of these deposits the mineral particles are almost entirely undecayed, and hence still contain the original ferromagnesian silicates, feldspars, calcite, micas, etc. The iron is still largely in the ferrous state, and the alkalis and alkaline earths are still present in large quantities.

Furthermore, most of the surface of Alaska is covered either with forest or that thick mossy carpet, the "tundra." Swamps are abundant, and in many parts of Alaska the entire surface, even on considerable slopes, seems to be merely one vast saturated sponge of moss and lichens grading down into black muck. If buried without disturbance, this material, which decays but slowly, would doubtless produce coaly layers, but a large part of the muck is washed out by the streams and redistributed among the sands and silts, thus forming black or gray carbonaceous sediments full of shreds of wood and fiber. The saturated and, in large part frozen, condition of most Alaskan deposits effectually prevents that aeration which is requisite for the complete oxidation of the iron-bearing constituents. The red and brown colors, which such deposits often take on in other countries, are, therefore, seldom seen in Alaska.

In brief, the modern terrestrial sediments of the territory, are typically gray or black in color, are rich in unaltered complex silicate minerals and carbonaceous matter, and are associated locally with either coal or glacial till. They contain no red, and but little brown, material, no saline deposits, no aluminous clays, and probably not even pure quartz sands. The marine deposits are similar in many respects but differ in others. They are not yet so well known.

Looking back over the geologic column of the upper Yukon Valley, and passing over the Pleistocene sediments, which we should readily presume were made under a climate no milder than the present, we first come to the Kenai (upper Eocene) formation in which black and gray shales and graywackes alternate with occasional beds of coal, and contain fossil leaves of the poplar, birch, sequoia and oak. These all suggest a moist temperate climate.

The next oldest formation of the district is the Upper Cretaceous, which here consists of dark grey or black carbonaceous shales varying through silt-rocks to complex blackish graywacke and conglomerate. In the coarser beds of this formation many fresh silicate minerals are visible under the microscope, testifying to the absence of effective chemical decomposition, and to the abundance of slowly decaying vegetable matter at the place of their formation. The Lower Cretaceous rocks of the Upper Yukon are almost exactly like those just described, except that they are much thicker. In 15,000 feet of beds exposed in a single section no bed of any color except black and dark gray could be seen.

Passing over the Triassic oily shale and limestone, and the Permian white limestone-marine strata the climatic significance of which may be different, although as yet uncertain—we come to the National River formation of Pennsylvanian age. This consists of several thousand feet of blackish shale and silt rock alternating with dark muddy graywackes and graywacke conglomerate. The sandy layers contain abundant fresh particles of feldspar, slate and mica, and shreds of woody fiber —the appropriate product of a moist and cool or temperate climate.

The Mississippian formations, being marine, are somewhat less positively interpreted, but even in them the prevailing rock is black shale rich in carbonaceous matter, and it is significant that the many intercalated beds of black limestone are devoid of reef corals or other organisms that are confined to tropical waters.

The Devonian consists largely of black coaly shales, cherts, dark limestones and unweathered volcanic greenstones, all of which are consistent with the supposition of a moist temperate or cold climate. In certain beds, perhaps of Devonian age, the shales and cherts are associated with a bed of glacial tillite containing striated subangular boulders.

The Silurian consists in part of massive gray or white limestones and dolomites, and so probably constitutes an exception to the monotony of the black formations. The return seems to be made to the Alaskan type, however, in the Ordovician where basaltic breccias and tufas have remained to this day with scarcely a trace of chemical decay. Even the olivine crystals preserve clear, sharp outlines, and the feldspars show no clouding.

In rocks which are probably not younger than early Paleozoic, and may prove to be of Lower Cambrian age, other beds of glacial tillite have been found in two places in association with the typical black and gray slates, graywackes, and limestones. Even in rocks which are believed to be of pre-Cambrian age, similar types persist; for the dark schistose graywackes, slates and chlorite schists contain much undecayed feldspar and ferromagnesian constituents darkened with a fine graphitic dust.

In order to see how districts outside of those with which I was personally familiar compared in this respect, I examined the stratigraphic sections in the geological reports on seven districts well distributed over the territory. Out of some twenty-two different formations described, there were four which differ from the typical Alaskan group of sediments. These were white limestone, buff sandstone, gray limestone, and red and green cherts. All the other formations consisted of black or dark gray carbonaceous shales, dark colored arkoses, graywackes, graywacke conglomerates, undecayed pyroclastics, tillites, etc. If the examination had been continued to include all of the Alaskan districts which have been studied in some detail, the results would not have been very different. This seems to show clearly that there is not only a characteristic modern type of Alaskan sediments, but that in earlier periods, back even to the pre-Cambrian, this type predominated. Carbonaceous shales, silt-rocks, and graywackes are characteristic, instead of the purer sandstones and clay shales of eastern United States.

As a corollary, it is significant that throughout Alaska there is an absence or rarity of certain types of sedimentary rocks. Among these are the saline deposits characteristic of desert regions, the red bed facies now generally ascribed to the influence of hot climates with alternating seasons, as well as the pure white limestones, coral reef rocks, and oolites, which are today forming in tropical seas.

In short, the combined evidence strongly suggests that the cool, moist climate of modern Alaska—oscillating now and then toward the glacial Arctic condition on the one hand and toward the moist temperate on the other—has been persistent, with but few real interruptions, throughout the known geologic history of Alaska. If this proves to be a sound conclusion, it will have to be reckoned with by those who have suggested the wandering of the earth's axis through 90 degrees or more of latitude, and also by those who may still favor the hypothesis that the earth has been progressively cooling off ever since it was organized as a planet.

THE PHYSICAL HISTORY OF THE UPPER MISSISSIPPI VALLEY DURING THE LATE PALEOZOIC

ABSTRACT

Francis M. Van Tuyl, University of Illinois

The physical history of the region is traced briefly from the close of the Silurian to the end of the Paleozoic. The relative importance of the different uplifts and the duration of the intervals of erosion following each are evaluated from the structural and stratigraphic evidence. Minor uplifts are known to have occurred at the close of the Niagaran, and at the close of the Upper Devonian. During the latter stages of the Mississippian, on the other hand, there were a series of oscillations culminating in a widespread emergence accompanied by a deformation believed to approach in magnitude that which succeeded the deposition of the Pennsylvanian. The relative importance of the last two uplifts are discussed and their influence on the present distribution of the Paleozoic outcrops noted.

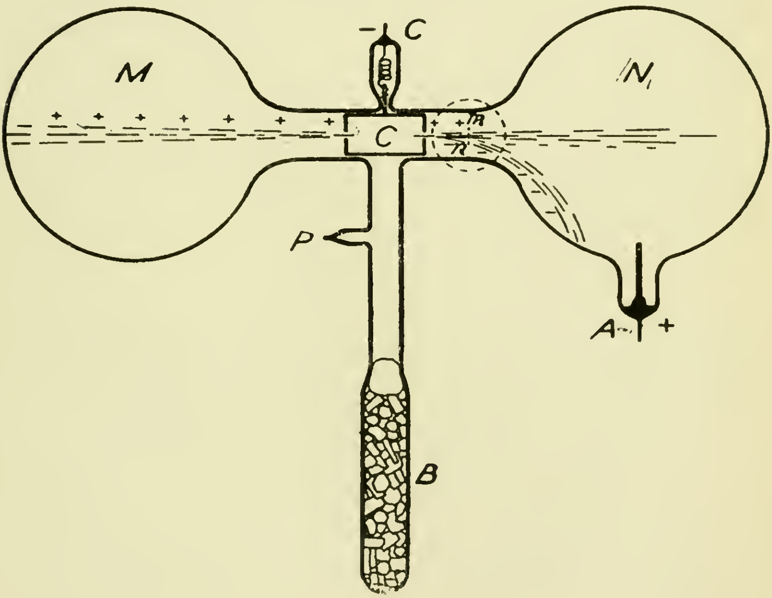
Papers on Physics

VISIBLE COLOR EFFECTS IN A POSITIVE RAY TUBE CONTAINING HELIUM

ABSTRACT

CHAS. T. KNIPP, UNIVERSITY OF ILLINOIS

In a recent number of Science[1] the writer described a positive ray tube, containing a hollow cathode, in which the distinguishing features are the color effects of the cathode and canal rays when the residual gas in the tube is either hydrogen, helium, argon or neon. For example, when the tube contains a trace of helium the cathode beam presents an apple green color, while in the same gas the canal ray beam is orange.



Recently the writer was able to show within the same tube by the visible color effect produced, the retrograde rays as well. The color of these rays borders on purple. By reference to the figure the relative position of the various beams is apparent. The cathode rays are bent out of the way by a magnetic field perpendicular to the plane of the paper and placed in the position of the dotted circle. This comparatively weak field has

1. Knipp, Science, 42, Dec. 31, 1915.

no deflecting effect on the heavy retrograde rays (ions negatively charged) streaming to the right in the bulb N, and of course none on the positively charged ions traveling to the left in M.

As pointed out, in the article referred to above, the positive rays have their origin at the edge of the Crookes dark space in front of the cathode, indicated by the broken line *mm.* To show the color of the retrograde rays to the best advantage the air must be all removed from the tube and the quantity of helium just right, also the bulbs should be of lead glass to avoid excessive fluorescence, and the cathode openings should not be too large.

These retrograde rays were overlooked for some time, though it was well known from their photographic effect that they were present in a tube of this construction. When the above conditions were complied with, we have the rather unusual spectacle of *three different colors,* all visible to the naked eye, in the region immediately in front of the cathode—a purple color due to retrograde rays; orange, due to positive rays; and apple green, due to cathode rays.

A SIMPLE DEMONSTRATION TUBE FOR EXHIBITING THE MERCURY HAMMER, GLOW BY MERCURY FRICTION, AND THE VAPORIZATION OF MERCURY AT REDUCED PRESSURES

ABSTRACT

Chas. T. Knipp, University of Illinois

When the pressure over mercury is reduced to that of mercury vapor only, vaporization with heat takes place at surprisingly low temperatures, and the resulting mechanical pressure exerted by the issuing vapor from the mercury surface is even more surprising. The magnitude of this pressure over a surface confined in a large bulb, so that the vapor stream is not concentrated, is sufficient even at temperatures as low as 130° C, to freely support bits of cork. That small drops of mercury

may be thus supported is common observation when working with mercury vapor lamps. To make this easy of demonstration the writer has designed a tube to show the above, together with the familiar mercury hammer, and glow by friction phenomena—all in one.

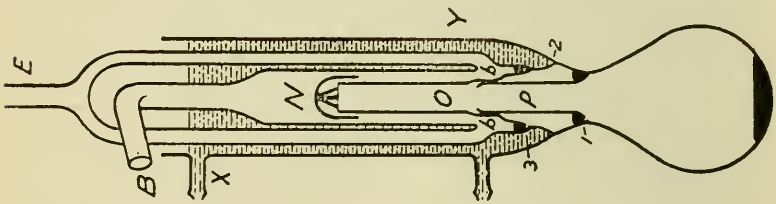
The tube should be about 35 cm. long by 1½ cm. in diameter, and have the usual bulb at each end that obtains for the mercury hammer. A stricture reducing the diameter to ½ cm. is placed near one end. A small quantity of mercury (about 5 grams) is put in the tube, and also a spherical pith ball about ¾ cm. in diameter is placed in the bulb farthest removed from the stricture. The tube is pumped out carefully and sealed off (the sealing off nipple should be attached to the stem and not to one of the bulbs). The tube is now ready for the exhibition of the three phenomena referred to above. To show the pressure of the mercury vapor it is only necessary to hold the tube by the upper bulb (the one farthest from the stricture) over a bunsen burner and allow it to heat gently. Soon condensed mercury vapor appears on the walls of the lower bulb and its progress up the tube is readily followed. The bombardment of the mercury vapor lifts the pith ball which, oscillating up and down, is forced into the upper bulb where it is violently agitated by the expanding mercury vapor stream. Removing the apparatus from the heat allows the oscillating pith ball to descend the tube until it again rests upon the stricture. At this moment if the bulb is shaken slightly the ball is again shot up momentarily. There is no danger of cracking the tube if it is blown out of pyrex glass.

AN IMPROVED FORM OF HIGH VACUUM HIGH SPEED MERCURY VAPOR AIR PUMP

ABSTRACT

CHAS. T. KNIPP, UNIVERSITY OF ILLINOIS

Dr. Gaede[1] of Berlin, in a recent number of the *Annalen,* described an air pump based partially upon the principle of the aspirator, in which the air to be evacuated diffuses through a narrow slit into a stream of mercury vapor and is carried away with it. Langmuir[2], of the General Electric Company, pointed out that even greater speeds in evacuation may be obtained by replacing the slit by a large nozzle opening into a condensing chamber surrounded by a water jacket. The un-



derlying principle is that the gas is trapped mechanically by the condensing mercury vapor and forced onward along the walls of the condensing vessel to a side opening through which the accumulated gas is drawn by the supporting pump.

The writer has improved the design and efficiency of this pump by making it more compact and at the same time securing better heat insulation at certain points and more effective cooling at others. An idea of the speed of evacuation may be obtained from the following test. A 6 litre flask was attached to the mercury vapor pump which in turn was supported by a Gaede rotary mercury pump. With the Gaede pump operating alone (it should be remarked that this pump is the type now generally used in the production of very high vacua) it required 52 minutes to produce an X-ray vacuum; while *with the mercury vapor pump operative it required but 2½ minutes to produce the same vacuum.*

1. Ann. Phys., 46, 357, 1915.
2. Phys. Rev., 8, 48, July 1916; Gen. Elect. Rev., 19, 1060, Dec. 1916.

Not only is the pump one of high speed, but it is also one giving an extremely high vacuum. The limit to which the pressure in the evacuated vessel tends is zero, or, more strictly, to the vapor pressure of glass, or of aluminum, i.e., to that of the material of which the electrodes are made. Obviously if no trap for freezing out the mercury vapor is attached, the limit of the pressure attainable is that of mercury. When made of pyrex glass the pump is durable.

THE RATE OF COMBUSTION OF SOME ILLINOIS COALS

FRED D. BARBER, ILLINOIS STATE NORMAL UNIVERSITY

The importance of studying the character and relative heating values of bituminous coals is every where recognized. Proximate and ultimate analyses of all important outputs of Illinois have been made, and their calorific values determined, by the State Geological Survey; these are easily accessible. The necessity of distinguishing between *total* volatile matter and *combustible* volatile matter is also well recognized. Many suggestions have been made regarding the classification of coals on the basis of facts revealed by proximate analysis. Similarly, generally accepted formulae have been worked out for determining the fuel units in coals from the facts obtained from analysis, thus saving the labor of determining directly their calorimetric values.

Notwithstanding the progress made in the study of coals, especially bituminous coals, and the vast amount of data collected, the statement by H. Foster Bain, Director of the State Geological Survey, in his letter transmitting Bulletin No. 3 on The Composition and Character of Illinois Coals to Governor Deneen, in 1906, is probably as true today as it was the day it was written. He said, "Much more information is needed regarding the real nature of coal and the state of combination of its elements. Professor Parr's earlier results had shown that coals of the same composition, as measured by ultimate and proximate analyses, might differ greatly in character and adaptability because of the different sorts of bond existing between the carbon, hydrogen and other elements. It is important to know what these combinations are and to devise a ready method of determining them. * * * It is believed that the method here worked out (referring to Bulletin No. 3) will prove useful in directing attention to certain little understood elements of coal, and that with a more complete understanding of the material it will prove possible not only to burn it with greater economy, but also to adapt various grades to coke making, gas producing and other uses from which they are now shut out.'"[1]

So far as the writer is aware, no important progress has been made in the solution of the problem stated by Director Bain during the ten years which have since elapsed. The study of the rate of combustion of some Illinois coals to be presented in this paper seems to the writer to have some bearing upon the problem. This study is, however, merely tentative and suggestive; it is moreover, a comparatively rough method directed especially to the study of the domestic use of coal—to the use of coal in the ordinary home. A sufficiently large proportion of the Illinois output is put to domestic uses, however, to justify such a study. The study was suggested by the recognition of the fact that for certain domestic uses, such as laundry work, a free-burning coal, one from which the available heat units may quickly be liberated, is most suitable, while for general heating purposes, whether used in furnace, steam, or hot-water plant, a coal giving a slow, steady heat is more desirable and a slow burning coal is preferable.

A free-burning coal is highly desirable for use in nearly all commercial plants, and especially in steam plants where automatic stoking is employed or where hand firing can be attended to by a fireman in constant attendance. In the case of the ordinary heating plant for a dwelling, however, the conditions are different. In the majority of cases the heating plant for a dwelling, whether it be a furnace, a steam heating plant, or a hot water plant, receives attention only at intervals of from 6 to 12 hours, and often even 24 hours. A steady heat is desirable at all times. The control of the heat is usually accomplished during the 6 or 12-hour period by the adjustment of the dampers either by hand or means of automatic heat-regulating devices.

1. Page 10, Bulletin No. 3, Illinois State Geological Survey, 1906.

One of the characteristics of a free-burning coal appears to be the rapidity with which its volatile matter is liberated at moderate temperatures. In a slow burning coal the volatile matter appears to be liberated much less rapidly at moderate temperatures, rapidly only at relatively high temperatures. If a heavy charge of fresh free-burning coal, sufficient for a 6 or 12-hour run, is shoveled into a furnace upon a bed of glowing coals, the volatile portion will be liberated rapidly and the distillation will soon be complete. In order to regulate the temperature and keep it fairly constant the draft damper must soon be closed and the check damper opened. With the oxygen supply thus shut off the volatile matter largely escapes up the chimney unburned, thus entailing a considerable loss of fuel and aggravating the smoke nuisance. A slow-burning coal, one in which the volatile matter is but slowly liberated at moderate heat, is therefore much to be preferred, other things being equal, for ordinary house heating.

The investigation here described was planned to show the relative rates at which some typical Illinois coals burn under similar conditions. The coals studied in Test I are shown in the chart on the page folllowing:

Experiment I.

A Majestic No. 1 laundry stove was used having a heating surface of 12x21 inches, or 251 sq. in., and a grate area of approximately 7x16 inches, or 114 sq. in. The fuel charge consisted of 2 pounds of yellow pine and ½ pint of kerosene for kindling and 25 pounds of lump coal broken into chunks of 1 pound or less. Upon the stove was placed a large copper boiler containing 80 pounds of water at 57° F. The temperature of the basement room in which the experiments were conducted remained at practically constant temperature, 68° F. In this experiment the boiler was covered with a fairly close-fitting cover. In every case care was taken to set the draft damper in exactly the same position. The graph (Fig. 1) shows the resulting temperatures of the last one of four determinations of each of the four samples of coal. It will be noted that these observations extended over a period of but four hours. They were taken at intervals of 15 minutes. It will also be noted that three of the four coals boiled the water

County	Seam	No. of Analyses	H_2O	Volatile matter	Free carbon	Ash	B. t. u.
No. 1, Christian	1 & 2	6	12.13%	38.93%	40.94%	7.89%	11,597
No. 2, Franklin	6	22	9.09%	34.55%	47.85%	8.55%	11,822
No. 3, McLean	2	6	11.27%	42.21%	37.72%	8.78%	11,564
No. 4, Saline	5	24	7.05%	35.44%	49.01%	8.55%	12,341

2. These data are from Bulletin 3, Chemical Study of Illinois Coals, by Professor S. W. Parr, State Geological Survey, 1916. The data given are the averages of all samples analyzed. Since the coals used in the following tests were obtained at different times from local dealers it was impossible in some cases to learn the particular mines from which they came.

for 1 hour or longer; the fourth sample, McLean County, 2nd seam coal, raised the temperature of the water only to 200° F. Since this coal has a heat value of but 0.3 of 1 per cent less than that of sample No. 1, which boiled the water most quickly, the question arises, How are the remaining heat units in this coal expended? To answer this question experiment II was planned.

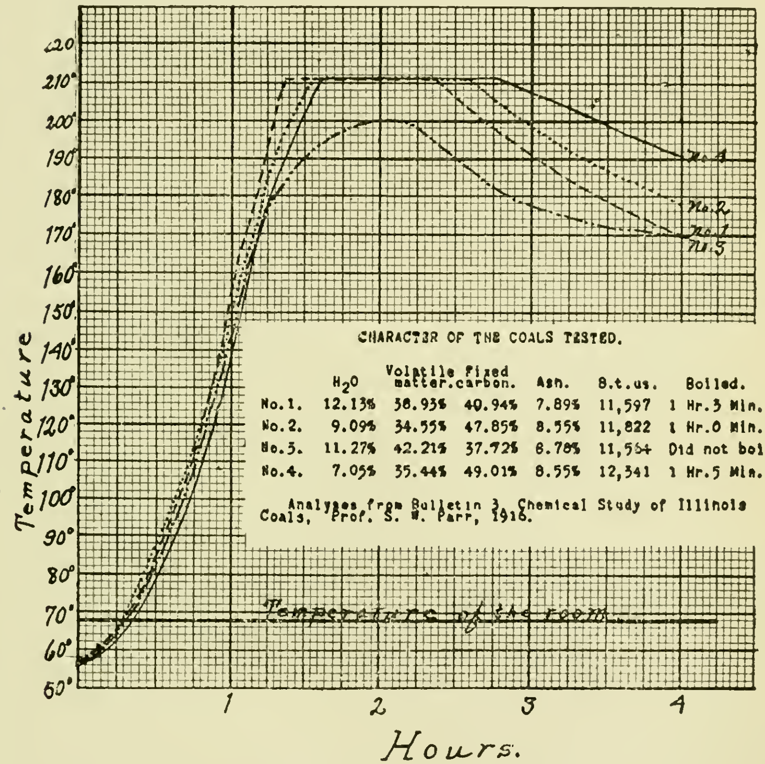


Fig. 1. Graph obtained from the 4th trial, Experiment 1. All four trials gave results approximately agreeing.

Experiment II.

The only modifications in Experiment II were the omission of the cover for the boiler and the use of but 60 pounds of water. The observations, however, were continued in this experiment for 12 hours for each trial. The graph (Fig. 2) shows the resulting temperature in the last one of three trials made with each sample tested. Only the first three samples,

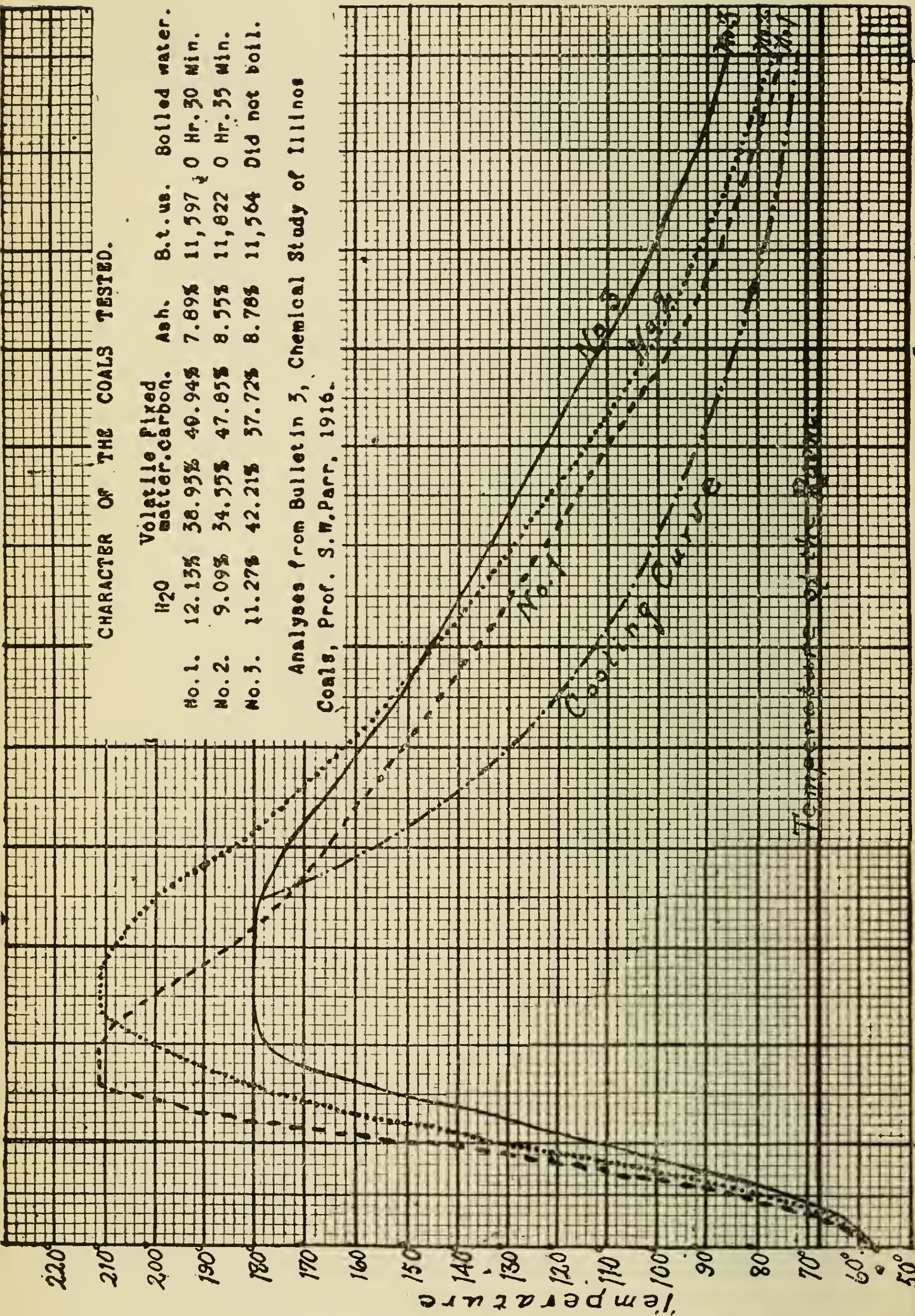


Fig. 3. Graph plotted from the 3rd trial, Experiment 2.

No. 1, No. 2 and No. 3 of the previous experiment were tested. Observations were taken at intervals of 15 minutes for the first 4 hours, of 30 minutes for the second four hours, and of 1 hour for the last four hours.

As a check upon the rate of cooling after the highest temperature had been reached, the normal cooling curve was obtained for coal No. 3. This was obtained by again heating the 60 pounds of water to 180° F., then removing the boiler from the stove and setting it upon a wooden bench. The rate of cooling was then determined.

CONCLUSIONS

1. I conclude that the rate at which these different Illinois coals burn varies greatly under unvarying conditions. Probably this variation is largely due to the bond, or bonds, which exist between the fuel elements in their composition. It is probable that the nature of this bond, or these bonds, determines largely the rate at which the volatile portion of bituminous coal is liberated when the coal is heated.

2. It does not appear from these tests that there is any evident connection between relative proportions of fixed carbon and volatile matter on the one hand and the rate of combustion on the other hand. In these tests the slowest burning coal had the highest percentage of volatile matter and the lowest percentage of fixed carbon, while the coal having the next highest percentage of volatile matter and the next lowest percentage of fixed carbon proved to be the most rapid burning coal. These facts confirm me in the belief that the rate of combustion of these coals is chiefly determined by the bonds which tie the fuel elements together and possibly also which tie these elements to the other elements composing the coal.

3. I further conclude that the use or uses to which the coal is to be put should be clearly recognized in the purchase of coal. It is my belief that the rate at which a coal distills when heated is a larger factor in determining the rate at which it burns under ordinary conditions of domestic use than is the relative proportions of volatile matter and fixed carbon. If the conditions under which the coal is to be burned permit of complete combustion, or as nearly complete combustion as is

possible, of the volatile matter, then a free-burning, easily distilled coal should be used. If the conditions are such that the fire must be controlled chiefly by preventing the combustion of the volatile matter then the less easily distilled coal, the slow burning coal, should be used.

4. When used for domestic purposes coal is usually used: First, for house heating; second, for laundry purposes; third, for cooking. If the foregoing conclusions are justified, generally speaking, a slow-burning coal is most suitable for house heating; a free-burning coal is most suitable for laundry purposes; and, depending upon conditions, either a free-burning or a slow-burning coal may be found most suitable for cooking purposes.

5. I believe that extensive study of the rate at which bituminous coals burn under ordinary conditions for domestic use would be of great value to the people of Illinois.

INDOOR HUMIDITY

FRED D. BARBER, ILLINOIS STATE NORMAL UNIVERSITY

Much has been written in recent years about the low indoor humidity prevalent throughout the winter months when artificial heat is required. The evil effects of low indoor humidity (and the consequent rapid evaporation from every moist surface) upon health have frequently been discussed. Much has been said in commendation of a dry climate, such as that of the southwestern United States, with moderate winter temperatures enabling the residents to live practically out of doors the year around; little has been said in favor of the winter climate of northeastern United States. The change from the outdoor air with its low temperature and high humidity, to the indoor air with its high temperature and low humidity, or *vice versa*, is generally conceded to be a trying ordeal. Many suggestions have been offered for controlling the humidity of residences, school-rooms and public halls. In some instances efforts in this direction have been more or less successful; it is to be feared that in most cases they have been less successful.

It was the writer's purpose to make a study of the possibilities of controlling indoor humidity of an ordinary furnace-heated residence located in central Illinois during a cold spell.

The residence used for this study is a frame structure approximately 22 by 42 feet, two stories, eight rooms, all rooms in daily use. The air supply for the furnace is fresh, outside air and is ample and the circulation is perfect. The abundance of air supplied the furnace prevents overheating; it is

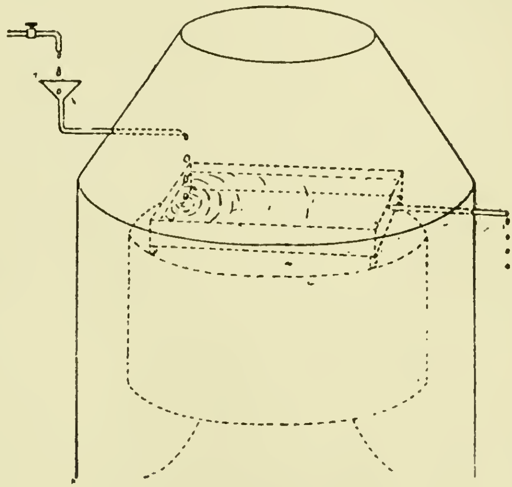


Fig. 1. The Humidifier

a *warm air* system, not a *hot air* system. The humidifier consists of a seamless copper tray or pan, 18 by 36 inches (4.5 square feet of evaporating surface) supported about 2 inches above the radiator and within the jacket. (Fig. 1.). The water for the humidifier is secured from the city supply and is controlled by means of a needle valve. The humidifier is provided with an overflow pipe. The furnace dampers are controlled by an automatic heat regulator which operates the dampers on a change of two degrees, or less, in the temperature of the living rooms. During this test the temperature was maintained at 70° at the warmest part of the living rooms, and about 65° at the coolest portions.

The data were taken during the nine days from December 20 to December 28, inclusive, 1914. This was probably the coldest week of that winter in this region.

Record of Outdoor and Indoor Humidity

Sunday, December 20, 1914

Temperature	Relative Humidity	1 a.m.	11:30 a.m.	8:30 p.m.
Maximum, 21°	Indoor Relative Humidity	36%	38%	33%
Minimum, 4°	Outdoor Relative Humidity	82%	81%	80%
Average, 12.5°	Average Outdoor Relative Humidity for the Day			81%

Calculation

Absolute humidity of outdoor air at 12.5° and 81% = .710 grains per cu. ft.

An absolute humidity of .710 grains of indoor air at 70° = 9% − relative Humidity.

Monday, December 21, 1914

Temperature	Relative Humidity	7 a.m.	12 m.	7 p.m.
Maximum, 20°	Indoor Relative Humidity	35%	34%	32%
Minimum, 5°	Outdoor Relative Humidity	94%	72%	80%
Average, 12.5°	Average Relative Humidity for the Day			82%

Calculation

Absolute humidity of outdoor air at 12.5° and 82% = .719 grains per cu. ft.

An absolute humidity of .719 grains of indoor air at 70° = 9% + relative humidity.

Tuesday, December 22, 1914

Temperature	Relative Humidity	9 a.m.	12 m.	3 p.m.
Maximum, 19°	Indoor Relative Humidity	35%	38%	35%
Minimum, 0°	Outdoor Relative Humidity	77%	64%	58%
Average, 9.5°	Average Relative Humidity for the Day			66%

Calculation

Absolute humidity of outdoor air at 9.5° and 66% = .500 grains per cu. ft.

An absolute humidity of .500 grains of indoor air at 70° = 6.3% relative humidity.

Wednesday, December 23, 1914

Temperature	Relative Humidity	8:40 a.m.	12:15 p.m.	4:30 p.m.	7 p.m.	9:45 p.m.
Maximum, 22°	Indoor Rel. Humid.	34%	33%	33%	34%	32%
Minimum, 5°	Outdoor Rel. Humid.	79%	76%	76%	86%	86%
Average, 13.5°	Average Relative Humidity for the Day					81%

Calculation

Absolute humidity of outdoor air at 13.5° and 81% = .744 grains per cu. ft.

An absolute humidity of .744 grains at 70° of indoor air = 9.3% relative humidity.

Thursday, December 24, 1914

Temperature	Relative Humidity	9 a.m.	10:30 a.m.	11 p.m.	4 p.m.
Maximum, 30°	Indoor Rel. Humid.	40%	40%	45%	35%
Minimum, 7°	Outdoor Rel. Humid.	98%	95%	92%	82%
Average, 18.5°	Average Relative Humidity for the Day				92%

Calculation

Absolute humidity of outdoor air at 18.5° and 92% = 1.062 grains per cu. ft.

An absolute humidity of 1.062 grains of indoor air at 70° = 13.3% relative humidity.

Friday, December 25, 1914

Temperature	Relative Humidity	9 a.m.	11 a.m.	1 p.m.	3:30 p.m.	8 p.m.
Maximum, 15°	Indoor Rel. Humid.	38%	35%	35%	31%	28%[1]
Minimum, -1°	Outdoor Rel. Humid.	78%	64%	57%	62%	72%
Average, 7°	Average Relative Humidity for the Day					67%

Calculation

Absolute humidity of outdoor air at 7° and 67% = .447 grains per cu. ft.

An absolute humidity of indoor air of .447 grains at 70° = 5.6% relative humidity.

Saturday, December 26, 1914

Temperature	Relative Humidity	7 a.m.	11 a.m.	12 m.	2:30 p.m.	4:30 p.m.	6:30 p.m.
Maximum, 14°	Indoor Rel. Hum	34%	33%	33%	35%	30%	32%
Minimum, -13°	Outdoor Rel. Hum.	74%	54%	53%	64%	68%	72%
Average, .5°	Average Relative Humidity for the Day						64%

Calculation

Absolute humidity of outdoor air at .5° and 64% = .376 grains per cu. ft.

An absolute humidity of indoor air of .376 grains at 70° = 4% — relative humidity.

Sunday, December 27, 1914.

Temperature	Relative Humidity	9 a.m.	11:45 a.m.	4 p.m.	9:30 p.m.
Maximum. 27°	Indoor Relative Humidity	33%	33%	33%	33%
Minimum, 12°	Outdoor Relative Humidity	80%	74%	78%	84%
Average, 19.5°	Average Relative Humidity for the Day				79%

Calculation

Absolute humidity of ourdoor air at 19.5° and 79% = .954 grains per cu. ft.

An absolute humidity of .954 grains of indoor air at 70° = 11.9% relative humidity.

Monday, December 28, 1914

Temperature	Relative Humidity	8:30 a.m.	11 a.m.
Maximum, 28°	Indoor Relative Humidity	32%	33%
Minimum, 23°	Outdoor Relative Humidity	82%	76%
Average, 25.5°	Average Relative Humidity for the Day		79%

Calculation

Absolute humidity of outdoor air at 25.5° and 79% = 1.253 grains per cu. ft.

An absolute humidity of 1.253 grains of indoor air at 70% = 15.7% relative humidity.

1. The humidifier ran dry at this point. The drop in temperature necessitated more heat and this produced more rapid evaporation. It was necessary to open the needle valve wider.

Additional Facts

Average outdoor temperature for the period = 13.3° or 12° below normal.

Average outdoor relative humidity (daytime only) = 77%.

Average indoor relative humidity (daytime only) = 34.5% with maximum of 45% and minimum of 28%.

Average calculated indoor humidity for the period = 9.3%.

The windows on the west and north side were provided with storm windows and the inside windows did not frost over; the single windows were covered with frost and much ice accumulated at the bottom of each. The outside wall of one west room showed considerable moisture on Saturday, December 26th.

On Saturday, December 26th, about six gallons of water were evaporated by the humidifier. On the average, probably about four gallons were evaporated daily. The water in the humidifier boiled on several occasions and stood near the boiling point frequently.

While the data given cover a period of nine days only, the humidifier has been in use for several years and I am confident that these data indicate correctly the usual operation of the plant when low temperature prevails. (Fig. 2).

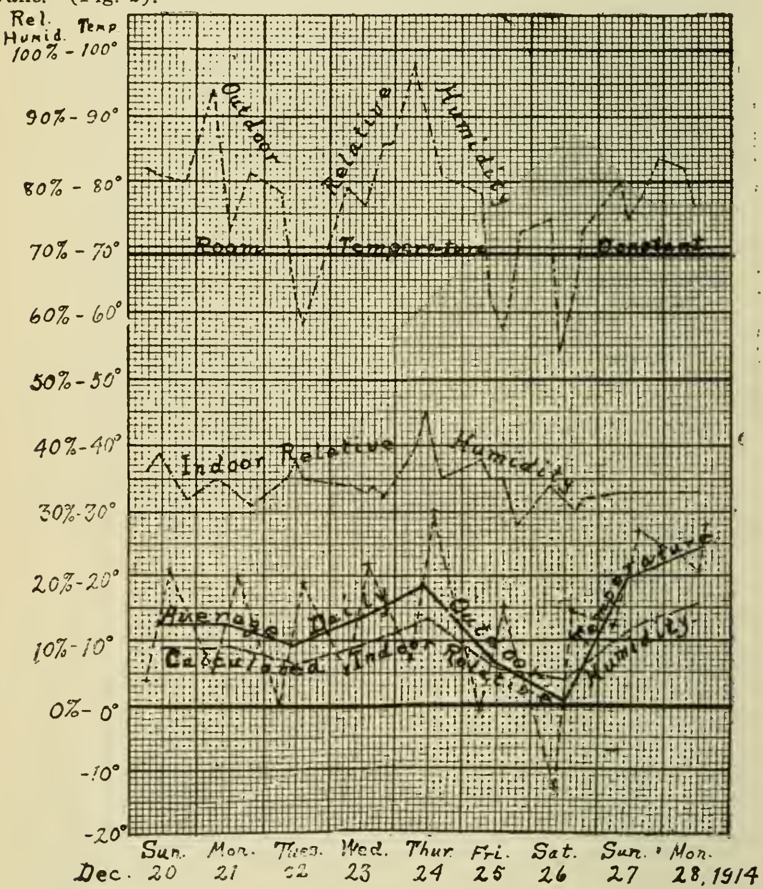


Fig. 2. Graphs: Outdoor Relative Humidity. Room Temperature, constant at 68°. Indoor Relative Humidity. Average Outdoor Temperature, Max. + Min. Calculated Indoor Humidity.
2

CONCLUSIONS

1. This device is nearly automatic in its operation and does control the humidity of indoor air, maintaining a fairly constant relative humidity of about 35 per cent. during both moderate and extreme outdoor temperatures.

2. It is folly to talk of materially increasing the indoor humidity of a well-ventilated residence by using the common furnace water pan or even by suspending vessels of water within registers. Any device which does not evaporate several gallons of water daily in a well-ventilated residence is nearly useless.

3. It is not practical to attempt to maintain a relative humidity of more than about 35 or 40 per cent. during cold weather. A higher humidity, if obtainable, results in excessive frosting of windows and the "sweating" of walls during zero weather.

4. While granting that the *calculated* relative humidity given above is considerably lower than actually would have prevailed but for the humidifier, it still is true that the thirsty air would have stolen the additional moisture from every available source such as the building itself, the furniture and the skin and mucous membrane of the residents.

5. A temperature of 65° to 68° in the living room or library is entirely adequate for most people if the relative humidity is maintained at 35 per cent or more.

Fig. 3. Average Temperature, $\frac{\text{Max.} + \text{Min.}}{2}$, for January for 25 years.

6. The records of the Weather Bureau show that the average temperature for January, for eastern Iowa, southern Wisconsin, the Lower Michigan Peninsula, Northern Illinois, Indiana, Ohio, Pennsylvania, New York, New Jersey, and most of New England is from 20° to 30°, while the average relative humidity of this region for January is from 75 per cent to 85 per cent. (Figs. 3 and 4). In this region live nearly one-half of the population of the United States and here is found more than one-half of the wealth and resources of the nation. If the control of indoor climate during the winter months is as important for human health and vitality as recent writers assert, we certainly need more information concerning the methods by which it may be obtained.

An outdoor temperature of 25° with a relative humidity of 80 per cent means an absolute humidity of 1.241 grains of moisture per cubic foot. If this air is admitted to the residence, school or counting room heated to 70° without the addition of moisture, a relative humidity of 15.5 per cent results. This is a much lower relative humidity than is to be found in outdoor air in any inhabitable region on the face of the earth.

The effect of frequently passing from indoor air at a temperature of 70° and a humidity of 20 per cent or lower into outdoor air at 25° and 80 per cent humidity is a matter which should receive more attention.

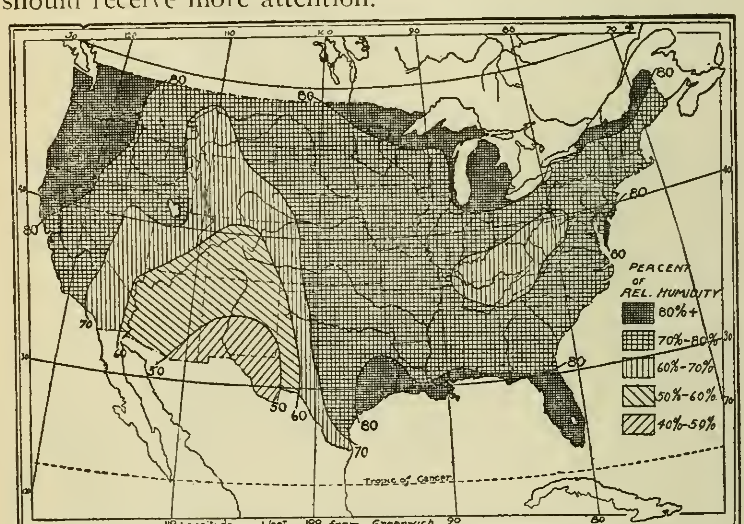


Fig. 4. Average Relative Humidity for January for 15 years.

Papers on Zoology and Physiology

SELECTION, REGRESSION, AND PARENT-PROGENY CORRELATION IN APHIS AVENAE FAB.

H. E. Ewing, Iowa State College, Ames, Ia.

The pure line theory, at one time considered by many as being established upon such a volume of evidence as to be almost unassailable, is passing, like so many of our biological theories, through a period of adverse criticism. Especially have certain workers raised very serious objections to the earlier experiments in pure lines that gave negative results in regard to the effects of selection. These criticisms have recently been summarized by Jennings (1916), but the writer will here call attention to four of them which he intends to consider especially in this paper. These four criticisms are to the effect that:

a. The characters used in the pure line work have been, for the most part, indefinite, and have not been structural characters that could easily be measured or counted.

b. The characters used have been such as to be easily affected by environment.

c. Not enough characters in any one line have been studied.

d. Selections have not been carried on for a sufficient number of generations in any one case to give a conclusive test of their effect upon somatic change.

In regard to this last point Middleton (1915), who claims his results show positive effects of selection, asks us to compare with his 39 plus selections; "the six made by Johannsen in obtaining his negative results with beans, the three or four made by East with potatoes, the two made by Winslow and Walker with bacteria, and similar small numbers made by most other investigators along these lines, even indeed the selection through fifteen generations made by Agar, in Cladocera."

Happily these criticisms so justly raised against the earlier experiments have been better met recently by the work of Middleton, Ackert, Jennings and others, and the writer believes also by his own work with *Aphis avenae* Fab. But subjected to these more rigorous tests what results do we get? They are just as contradictory as before. Middleton (1915), who made 39.86 (average) plus selection with *Stylonychia*, comes to this conclusion: "Thus in *Stylonychia*, from a single clone of given genotype it is possible to obtain through long continued selection during reproduction by fission, two sets (clones?) of diverse genotype, differing characteristically from each other in rate of fission under identical conditions; and retaining these differences from generation to generation. The selection of small variations, such as appear within the 'pure strain' or clone, is then an effective evolutionary procedure." Jennings (1916), whose work with *Difflugia corona* was carried on in a very thorough manner, comes to similar conclusions in regard to the effectiveness of long-continued selection. He concludes his work with the following statement: "Thus in general the investigation shows that in *Difflugia corona* a population consists of many hereditarily diverse stocks; and that a single stock, derived by fission from a single progenitor, gradually differentiates into such hereditarily diverse stocks; so that by selection marked results are produced." Ackert (1916), however, working with *Paramecium* obtains opposite results, and substantiates Jennings' earlier findings with Protozoa, and thus gives further support for the pure line theory. In his summary he states: "In these experiments, in which nearly six thousand animals were measured, the results indicate that selection within the progeny of a single Paramecium is without effect. Even when one of the animals selected was twice as long as the other, diverse groups failed to develop, each of the groups under comparison either having the same mean lengths, or the progeny of the longest Paramecium having the smaller mean length." The writer's results with *Aphis avenae* (Ewing, 1916) are in accord with those of Ackert and the prevailing ideas of the pure line advocates. In my summary they are indicated by the following: "The results of this work with *Aphis avenae* Fab. are, we believe, sufficient to warrant the following generalization: Fluctuating variations in a parthenogenetic pure line of *Aphis avenae* Fab., and presumably in all parthenogenetic pure lines, are in general not dependent upon germinal variations, and for this reason are not capable of increase or summation through the action of continued selection. Or to put it in another way: Fluctuating variability in a parthenogenetic pure line is devoid of one of its most important causes when exhibited in higher animals that reproduce sexually that is, germinal variability.

When we subject to analysis those experiments that seem to be positive in regard to the effectiveness of selection, and contrary to our accepted ideas in regard to the permanency of a pure line or the genotype, do we find that they were so conducted as to be exempt from the criticisms such as Pearson, Harris, and Castle have raised in regard to the earlier experiments that gave negative results? We find that one of these common objections, that not enough selections were made can hardly apply to the work of Middleton with *Stylonychia,* for he states that in his main experiment on the average 39.86 plus selections were made in the fast-selected lines; 34.36 minus selections in the slow-selected lines. Yet in respect to the other points Middleton's work is open, it appears to me, to the same objections raised in regard to the earlier experiments in pure lines. We find only a single character was studied, that this character, the fission rate, is a physiological one and does not lend itself as accurately to measurement as morphological characters, and is more or less influenced by environment.

Probably the work of Jennings (1916) comes more nearly meeting the various requirements that the critics of the pure line work would impose than those of most others. In his work with *Difflugia corona* six different characters were used. These were all morphological characters, parts easily counted or structures easily measured. Further, they were little affected by environment, and their coefficients of correlation in regard to variation were ascertained. Jennings has applied finer methods of statistical study in regard to variation and correlation in a thorough manner to his work; also controls were run, checks made, and pedigrees kept. Thus it is made possible for other workers to examine his results from different angles, and formulate their own interpretations. The work of Jennings, it appears to me, must be conclusive in most respects for *Difflugia corona.* However, the selections in certain cases were carried on for only a few generations, yet the mass of data given for such selections might cause one, unless making the closest scrutiny, to think that a very large number of generations had been obtained. Again, such strong positive parent-progeny correlations as were obtained in family 305, were found in a family that appeared abnormal in several respects.

But has the pure line theory been overthrown by these recent experiments? I think far from it. The strongest evidence against the concept is that found in Jenning's work with *Difflugia.* In fact, I believe that this is the one piece of work that shows definite positive results in regard to somatic change through selection (in pure lines), that is not open to the serious objections raised against the earlier work in this field. Jennings himself, apparently does not claim that his results necessarily overthrow his conclusions based on his earlier work with Paramecium, or the pure line theory as it applies to higher plants or animals that reproduce by self fertilization or parthenogenesis. In fact, he states that there is a srong probability that selection was effective in *Difflugia* because of a peculiar role the mechanism of inheritance plays in these forms. In his discussion we read: "It would appear therefore that the substances determining the hereditary characters may be distributed with less accuracy than in higher organisms, so that the two products of fission may often receive parts that are not equivalent. As a result, the two products of fission would differ in hereditary characters; and in time diversities of strains would be brought about such as are described in the present paper. The possibility that this is the state of affairs is entirely open, so far as our present knowledge is concerned."

The writer in his work with *Aphis avenae* (Ewing, 1916), attempted, as did Jennings, to meet the objections that had been raised in regard to the earlier experiments in pure lines. My results, I believe, in the main, have met these objections. There is one phase of the work, however, that was not reported in the recent summary of the experiments with *Aphis avenae* in the "Biological Bulletin" for August (1916); that is, the statistical study of selection, regression, and the parent progeny correlation. The data for most of these were collected and in part put in manuscript form at the time the published results were first written. In order to forestall criticisms of the omission of these features in the work with *Aphis avenae,* and in order to help us obtain a more intelligible interpretation of the facts in our pure line work. I submit them in this paper.

Parent-Progeny Correlation in a Subline where Selection was Made in an Attempt to Change the Ratio of the Length of the Third to the Fourth Segments of the Antennae.

The first character which was used in the selection work with *Aphis avenae* Fab. was the ratio existing between the length of the third and fourth segments of the antennae. Eight selections were made in attempting to increase this ratio in the fifteen generations obtained. Already there has been published (Ewing, 1914, b) a statistical study of regression in this subline or isolation, and here I will give the results of working out the parent-progeny correlation and add a few notes on regression. If we group the parents into classes each with a mean difference of 0.10 points in the antennal ratio, the length of the shorter segment (segment four) being taken in each case as unity, we will have the arrangement found in Table I. This has been done and the offspring are grouped into the same classes as the parents, thus making a symmetrical table.

TABLE I.

PARENT-PROGENY CORRELATION TABLE WITH RESPECT TO ANTENNAL FORMULA (RATIO OF LENGTH OF THIRD TO FOURTH SEGMENT.)

Offspring \ Parents	1.20-1.29	1.30-1.39	1.40-1.49	1.50-1.59	1.60-1.69	1.70-1.79	1.80-1.89	1.90-1.99	2.00-2.09	2.10-2.19	2.20-2.29	2.30-2.39	2.40-2.49	2.50-2.59	2.60-2.69	2.70-2.79	2.80-2.89	2.90-2.99	
1.20-1.29																			
1.30-1.39																			
1.40-1.49																			
1.50-1.59									1								1		2
1.60-1.69				1	3	2	3	1	4										14
1.70-1.79				1	6	5	7		1	2							2		24
1.80-1.89				1	3	7	10	1	1								1		24
1.90-1.99					3	3	7			2							1		16
2.00-2.09					2		5	1		1									9
2.10-2.19				1			1												2
2.20-2.29							1												1
2.30-2.39																			
2.40-2.49							1												1
2.50-2.59																			
2.60-2.69																			
2.70-2.79																			
2.80-2.89						1													1
2.90-2.99																			
				4	17	18	35	3	7	5							5		94

An examination of this table shows a lack of correlation. The offspring of the three parent classes having the highest antennal formula have means even below the average. On the other hand the offspring of the 1.80-1.89 class have the highest progeny mean of any parent class.

If we compute the average fraternal mean for all the offspring of the eighteen parents considered in this isolation, we find it to be 1.823 which is only 0.023 above the mean obtained for the line, showing regression to be practically complete. In a previous paper (Ewing, 1914 b), the writer found by computing the regression according to parent-class method that it was more than complete. The correlation table substantiates my earlier conclusions in regard to the negative results of selection in this subline..

An Analysis of the Results of Selection Made in an Attempt to Increase the Length of the Cornicles in Aphis avenae.

In isolation 3, selections were made in an attempt to increase the absolute (not relative) length of the cornicles in *Aphis avenae*. Selections were begun in the 15th generation and were made in each generation up to the 26th. Eleven selections were made in all, and sixty-seven progeny obtained. In Table II there is given a parent-progeny correlation table for the cornicle length for these eleven selected generations as well as for several generations previous during which no selections were made. In these latter generations work was done on the determination of the cornicle length of the genotype.

This table shows a strong correlation between parent and immediate progeny in regard to cornicle length, and the graph which was made in my previous paper (Ewing, 1916, p. 59), showing the results of selection on cornicle length, for the most part appeared to show the same thing. In fact, I was so certain of positive effects after six or seven selections that I presented a seminar paper on my success in creating a new strain of plant lice through selection in a pure line. Continuing the work a few generations farther, however, it was found that there was almost a complete regression in regard to cornicle length, and this in the face of rigid selection. Considering the fact that in these latter generations there was such a strong regression, I am inclined to attribute the earlier gains in cornicle length not to selection, but to environmental

TABLE II.

Parent progeny correlation table with respect to absolute cornicle length

Offspring \ Parents	2.00-2.09	2.10-2.19	2.20-2.29	2.30-2.39	2.40-2.49	2.50-2.59	2.60-2.69	2.70-2.79	2.80-2.89	2.90-2.99	3.00-3.09	3.10-3.19	3.20-3.29	3.30-3.39	3.40-3.49	3.50-3.59	3.60-3.69	3.70-3.79	3.80-3.89	3.90-3.99	
2.00-2.09								1													1
2.10-2.19				1				1													2
2.20-2.29				1	1			1													3
2.30-2.39								1													1
2.40-2.49							1														1
2.50-2.59				1	1		2														4
2.60-2.69				1				2				1									4
2.70-2.79								2				2	1								5
2.80-2.89							1	1													2
2.90-2.99							1					1				1					3
3.00-3.09			1								1	2	3			2		2			11
3.10-3.19			2								1		2			1					6
3.20-3.29			1								1		3			4		3			12
3.30-3.39											1				1	2	1	2			7
3.40-3.49													1			6	1	2			10
3.50-3.59											1		1		3	7		1			13
3.60-3.69																1					1
3.70-3.79															1						1
3.80-3.89																					
3.90-3.99																					
			4	4	2		5	9			5	6	11		5	24	2	10			87

changes and believe that if the selections had been continued for several generations farther no marked correlation would have been noticed.

Parent-progeny Correlation and Regression in Two Check Sublines, where Selections were Made in One for Increasing the Body Length and in the Other for Decreasing It.

After making selections for several different characters it was decided to select for increasing the body length, and in order to obviate errors through environmental influences on this character, a check subline was run in which minus selections were made. In one subline, No. 5, selections were made for increasing the body length, while in another, No. 6, selections were made for decreasing the body length. Both of these sublines were treated in as nearly the same way as possible. The results obtained for these selections, which were carried on for seven generations, I have already summarized. "Where selections were made in opposite directions (plus and minus) in two isolations, each being used as a check against the other, it was found that fluctuations were simultaneous in both isolations, and in the same directions, being thus independent of the effects of selection." As additional data on the effects of selection, the parent-progeny correlation table is here given.

TABLE III.

Parent-progeny correlation table with respect to body length in two sublines in which plus and minus selections were made.

Progeny \ Parents	1.00-1.19	1.20-1.39	1.40-1.59	1.60-1.79	1.80-1.99	2.00-2.19	
1.00-1.19		1		1			2
1.20-1.39		3	3	3	1		10
1.40-1.59		1	6	2	1		10
1.60-1.79	2	1	7	7	6		20
1.80-1.99			5	3	6	5	19
2.00-2.19					2		2
	2	6	21	13	16	5	63

In this table we see a marked correlation between parents and progeny. The highest progeny mode is 1.80-1.99 mm. which was reached by the parent class having the greatest length. The lowest progeny mode 1.20-1.39 mm. is by the parent class having next to the shortest body length. The other progeny modes fall in the 1.60-1.79 group. Thus a considerable correlation is shown.

When we run two check strains, keeping both under as nearly identical conditions as possible, and selecting in one in a plus direction and in the other in a minus direction, we have one of the best tests known for the effectiveness of selection. This was done in the case of the two sublines in question. It was impossible to separate the two sublines into strains differing genetically in regard to size. The correlation shown in the table presented, Table III, was equally evident in the plotted curves which were given (Ewing 1916, p. 64) for the results of selection in isolations No. 5 and No. 6; but more evident than this was the fact already mentioned, *i.e.*, that the fluctuations in the two sublines went together, and that the two could not be separated genetically in regard to body length.

An Analytical Study of Variation and Regression in All Sublines where Selections were Made for Increasing Body Length.

In the work with *Aphis avenae,* a special attempt was made to test the effectiveness of selection on body length, which corresponds to stature in upright animals. The chief reasons for this were that body length was well known to be affected by selection in higher animals that reproduce sexually, and because body length is a character easily and accurately measured. In three different isolations selections were made in an attempt to increase the size or body length in the pure line. This was done by picking out the longest individual of each fraternity as the parent for the succeeding fraternity (next generation) in that isolation or subline. In isolation 5, selection was begun in the 26th generation, and continued for seven generations; in isolation I, selection was begun in the second generation, and continued for five generations; in isolation 11 selections were begun in the 43rd generation and continued for forty-four generations. This last series of selections is, I believe, about as long a series as has been obtained in any pure line work and gives us the rigid test so often suggested by pure line critics. In my previous paper (Ewing, 1916), it was shown that in all three of these selection tests no shifting of the fraternal mean in regard to size had been detected. But critics may insist that if a careful statistical study had been made a shifting might have been detected. In order to find out if such is the case, the following statistical studies are submitted in regard to selection, correlation and regression in the case of these three isolations, or sublines, where selections were made in an attempt to increase the size of the individuals.

In isolations 5, I and 11 we find 55 parent individuals included, which gave 542 measured adult offspring. Let us now place these 55 parent individuals in different classes according to their length. We get the following arrangement:

Lengths in mm.	1.25-1.29	1.30-1.34	1.35-1.39	1.40-1.44	1.45-1.49	1.50-1.54
No. of parents	1	0	0	2	0	4

1.55-1.59	1.60-1.64	1.65-1.69	1.70-1.74	1.75-1.79	1.80-1.84	1.85-1.89
3	6	4	8	6	12	5

1.90-1.94	1.95-1.99	2.00-2.04	2.05-2.09	2.10-1.14	2.15-2.19
1	2	0	0	0	1

How do these positions compare with the mean for the line?

If we compute the mean for all the individuals[1] (both parents and offspring) for these three isolations we get 1.544 mm. as the mean for the whole line. Above this mean we find 48 of the 55 parents, and below it only 7 parents. This shows how severe was the test of selection in these experiments. Further, the mean of all the parents selected is found to be 1.728 mm. which is 0.184 mm. greater than the mean for the line, or about 12 per cent greater in length than the average length of all individuals of the three sublines. In Table IV we find correlations given for the size of these 55 parents and their offspring.

The results observed in Table IV appear to give us a considerable correlation between parents and offspring. But, knowing as I do the conditions of the experiment, I would attach little significance to this table as far as indicating any inherited differences between parent and offspring. We find in the three lowest parental classes containing any individuals, 1.25-1.29, 1.40-1.44, and 1.50-1.54, that the modes for the offspring as well as the means are unusually low, except for the one offspring in the class 1.25-1.29 which can be disregarded. Certainly this shows correlation, our critics say. Yes it does, but not necessarily inheritance. An examination of my notes shows that three of the seven parents included in this class were produced while feeding on older wheat plants than usual, as also did their offspring. It was shown clearly in my experiments that older wheat plants caused a diminution of the size of the individuals. Two of the remaining parents as well as their offspring were produced under exceptionally low temperature, in fact the temperature was many degrees lower than usual. These conditions of course would affect both parent and offspring. The parent going in the highest class, 2.15-2.19, is of special interest. This individual is four classes ahead of the next longest parents which go in the 1.95-1.99 class. Certainly this must be an example of mutation! The mean of its offspring also is far above any other mean. But let us examine the case farther. The parent of this fraternity, measured 2.15 mm., yet this great size was not permanently inherited, for the mean of its grandchildren came down to

1. For the actual measurements of these individuals, of which there were 543, the reader is referred to the previous paper by the writer (Ewing, 1916). The measurements of two individuals were lost, and in a few cases measurements were not made of abnormal ones or those that were seriously distorted.

TABLE IV.

CORRELATION TABLE BETWEEN PARENTS AND OFFSPRING IN REGARD TO SIZE.

Offspring \ Parents	0.95-0.99	1.00-1.04	1.05-1.09	1.10-1.14	1.15-1.19	1.20-1.24	1.25-1.29	1.30-1.34	1.35-1.39	1.40-1.44	1.45-1.49	1.50-1.54	1.55-1.59	1.60-1.64	1.65-1.69	1.70-1.74	1.75-1.79	1.80-1.84	1.85-1.89	1.90-1.94	1.95-1.99	2.00-2.04	2.05-2.14	2.10-2.14	2.15-2.19	2.20-2.24	2.25-2.29	2.30-2.34	
0.95-0.99												2					1												3
1.00-2.04												1		1			1												3
1.05-1.09																	1												1
1.10-1.14												1					4												6
1.15-1.19										1							2	1											4
1.20-1.24										2			1	1	1	2	1	1											9
1.25-1.29										1			1	2	1	2	4	3											14
1.30-1.34												1	3	6	4	7	4	11			1								37
1.35-1.39										2		4	1	4	3	5	3	8	2		1								33
1.40-1.44										7		1	3	4	2	9	5	17	8		3								59
1.45-1.49										1		1	4	4	6	8	4	11	4										43
1.50-1.54										3		3	3	8	8	11	6	14			2								58
1.55-1.59										3				6	2	11	5	5	6	1	6								45
1.60-1.64							1						5	4	7	11	10	8	17	3	7								73
1.65-1.69										1			1	2	2	6	11	9	10	2	2								46
1.70-1.74												1		4	1	10	6	6	7	2	1								38
1.75-1.79														1	2	8	4	6	2	1	1								25
1.80-1.84												1	1	2	2	4	3	3	3	2	1				1				23
1.85-1.89															2		1	3	1		1				2				10
1.90-1.94																		3							1				4
1.95-1.99																		3		2					1				6
2.00-2.04																													0
2.05-2.09																		1											1
2.10-2.14																													0
2.15-2.19																		1											1
2.20-2.24																													0
							1			21		17	23	49	43	94	76	114	60	13	26				5				542

1.603 mm., or but little above that of the genotype. The conditions that produced this parent must have been favorable indeed in order to give a parental length of 2.15 mm., and a mean of 1.890 mm. for the offspring. Here again we find an annotated pedigree saving us from a wrong interpretation. I doubt if these correlation tables tell enough of the story to justify us in drawing any conclusions in regard to inheritance. They show correlation, but in doing so may give us wrong conceptions in regard to inheritance unless we know something about the *why* of the correlation.

Probably a more accurate way of detecting inherited effects is by a graphical and statistical study of regression, provided of course that the numbers of individuals obtained are sufficient for such a test, which happily is here the case. The means obtained for the offspring of the parents going in the different classes are as follows:

i

TABLE V.

THE MEANS OF ALL THE OFFSPRING OF PARENTS BELONGING TO THE DIFFERENT SIZE CLASSES

Classes (Length indicated in mm.)	Means of Progeny
1.25-1.29	1.600
1.30-1.34	——
1.35-1.39	——
1.40-1.44	1.430
1.45-1.49	——
1.50-1.54	1.357
1.55-1.59	1.486
1.60-1.64	1.497
1.65-1.69	1.538
1.70-1.74	1.556
1.75-1.79	1.508
1.80-1.84	1.554
1.85-1.89	1.614
1.90-1.94	1.742
1.95-1.99	1.585
2.00-2.04	——
2.05-2.09	——
2.10-2.14	——
2.15-2.19	1.890

We can make a plot showing the position of the different parent classes, the means of the offspring of the parents going into these various classes in regard to the mean of the line. This is done in Figure 1.

We find by observing Figure 1 that nearly all of the parents are above the mean of the pure line, which is what we should expect since in each case of selection the longest individual was chosen as the parent for the succeeding generation. Of the thirteen parental groups or classes we find in 12 instances that regression is shown by the offspring. In seven of these the regression is not complete, in five it is more than complete. or beyond the mean of the line. If we compute the mean for all of the parents above the mean of the line, we find it is 1.768 mm., (it is indicated by the heavy circle in figure), and if we compute the mean for all the offspring of these parents we get 1.555 mm., (indicated by heavy arrowhead in figure.)

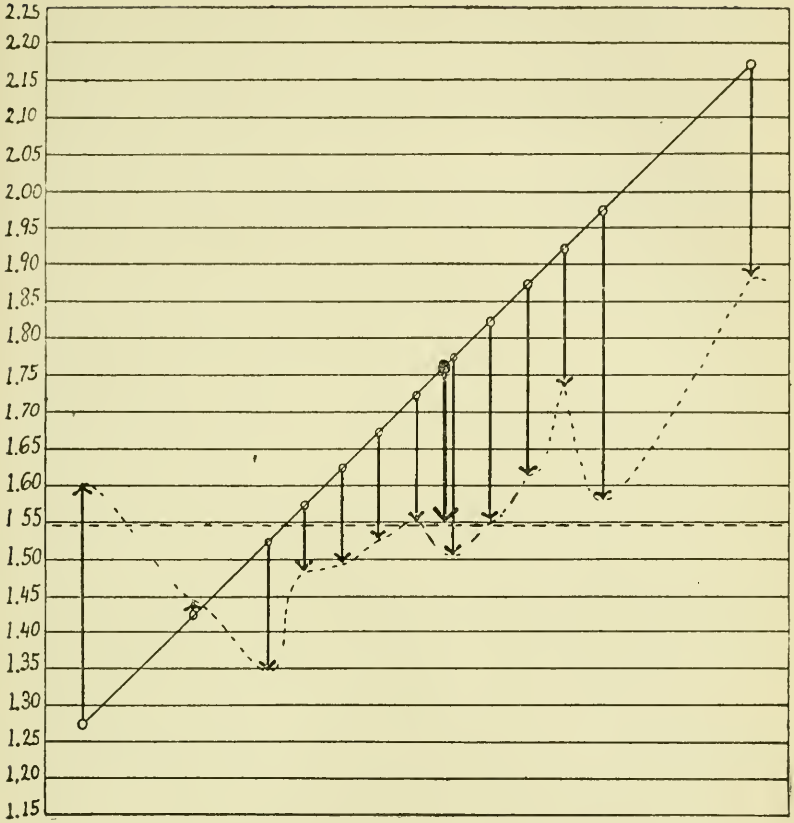


Fig. 1. Graph showing regression in sublines of a pure line of the parthenogenetic plant louse (*Aphis avenae* Fab.). Parents are arranged into groups representing variations in lengths of 0.05 mm. These parental groups or classes are represented in figure by circles showing their respective lengths. The mean length of all the offspring of parents belonging to each group are represented by arrowheads. Amount of regression is in each instance indicated by arrow. The broken line just below 1.55 represents the mean of the line. The heavy circle is for the position of the means of all the parents above the mean of the line, and the heavy arrow for the regression of their offspring.

This mean is only 0.011 mm. above the mean of the line, hence regression, thus measured is found to be practically complete (see heavy arrow in Figure 1). Since so few parent individuals are below the mean, we will have to regard their numbers as being insufficient for a test similar to those above the line.

If the means of the parent groups and the means of the offspring for these groups are reduced to the scale of 100 for the mean of the pure line (by multiplying by 65) we get the following interesting series in which parental lengths are given above, and the means of the offspring below:

Length of parents in mm.; scale, mean of race=100	82.87	92.62	99.12	102.37	105.62	108.87	112.12	115.37	118.62	121.87	125.12	128.37	141.37
Mean length for offspring; scale, same as for parents.	116.00	92.65	88.20	96.59	97.50	99.97	101.14	98.02	101.01	104.91	113.23	103.25	122.85

Although we note that two of the low parental groups have low means for offspring, and two of the high parental groups have unusually high means for offspring, yet one of the low parental groups has a high mean for offspring and three of the high parental groups have low means for offspring. The general disagreement of the two sets of figures is evident, hence we see the lack of correlation while the regression is made evident.

Let us study further the regression found in the ten parental classes above the mean of the line. This can be done by the use of common fractions. Let the amount of regression in each case be indicated by a fraction, the numerator being the difference between the mean of the parent class and the mean of the offspring for this class, and the denominator the difference between the mean of the parent class and the mean of the pure line. If the numerator is smaller than the denominator the regression is not complete, if greater it is more than complete, if equal to the denominator it is just complete. If we do this we get the following series for the ten parental groups above the mean:

$$\frac{5.78}{2.37}+\frac{8.32}{5.62}+\frac{8.90}{8.87}+\frac{10.88}{12.12}+\frac{17.35}{15.37}+\frac{17.61}{18.62}+\frac{16.96}{21.87}+\frac{11.89}{25.12}+\frac{25.12}{28.37}+\frac{18.32}{41.37}$$

There being some regression in each case all of the fractions are positive. If we reduce the series to decimals we get:

2.44, 1.48, 1.00, 0.89, 1.13, 0.94, 0.77, 0.47, 0.88, 0,45.

Now then, if we add these fractions together and divide by their number we will get the average amount of regression, which if complete should give 1.00. The actual number which we obtain is 1.0465, which means that the regression was a little more than complete according to this way of measuring it. We find then that this statistical method of measuring the amount of regression confirms my earlier findings in regard to the effectiveness of long continued selection in a parthenogenetic pure line.

Variation, Selection and Regression under Similar Suboptimum Food and Temperature Conditions.

It has previously been mentioned that environmental conditions in two instances caused such a marked change in the size of both parents and offspring as to give a considerable amount of correlation between the two in size variation. For this reason the correlation noticed in Table I is misleading without the use of the annoted pedigree. During the second score of generations in isolation 11, selections were made under similar suboptimum food and temperature conditions. For this reason we should expect but little influence in size fluctuations coming from variations of these two factors, which were determined as being the two chiefly affecting size. We would expect, therefore, that the common statistical methods in analysis should be more applicable for selections made un-

TABLE VI.

TABLE SHOWING GROUPS TO CONTAIN PARENTS OF SECOND SCORE OF GENERATIONS OF ISOLATION 11, THE NUMBER OF PARENTS TO EACH GROUP, THEIR LENGTHS AND THE MEAN LENGTHS OF PROGENY OF PARENTS BELONGING TO EACH GROUP.

Group (length in mm.)	No. of parents in group	Length of parent	Mean length of offspring
1.50-1.54	1	1.53 mm.	1.518 mm.
1.55-1.59	1	1.59 mm.	1.549 mm.
1.60-1.64	1	1.61 mm.	1.407 mm.
1.65-1.69	2	1.69 mm.	
-		1.69 mm.	1.552 mm.
1.70-1.74	4	1.70 mm.	
-		1.73 mm.	
-		1.74 mm.	
-		1.71 mm.	1.515 mm.
1.75-1.79	3	1.79 mm.	
-		1.76 mm.	
-		1.79 mm.	1.574 mm.
1.80-1.84	5	1.80 mm.	
-		1.81 mm.	
-		1.80 mm.	
-		1.81 mm.	
-		1.84 mm.	1.495 mm.
1.85-1.89	3	1.89 mm.	
-		1.86 mm.	
-		1.86 mm.	1.638 mm.

der more constant conditions. Let us apply them to these 20 generations of isolation 11. We find the 20 parents fall into eight classes or groups which we made before for the parents of the three sublines. The number of these parents in these different classes, their lengths, and the means of the offspring of the parents belonging to each class are given in the following table:

If we make a plot to show the position of these parent classes and the means of the offspring in relation to the mean of the line, we get the following graph:

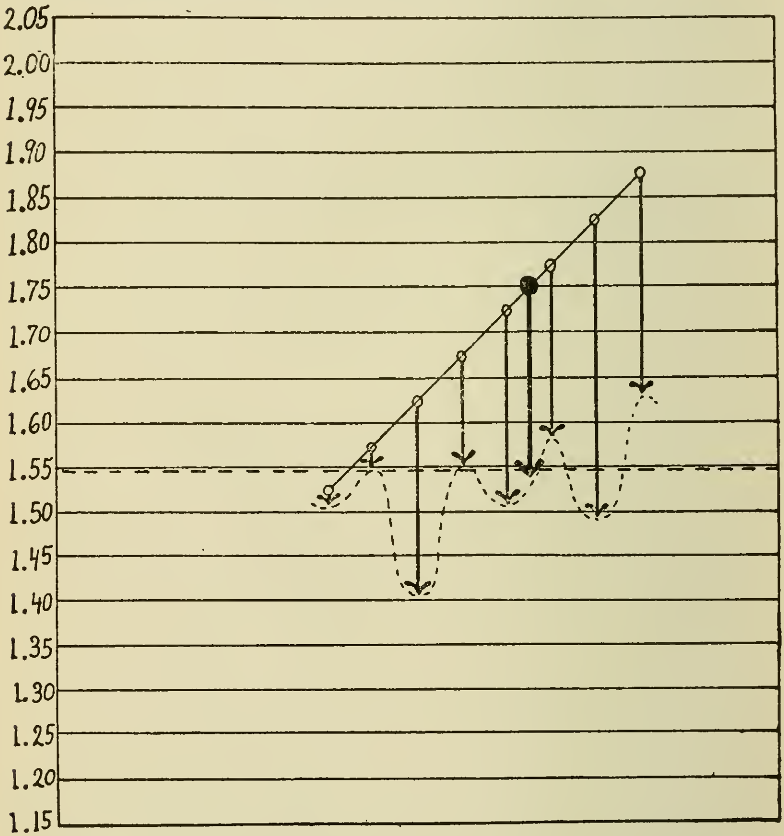


Fig. 2. Graph showing regression in the second score of generations of isolation 11, in which selections were made from the extreme variant of each fraternity in regard to body length. Plan of graph the same as for figure 1.

If we examine this diagram we notice that if the dotted line joining the arrowheads (which we may call the line of regression) were straightened out it would be almost identical with the mean of the pure line. The mean of the 20 parents represented in this second score of generations is 1.750 mm. The mean for the 221 offspring is 1.538, or 0.006 mm. below the mean for the genotype or pure line. What more could be asked in demonstrating the ineffectiveness of selection!

The mean lengths for the parents in these eight classes are here given reduced to the scale; mean of the line=100, and likewise under these in each case the mean of the offspring reduced to the same scale.

1.50-1.54	1.55-1.59	1.60-1.64	1.65-1.69	1.70-1.74	1.75-1.79	1.80-1.84	1.85-1.89
99.45	103.35	104.65	109.85	111.80	115.70	117.65	119.60
98.80	100.75	91.65	100.75	98.15	102.05	96.85	106.60

If we now express the regression by a series of fractions as was done with all three sublines we get the following:

$$\frac{-0.65}{0.55}+\frac{2.60}{3.35}+\frac{13.00}{4.65}+\frac{9.10}{9.85}+\frac{12.65}{11.80}+\frac{13.65}{15.70}+\frac{20.80}{17.65}+\frac{13.00}{19.60}$$

These fractions reduced to decimals give the following series:
—1.18+0.78+2.77+0.92+1.08+0.87+1.17+0.66.

In order to measure the regression as usual let us add these fractions and divide by their number. This gives the decimal 0.884, which indicates that the regression is 884/1000 complete. However, if we leave out one parent in the 1.50-1.54 class, the only one selected which was below the mean of the line, we get as the result for the nineteen parents above the mean the decimal 1.031, showing the regression to be more than complete. I think that the method of putting the parents into classes and computing the regression for each class is certainly open to serious objection, as it is not an accurate measure of regression in all cases, even though an enormous number of individuals be included. Of course more important than the number of either parents or offspring is the number of classes considered. If the results are to be plotted, here again we are limited to a relatively small number. Certainly the regression (digression in this case) of the offspring of the single parent in the 1.50-1.54 class should not count for as much as the regression of the five parents in the 1.80-1.84 class. Would it not be better to multiply each fraction by the number of parents belonging to the class (for which the fraction is supposed to indicate the amount of regression) by the number of parents in this class, then after adding the fractions divide by the total number of parents? This will not be an actual computation of the average for the amount of individual regression between each parent and each of the offspring, yet it will give a more accurate measure of regression according to class grouping method. If we do this we get the decimal 0.943 as a measure of regression, which is only 0.057′ from being complete.

What then is the result of these statistical studies? We find that they constitute a further substantiation of my earlier findings in regard to the ineffectiveness of selection in *Aphis avenae* Fab. It is noted, however, if these studies are not carefully applied, especially in the light of a fully annotated pedigree, they may cause us to make very faulty conclusions. A brief summary of this short mathematical study of selection and regression in *Aphis avenae* Fab. is here given:

SUMMARY

1. This statistical study of the selection work done with *Aphis avenae* Fab., in which eighty-seven generations were obtained, substantiates my earlier conclusions in regard to the negative effects of selection. Long continued selection (in one case forty-four) does not produce any positive effect in regard to somatic characters in general, these remaining true to the genotype.

2. By computing the regression through the parent class grouping method and using the mean of the line as standard of reference, it being reduced to 100, such figures as 1.0465 and 0.906 are obtained (according to this method complete regression would be expressed by 1.)

3. Measuring the amount of regression through the parent class grouping method facilitates the plotting (in the form of a graph) of the results, but does not give a very accurate measure of the amount of regression. However, this method is much improved from the standpoint of accuracy, if we multiply the results obtained for each parent class by the number of parents in the class, and divide the sum of such amounts by the total number of parents included.

4. Correlation tables between parents and immediate progeny in regard to any variable characters are deceptive in showing the results of selection in inheritance work. They should only be used in connection with graphic pedigree charts, and complete notes on environmental factors. When correlation tables were so used in regard to my selection work in *Aphis avenae* they substantiated in almost every case, the interpretations previously made.

5. The recent work which has been done in pure lines giving positive results in regard to selection, is to a certain extent open to the criticisms of the earlier work in pure lines which gave chiefly negative results.

6. It is very probable, as Jennings has pointed out, that the mechanism of inheritance in certain lower organisms is quite different from that of higher animals which have a uniparental type of reproduction. This difference may be so great that the principles of the pure line theory will not apply to them, in most respects at least.

7. Recent investigations in pure lines seem to have given us the much desired rigid tests called for by earlier critics, and these results are not in accord.

8. The pure line theory will probably not apply to such large classes of organisms as was at one time supposed, and may be modified in some respects in regard to those classes to which it does apply.

9. In higher organisms with a uniparental type of reproduction we have no strong evidence against the application of the main principles of the pure line theory of inheritance.

LITERATURE

Ackert, J. E., 1916. On the Effect of Selection in Parmaecium. Genetics, Vol. I, pp. 387-405.

Barber, M. A., 1907. On Heredity in Certain Micro-organisms, Kan. Univ. Sci. Bul., Vol. IV., No. 1, 48 pp.

East, E. M. 1910. The Transmission of Variations in the Potato in Asexual Reproduction. Conn. Exp. Sta. Rept., pp. 119-160.

Ewing, H. E., 1914, a. Pure Line Inheritance and Parthenogenesis. Biol. Bul. Vol. XXVI, pp. 25-35. 1914 b., Notes on Regression in a Pure Line of Plant Lice. Biol. Bul. Vol. XXVII, pp. 164-168. 1916, Eighty-seven Generations in a Parthenogenetic Pure Line of Aphis Avenae Fab. Biol. Bul., Vol. XXXI, pp. 53-112.

Jennings, H. S., 1908. Heredity, Variation and Evolution in Protozoa II. Proc. Amer. Phil. Soc., Vol. XLVII, pp. 393-545. 1909, Heredity and Variation in the Simplest Organisms. Amer. Nat. Vol. XLIII, pp. 321-337. 1911, Pure Lines in the

Study of Genetics in Lower Organisms. Amer. Nat., Vol. XLV. pp. 79-89. 1916, Heredity, Variation and the Results of Selection in the Uniparental Reproduction of Difflugia corona. Genetics, Vol. I, pp. 407-534.

Johannsen, W., 1903. Ueber Ehrlichkeit in Populationen und in Reinen Linein. V+I 68 pp. Jena: Gustav Fischer. 1911, The Genotype Conception of Heredity. Amer. Nat., Vol. XLV. pp. 129-159.

Lashley, K. S., 1915, Inheritance in the Asexual Reproduction of Hydra. Jour. Ex. Zool., Vol. XIX, pp. 157-210. 1916, Results of Continued Selection in Hydra. Jour. Exp. Zool., Vol. XX, pp. 19-26.

Middleton, A. P., 1915. Heritable Variations and the Results of Selection in the Fission Rate of Stylonychia Pustulata. Jour. Exp. Zool., Vol. XIX, pp. 451-503.

Shull, A. F., 1910. The Artificial Production of the Parthenogenetic and Sexual Phases of the Life Cycle of Hydatina sena. Amer. Nat., Vol. XLIV, pp. 146-150.

Stocking, Ruth J., 1915. Variation and Inheritance in Abnormalities Occurring after Conjugation in Paramecium caudatum. Jour. Exp. Zool., Vol. XIX, pp. 387-450. Whitney, D. D., 1912. "Strains" in Hydatina senta. Biol. Bul. Vol. XXII, pp. 205-218.

Winslow, C. E. A., and Walker, L. T., 1909. A case of Non-inheritance of Fluctuating Variations in Bacteria. Jour. Infect. Diseases, Vol. VI, pp. 90-97.

Woltereck, R., 1910. Weitere Experimentelle Untersuchungen über die Artevänderung, spezielle über das Wesen quantitativer Artunterschiede bei Daphniden. Biol. Central bl., XXX, pp. 679-688.

Woodruff, L. L., 1912. A Five-year Pedigree Race of Paramecium without Conjugation. Proc. Soc. Exp. Biol. and Med., Vol. IX, pp. 121-123.

AMPHIBIANS AND REPTILES OF THE CHARLESTON REGION

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Collections of amphibians and reptiles have accumulated in the zoology laboratory of the Eastern Illinois Normal School, and some notes have been obtained on representatives of these two groups in the region, chiefly in connection with the field work necessitated by the teaching of zoology classes. A study of the data from these sources has been made, and it seems important to print the results of this in the form of an annotated list, preliminary to more thorough investigations of the amphibians and reptiles of the Charleston region to be made in the future.

Specimens of several species could not be named by the writer unaided, so they were sent to A. G. Ruthven and Helen Thompson Gaige of the University Museum, Ann Arbor, Michigan, who identified the specimens. Credit is due them for this assistance.

Necturus maculatus Raf., Mud Puppy. Common in early spring just below the Dam on the Embarrass River near

Charleston, where the bottom is rocky. Mr. Charles Finley tells me that they are common in the Kaskaskia River at Cooks Mill in the northwest part of Coles County, Illinois, and not far from Charleston.

Fishermen frequently catch them on their hooks in the spring. One taken by the writer on March 23, 1908, had swallowed a Brook Lamprey, *Lampetra wilderi*.

Ambystoma tigrinum (Green), Tiger Salamander. Common about Charleston, where it dwells in dark, damp situations, like cellars, little used wells or cisterns. Many have been brought to the laboratory from such places and commonly from near breeding ponds.

Breeding occurs in the region in late February or March, as soon as it is warm enough to keep open water in the ponds for any length of time. The period is made evident by finding ovoid, gelatinous capsules with their eggs in ponds. Typically there are some twenty or thirty eggs together, and the whole mass is about three inches in length. The eggs are excellent for elementary embryological work. Tadpoles reared in the laboratory reached the adult form in late summer.

Ambystoma microstomum Cope. Small-mouthed Salamander. Several specimens have been brought to the laboratory. They have all been found in wooded regions about logs and brush.

Desmognathus fusca Raf., Dusky Salamander. (?) In August, 1910, two salamander larvae were caught that appeared to belong to this species, and Dr. Ruthven says that he has little hesitancy in referring them to this, but positive identification requires adults which have not been found in the region.

Diemictylus viridescens Raf., Green Newt. An example of the red form of this species was brought to me by Mr. Lee Morgan of Charleston, on September 15, 1906. It was found in some fire wood that had been brought in from the country. The species is apparently very rare in the region. Garman ('92) reports it as "throughout the state." Hurter, ('11) finds it in Illinois near St. Louis.

Bufo americanus Le Conte, Common Toad. This is the most conspicuous amphibian in the Charleston region. Its eggs are laid usually in April in the larger and more permanent ponds. Very few of these have been found in small temporary pools or in streams. This preference as to breeding habitat is undoubtedly a strong factor in making the toad so abundant compared with other amphibians in the region. Transformation stages are found in June, but they have been noted as late as September (September 10, 1902).

Acris gryllus Le Conte, Cricket Frog. Very common along shores of ponds and streams, preferring open, exposed shores to wooded ones and larger and more permanent bodies of water to small temporary ones. It has a longer active season than any other amphibian in the region and is common in early spring and late fall. Often it is seen in winter about streams, sometimes on the snow or ice there. Its breeding time has not been determined, but tadpoles an inch long have been found in late April (1904).

Hyla pickeringii Holb., Spring Peeper. The frogs have not been noted, but on May 30, 1912, some transformation stages were found in a pond some eight miles southwest of Charleston.

Hyla versicolor Le Conte, Tree Frog. Frequently heard, but specimens are rarely found on account of their inconspicuousness.

Chorophilus nigritus (Le Conte), Swamp Tree Frog. Common. Their calls are one of the signs of the arrival of spring. Their eggs appear to be laid in ponds of all kinds, including small temporary pools in which they commonly meet their destruction through these drying up within a few days after the eggs are laid. Typically some seventy-five or a hundred eggs are laid at once. These are embedded in an ovoid, gelatinous envelope about two inches in length and attached commonly to a submerged leaf or grass blade.

Some transformation stages were found on May 27, 1912, and on July 22, 1910, and August 17, 1910. The habitat of the adult in the region at times other than the early spring, has not been determined, for only one specimen has been found away from the breeding places and that one was in a clover field, July 23, 1909.

Rana pipiens Shreber, Leopard Frog. Rather common in the region but more often seen in early spring, when breeding takes place. Mr. Ruthven in examining the Leopard Frogs sent him found them to be very similar to *Rana sphenocephala* Cope.

The eggs are laid in early spring chiefly in isolated ponds and pools, even those that dry up in a short time producing much mortality of the tadpole progeny. Very few eggs have been found in the quiet pools of streams, although frogs are often about these places in numbers during the breeding season. The gelatinous egg masses are commonly conspicuous for they are large, often about the size of a double fist, and subglobular in form; each contains many hundred eggs.

The life cycle of the Leopard Frog is usually if not always completed during the season that the eggs are laid. Transformation stages and young frogs have been found on the following dates: July 7, 1904; June 27, 1913; July 7, 1913. A large frog of this species was in the stomach of a large Garter Snake, *Thamnophis sirtalis*, taken on November 24, 1913, (Hankinson, '15).

A Leopard Frog, brought in on September 29, 1905, by Mr. Elmer McDonald, is abnormal in having two arms on the right side, one of which is small and lacks the hand; and the left arm is two-branched at the elbow, each branch is the same size and with a complete hand. Wagner ('13) found a similar specimen with supernumerary arms.

Rana cantabrigensis Baird, Wood Frog. Sometimes found in deep ravines; apparently uncommon.

Rana catesbeana Shaw, Bull-frog. Common about larger streams and ponds in the region. Frogs with bodies six or more inches in length are frequently seen along the Embarrass River where they are sometimes shot with small rifles on account of their edible hind legs. Large tadpoles of this species nearly six inches long are often found.

Storeria dekayi (Holb.), De Kays Snake. Only one has been found in the region, and this came from a piece of upland woods along a ravine. Garman ('92) says that it is found in all parts of the state, but it is not very common.

Storeria occipitomaculata (Storer), Red-bellied Snake. Two have been found in a piece of upland woods near Charleston. It is generally distributed in Illinois, according to Garman ('92).

Heterodon platyrhinus Lat., Hog-nosed Snake. One of the more common snakes of the region. It is very generally distributed at least in the wooded regions about Charleston, and a number have been found in the city. Locally, it is known as "Spreading Adder" and is commonly and erronously considered poisonous. It may be indirectly injurious to man through destroying toads, which are thought to be its chief food.

Elaphe obsoletus (Say), Pilot Snake. This appears to be one of the most common snakes in the region. More have been found to the writer's knowledge about wooded bottom lands along the Embarrass River than elsewhere about Charleston. All have been large, four to five feet in length. They frequently reside among tree branches, where they are very inconspicuous and probably do much damage to birds. The writer knows of one of them killing four young robins, three of which it swallowed. These were the contents of a nest some fifteen feet up in a tree in a farm yard near Charleston. Robert Ridgway ('14), writing of the Pilot Black Snake in Southern Illinois, says: "It is without question an inveterate enemy of bird-life, swallowing old, young, and eggs alike." A detailed study of the food of this reptile would undoubtedly yield important results.

Natrix sipedon (Linn), Watersnake. Common in spring along larger streams where they are most often seen about places where fish congregate. They undoubtedly destroy many fish. One was seen to capture a Common Sucker, *Catastomus commersonii*. The fish was 9 in. long and the snake 4 ft.. It required a violent struggle to land the fish. When to shore the snake began immediately to swallow its prey. This was about ten o'clock at night, which makes it evident that Watersnakes hunt to some extent at least, at night as well as by day.

It is possible that the above notes refer to more than one species of *Natrix*, but it is very evident that *sipedon* is the common species in the region.

Clonophis kirtlandi (Kenn.), Kirtland's Snake. One was found in a pasture near the Normal School, under a board on the ground, August 24, 1912.

Opheodrys aestivus (Linn.) Green Snake. Several specimens of this beautiful species have been found in the region. Its grass-green color very effectively conceals it, so it is likely that more of them are present than our few records show.

At one time a Green Snake was seen climbing up the trunk of an oak, which it appeared to be doing with difficulty and was depending much upon bark projections and short twigs.

Bascanion constrictor (Linn.), Blue Racer. Apparently scarce in the region. Only one has been taken, but another was at one time seen about the tops of the bushes in a patch in an open ravine. Garman ('92) records it as throughout the state. Some eggs of Blue Racer were brought to the writer, that had been ploughed up on the farm of Grover Millage in Coles County, Illinois, about September 22, 1917. Three of the eggs hatched soon after they were collected.

Lampropeltis doliatus Linn. Milk Snake. A few very small examples of the species have been taken about Charleston to the writer's knowledge. Garman, ('92) considers it as moderately common throughout the state.

Lampropeltis calligaster Harlan. King Snake. One of the more common snakes of the region. A number have been brought to the laboratory, including some large ones, between two and three feet long. Garman ('92) says it occurs on prairies throughout the state and is not very common.

Thamnophis radix Baird and Girard, Prairie Garter Snake. Two specimens of this garter snake were found in a ploughed field on April 15, 1912. Garman, ('92), says that it occurs in all parts of the state but is more common north.

Thamnophis sirtalis (Linn.), Common Garter Snake. Quite often found, but it is not abundant in the region. One was found that had swallowed a large frog, *Rana pipiens*, (see infra).

Crotalus horridus Linn., Timber Rattlesnake. Scarce and apparently local in distribution in the Charleston region. Four have been taken in the last thirteen years and brought to the laboratory. All were from a farm or two along the Embarrass River about three miles east of Charleston. Others have been reported from this restricted area and none from any other about Charleston. One of these snakes, about 3 feet long and with eleven rattles, has been kept alive for nearly a year and without food, which it refuses. It will kill mice and other small living animals but will not swallow them. It drinks water readily.

All of the four snakes were large; one was 44.5 inches long. Garman ('92), says that it is common throughout the state in hilly forest regions, but it is being exterminated rapidly.

Platypeltis spinifera (LeSueur), Soft-shelled Turtle. Quite common in the larger creeks near Charleston, and a few have been seen in the Embarrass River. Garman ('92), records it as throughout the state.

Chelydra serpentina (Linn.), Snapping Turtle. This is one of the most common reptiles in the region, where it is common about streams and the larger, more permanent ponds. In late spring examples are frequently found wandering remote from water, probably looking for places to lay eggs or looking for bodies of water after the process is completed. A farmer, whose land is cut up by a small stream system where these turtles occur, says that he sometimes plows up eggs that seem, from his description, to be of this species. They are found in the lowest portions of fields.

Chrysemys (species?), Painted Turtle. A few have been seen about drainage ditches on prairies, but none have been taken.

Emyboidea blandingii (Holb.) Blandings Turtle. A fine large specimen was taken in a prairie pond on April 15, 1914, some four miles north of Charleston. The specimen was lost; nevertheless, there can be no doubt as to its identity. Garman ('92) says of the species: "Throughout the state, commoner north; formerly abundant on the prairies, but rare at present."

Terrapene carolina (Linn.) Box Turtle. Sometimes found in woods, especially in wooded ravines. In June, of 1912, three were found together on the bank of a small stream; more often they are solitary.

SUMMARY AND CONCLUSIONS

Thirteen species of amphibians and eighteen species of reptiles have been found by the writer and his students in the Charleston region. Since no special effort has been made to study these forms, it is very evident that other species also belong to the fauna.

The region is not now a favorable one for amphibians and reptiles, which is due in a large measure to the extensive cultivation of land and to the ephemeral character of so many bodies of water in which amphibian eggs are laid. Only three species of amphibians are abundant; these are the Common Toad, Cricket Frog and Bull-frog. There is no really abundant reptile. Poisonous snakes are very scarce, and the only species found recently to the writer's knowledge is the Timber Rattlesnake.

Reptiles and amphibians undoubtedly existed in large numbers in former times about Charleston, before the large prairie ponds were drained. Reports by old residents of the many rattlesnakes that lived about these places are common. These were probably Prairie Rattlers, *Sistrurus catenatus*.

Amphibians and reptiles appear to be of little economic importance in the region, but this may be due to our lack of knowledge of their food and habits and ecology. Profitable studies of this kind might be made on the toad and its enemy, the Hog-nosed Snake and the two well-known bird destroyers, the Pilot Snake and the Blue Racer, and the amount of destruction to fish done by the Watersnake. The Bull Frog is used to some extent as an object of sport and food.

Efforts should be made to prevent undue decrease in numbers of our amphibians and harmless reptiles, if for no other reason than their biological interest and their adaptability for zoology studies. They are easily collected, preserved as speciments, or kept alive in aquaria or terraria; and they lend themselves readily for life-history studies.

LITERATURE CITED

Davis, N. S., and Rice, F. L., 1883. List of Batrachia and Reptilia of Illinois, Bulletin of the Chicago Academy of Science, Vol. I, pp. 25-32.

Garman, H., 1892. A synopsis of the Reptiles and Amphibians of Illinois. Bulletin of the Illinois State Laboratory of Natural History, Vol. 3, pp. 215-385. Plates I-XV.

Hankinson, T. L., 1915. The Vertebrate Life of Certain Prairie and Forest Regions near Charleston, Illinois, Bulletin of the Illinois State Laboratory of Natural History, Vol. 11, pp. 281-303. Plates LXIV-LXXIX.

Hay, O. P., 1892. Batrachia and Reptilia of the State of Indiana, Seventeenth Annual Report of the Department of Geology and Natural Resources of Indiana, pp. 409-602.

Hurter, Julius, 1911. Herpetology of Missouri, Trans. of the Academy of Science of St. Louis, Vol. 20, pp. 59-271. Plates XVIII-XXIV.

Ridgway, Robert, 1914. Bird Life in Southern Illinois. Bird Lore, Vol. 16, pp. 409-420.

Wagner, George, 1913. On a Peculiar Monstrosity in a Frog, Biological Bulletin, Vol. 25, pp. 313-317.

Wilson, C. E., 1906. History of Coles County, Illinois, Historical Encyclopaedia of Illinois, Munsell, Chicago.

CRANE TOWN DESTROYED

W. S. Strode, Lewiston

The village of Cranetown was on Spoon River about four miles southwest from the little city of Lewiston, the county seat of Fulton county, state of Illinois. It was surrounded by a great primitive forest of about 300 acres enclosed on three sides by an ox bow bend of the river. On the south the bluffs arose to a height of 150 feet. These hills were heavily timbered, but not with such gigantic trees as grew in the valley below. At the time of which I write it was one of the finest tracts of native timber to be found anywhere in the state. On the north, along the banks of the stream, grew several hundred hard or sugar maple trees. The timber farther back consisted mainly of great unbending sycamores, soft maple, elm, hackberry, cottonwood, buckeye, walnuts of both kinds, and a fringe of willows along the river banks. Of the undergrowth there were large spaces covered with elderberry, much loved by the wild turkeys, patches of blackberry vines, kinnikinick, wahoo, several kinds of wild grape vines, both the three leaved and five leaved ivies, greenbrier, yellow root vines and in the lowest places were acres of wild balsams or touch me nots, much sought for by the humming birds for the nectar contained in their cub-like blossoms.

Big spaces were covered with stinging nettles; in places the ground was carpeted with a mass of wood violets, many jack-in-the-pulpits and an occasional trumpet creeper that climbed to the top of the big trees. The urban village of Cranetown was builded in the very tops of a half dozen of the giant sycamores that grew in a group close together. Each tree had from six to a dozen or more houses in it. In the summer time when all were at home, including the babies, the population was 100 or more. They were all fishermen and adhered strictly to business. They were peaceful people, minded their own business, bothered no one and asked only to be let alone. Here they had lived from time immemorial. It was a picturesque sight to stand on High point to the south and look over the intervening trees and see this village of tree dwellers in the tops of those giants of the forest towering over all the rest of the woods.

Like some others of our citizens the people of this village all journeyed to the south in the autumn and remained there through the winter time, but their domiciles remained and were conspicuous objects in the landscape for long distances around.

They were an industrious people, laboring day and night when the appetites of an hungry young family demanded much food of fish, crayfish and frogs. The Indians probably respected them and passed them by without molestation and so did the early pioneer hunters and farmers.

But this is a world of change. All things mundane must have an ending and so did this ancient village of Cranetown. The increase of population, the clearing of the forests and the introduction of modern firearms sounded their doom.

One time a part of us went down into this wood one bright moonlight night to cut an early found bee tree. Passing under Cranetown which was at a time when the young ones were nearly big enough to leave their nests, we were surprised at a great commotion raised by the three or four dogs that had accompanied us. Approaching we found them surrounding a great blue heron who was then on the ground with a broken wing. He was making a valiant fight for his life, stabbing at the dogs with his long dagger-like bill and every hit brought a howl. We called off the dogs and on examining the ground under the trees found a number of dead immature young birds.

Up in the nests in the tops of the trees other young birds were uttering hunger-distressed cries which plainly said, "We are deserted and very hungry."

We subsequently learned that a day or two before some young fellows from the city had been down here and with new fangled, hard-shooting guns had amused themselves as no Indian would have done by shooting up Cranetown. They had killed or crippled many of the young birds and some of the old ones that had ventured within range of their rifles.

The next year a lesser number of the herons came back and tried to resurrect the town, but they were again shot up and thenceforth Cranetown was a deserted village—a thing of the past.

It is not generally known that the birds were the original dancers, and of the several kinds of dancing birds the cranes "took the cake." Nearly all the Phasianidae at times do more or less dancing. The old wild gobbler, I have seen several times do a very neat "hoedown" and the darling little quails do a good imitation of a cake-walk. For a regular quadrille the sandhill cranes take the blue ribbon. In the early days I have seen a party of them on a high piece of ground on the Bushnell or West Prairie Country go through a stunt that would make a dog laugh. They would form a square and after a few preliminary bowings and salutings, they would promenade all, four hands forward and back, balance all and all the time with an accompaniment of clattering bills much like castanets, wings half raised, or an old male with one wing raised as he promenades with his partner. Of course it is all a matter of courtship and for that matter the modern dance is also.

THE EFFECT OF STARVATION ON THE CATALASE CONTENT OF TISSUES

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When an animal is starved or is supplied with an insufficient amount of food to meet the wear and tear and energy requirements of the body, the tissues themselves are consumed. The extent of this consumption differs very widely in the different organs. The heart for example, loses very little in weight while the skeletal muscles lose much, the fat and glycogen completely disappear. The organs in which metabolism is most intense, such as the heart and central nervous system, preserve themselves best while the organs in which metabolism is less intense waste away. The preservation of the working tissues is thought to be brought about by the autolysis of the other less active tissues. The products of autolysis of these less active tissues pass into solution in the blood, are carried to the master tissues and used. The object of this investigation was to determine what change, if any, occurs in the catalase content of the heart, skeletal muscles and fat during starvation with the hope of finding an explanation for the fact that the heart muscle is not autolyzed during starvation while the skeletal muscles and fat are.

Twelve rabbits were placed in a cage and fed for six days on cabbage, turnips and apples. At the end of this time two of the rabbits were etherized and the blood vessels washed free of blood by the use of large quantities of 0.9 per cent sodium chloride. The heart, soleus muscle (red muscle) and fat around the kidney were removed and ground up separately in a hashing machine. The catalase content of these tissues was determined by adding one gram of the material to 45 cc. of hydrogen peroxide in a bottle. As the oxygen gas was liberated it was conducted through a rubber tube into an inverted burette previously filled with water. After the oxygen gas thus collected was reduced to standard atmospheric pressure the resulting volume was taken as a measure of the amount of catalase in one gram of the tissue. The catalase content of the heart, soleus muscle and fat of rabbits starved for two, four and six days respectively was determined as it had been for the normal rabbits. The results of these determinations are given in table 1. Each of the determinations represents an average for two animals.

TABLE 1.

After heart, leg and fat are given the amounts of oxygen in cubic centimeters, liberated in ten minutes from 45 cc. of hydrogen peroxide by the catalase in 1 gram of the respective muscles of rabbits.

Rabbits	Normal	Starved Two days	Starved Four days	Starved Six days
Fat	33	13	12	No fat
Heart	73	71	75	75
Leg	72	58	54	44

It may be seen in table 1 that one gram of the heart muscle of the normal rabbit liberated 73 cc. of oxygen in ten minutes from 45 cc. of hydrogen peroxide; that of the rabbits starved for two, four and six days liberated 71, 75 and 75 cc. of oxygen respectively; that 1 gram of the leg muscle of the normal rabbit liberated 72 cc. of oxygen; that of the rabbits starved for two, four and six days liberated 58, 54 and 44 cc of oxygen respectively; that one gram of the fat of the normal animals liberated 33 cc of oxygen, that of the animals starved for two and four days liberated 13 and 12 cc. of oxygen respectively while there was not sufficient fat in the animals starved six days for a determination.

By comparing the amounts of oxygen liberated by the heart of the animals starved for the different lengths of time, it will be seen that starvation produced no effect on the catalase content of the heart muscle, that it reduced the catalase content of the leg muscle by 37 per cent as is indicated by the decrease from 72 cc. of oxygen, the amount liberated by 1 gram of the muscle of the normal animals to 44 cc., the amount liberated by the muscle of the animals starved for six days. It may also be seen that the catalase content of the fat was reduced during the first two days of starvation by about 61 per cent as is indicated by the reduction of oxygen liberated from 33 cc., the amount liberated by one gram of fat of the normal animal to 13 cc., the amount liberated by one gram of fat of the animal starved for two days, and that the catalase content of the fat remained low during the rest of the period of starvation.

The preceding experiments show that the catalase content of fat and skeletal muscles which are autolyzed during starvation is decreased while it remains normal in amount in the heart which is not autolyzed during starvation. It has been shown that the amount of oxidation in a tissue is proportional to the amount of catalase present (1). From this it follows that oxidation is decreased during starvation in tissues such as fat and skeletal muscles in which the catalase is decreased, and remains normally high in a tissue such as the heart muscle. It is known that the autolyzing enzymes in common with other enzymes are destroyed by oxidation (2). The great resistance of the heart muscle to the digestive action of the autolyzing enzymes during starvation may be due to the intense oxidation in this organ, the assumption being that the autolyzing enzymes are oxidized and thus rendered inert. By the great decrease in the oxidative processes of skeletal muscles and fat during starvation the check on the autolyzing enzymes is removed and they are thus left free to digest these tissues.

Conradi (3), Rettger (4), and Effront (5) showed that when bacteria and yeasts were starved by being placed in a physiological salt solution, where there was no food, they were autolyzed. The explanation usually offered this bacterial autolysis is that "the normal existing autolytic processes are not counteracted by synthesis of new protein material." A more plausible explanation would seem to be that by starvation the oxidative processes are decreased, thus removing the normal check on the autolytic enzymes, with resulting digestion of the cells.

Neuberg (6) found that when cancer tissue was exposed to radium rays the rate of autolysis of this tissue was greatly increased. He also found that the autolyzing enzymes of this tissue were not destroyed as were the oxidizing and other enzymes by the exposure. On the basis of these experiments it is assumed that the great increase observed in the activity of the autolyzing enzymes in the cancer tissue when exposed to radium rays was made possible by the decrease in oxidation in this tissue which in turn was due to the destruction of the oxidizing enzymes by the rays, thus leaving the autolyzing enzymes free to digest the cancer tissue.

It has been shown that the resistance to the digestive action of trypsin of unicellular organisms, paramecia, living in a solution of this enzyme can be decreased by decreasing the oxidative processes so that these organisms are literally digested alive and that they are revived provided digestion has not proceeded too far, when normal oxidation is restored (7). From these and similar experiments (8) the authors conclude that the means by which living cells protect themselves from being digested by intracellular as well as extracellular enzymes is oxidation.

CONCLUSIONS

From the evidence presented in this paper the conclusion is drawn that the catalase content of the heart, which is not autolyzed during starvation, remains normally high while the catalase content of the fat and skeletal muscles, which are autolyzed during starvation, is greatly decreased. In view of the fact that the catalase content of a muscle is directly proportional to the amount of oxidation in the muscle and that the autolyzing enzymes are destroyed by oxidation, the further conclusion is drawn that the heart is not autolyzed during starvation because oxidation in this organ remains normally intense and thus provides for this oxidation of the autolyzing enzymes and the maintenance of the normal balance between oxidation and autolysis; on the other hand the fat and skeletal muscles are autolyzed during starvation because of the decreased oxidation which leaves the autolytic enzymes free to digest these tissues.

BIBLIOGRAPHY

1. Burge: This Journal, 1916, XLI, 153.
2. Burge: This Journal, 1914, XXXIV, 140.
3. Conradi: Deutsch. med. Wochenschr., 1903, XXIX, 26.
4. Rettger: Journ. Med. Research, 1904, XIII, 79.
5. Neuberg: Zeitschr. f. Krebsforschung, 1904, II, 171; Berl. Klin. Wochenschr., 1904, XLI, 1081.
7. Burge and Burge: Journ. Amer. Med. Assoc., 1916, LXVI, 998.
8. Burge and Burge: Journ. of Parasitol., 1915, I.

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 *Active Members, Non-resident Members, and Life Members.*

Active Members shall be persons who are interested in scientific work and are residents of the State of Illinois. Each active member shall pay an initiation fee of one dollar and an annual assessment of one dollar.

Non-resident Members shall be persons who have been members of the Academy but have removed from the State. Their duties and privileges shall be the same as those of active members except that they may not hold office.

Life Members shall be active or non-resident members who have paid fees to the amount of twenty dollars. They shall be free from further annual dues.

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.

All workers in science present at the organization meeting who sign the constitution, upon payment of their initiation fee and their annual dues for 1908, become charter members.

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, 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 Librarian, 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. Publication

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 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 last 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 commitees.
7. Unfinished business.
8. New business.
9. Election of officers.
10. Program.

    Adjournment.

II. No meeting of the Academy shall be held without thirty days' previous notice 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 Secretary 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.

IX. The Secretary and 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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(Revised January, 1918.)

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Wilson, Eva M., M.D., Manhattan. (Medicine.)
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*Winter, S. G., A.M., Lombard College, Galesburg. (Histology.)
Wirdlinger, Sidney, Ph.D., Galesburg. (Chemistry.)
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Woods, F.C., Galesburg. (Physics.)
Woodburn, William L., Northwestern University, Evanston. (Botany.)
Woodruff, Frank M., Chicago Academy of Science, Chicago. (Taxidermy).
Zehren, Karl C., Antioch. (Agriculture.)
Zeleny, Charles, Ph.D., University of Illinois. (Experimental Zoology.)

*Charter Members.

TRANSACTIONS

OF THE

Illinois State Academy of Science

ELEVENTH ANNUAL MEETING

Joliet, Illinois, February 22 and 23, 1918

VOLUME XI

1918

[PRINTED BY AUTHORITY OF THE STATE OF ILLINOIS]

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EDITED BY

J. L. PRICER AND A. R. CROOK

(30790-1M)

ILLINOIS PRINTING CO., DANVILLE, ILL.

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PAST OFFICERS OF THE ACADEMY

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President, T. C. Chamberlin, University of Chicago.
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1909

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President, John M. Coulter, University of Chicago.
Vice-President, R. O. Graham, Illinois Wesleyan University.
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Treasurer, J. C. Hessler, James Millikin University.

1911

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

1912

President, Henry Crew, Northwestern University.
Vice-President, A. R. Crook, State Museum of Natural History.
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1913

President, Frank W. DeWolf, State Geological Survey.
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1914

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

1915

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Secretary, A. R. Crook, State Museum, Springfield.
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1916

President, William Trelease, University of Illinois, Urbana.
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1917

President, J. C. Hessler, James Millikin University, Decatur.
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.

MINUTES OF THE ELEVENTH ANNUAL MEETING

The eleventh annual meeting of the Illinois State Academy of Science was called to order, in the Township High School building of Joliet, at 2:00 P. M. Friday, February 22, 1918, by the President of the Academy, Dr. J. C. Hessler.

The minutes of the 1917 annual meeting were read by the Secretary, and approved as read. Reports were made by the Secretary and the Treasurer. Both were accepted on motion, and the latter was referred to the auditing committee. The Secretary's report related how the committee on publications, had acted on what they believed was sure information to the effect that the appropriation of $2,000.00 for the Academy by both houses of the legislature, had received the sanction of the governor, and had contracted for and about completed the publication of Volumes IX and X of the Academy transactions, only to find out later that the governor had really vetoed the measure. This error gave the Academy two perfectly good publications, but unfortunately left it with a debt of something over $1,400.00 While this matter was under discussion, the Secretary read a brief paper which had not been announced in the printed program, and which consisted in the main of a plea to the members to stand by the organization and to help raise the funds necessary to pay the debts, by paying life membership fees and by personal donations. However much or little this paper may have had to do with it, it is true that a splendid spirit pervaded the whole meeting, and as will be shown by the Treasurer's report this year, this spirit continued pretty well thruout the year.

Professor S. A. Forbes gave the annual report for Committee on Ecological Survey, and Dr. A. R. Crook and Professor R. E. Wager gave brief oral reports for the committees on Legislation, and on Conservation of Wild Life, respectively.

Following the reports of officers and committees, Professor H. H. Stock gave a brief address on the then existing need for the conservation of coal.

Mr. C. H. Smith next presented a list of about 35 names of candidates for membership in the Academy and all were duly elected.

Next, a rather long list of amendments to the Constitution of the Academy were presented, and after some discussion, were adopted as originally proposed. These amendments have been incorporated in the constitution as it is printed in Volume X of the Academy transactions.

Next President Hessler presented to the Academy an invitation to join with the Indiana Academy of Science in a joint meeting some time later in the spring. It was voted to accept the invitation and eighteen members present expressed a desire to attend such a meeting.

Committees were appointed by President Hessler as follows: Committee on Nomination of Officers: Cowles, Noyes, Spicer, Vestal, and Waterman.

Committee on Auditing: Barber, VanCleave, and Lutes.

Committee on Resolutions: Knipp, Pepoon, Wager, and Miss Marshall.

Following this business session, a number of papers of general interest were presented, this concluding the program for the afternoon.

At 7:00 o'clock in the evening the members of the Academy present, together with a goodly number of citizens of Joliet, enjoyed a delightful banquet at the Woodruff Inn.

At 8:00 o'clock, the Academy and a good sized audience of Joliet people again assembled in the high school building and listened to two addresses as follows: One on Science and Patriotism, by President J. C. Hessler, and the other by Professor John M. Coulter, on The Mission of Science in Modern Civilization.

The program for Saturday morning consisted of a Symposium on the general topic, Science and Education. It included seven most excellent papers each of which set forth in most admirable form the claims of some branch of science to a place in general education.

Valuable discussions of the papers were added by Dr. Downing, and Dr. Latham, and others.

At 12:00 o'clock noon, the visiting members of the Academy were delightfully entertained at luncheon by the faculty of the Joliet Township High School.

At the opening of the Saturday afternoon session the committee on Nomination of officers reported the following for the officers for the ensuing year: For President, Professor R. D. Salisbury, Chicago; for Vice-President, Isabel S. Smith, Jacksonville; for Secretary, J. L. Pricer, Normal; for Treasurer, T. L. Hankinson, Charleston; for member of the committee on publications, Dr. H. J. Van Cleave, Urbana; for members of the membership committee, Dr. Frank C. Gates, Carthage, chairman; Dr. John S. Rich, Urbana; Professor F. D. Barber, Normal; Dr. W. S. Woodburn, Evanston; and Professor W. J. Risley, Decatur.

On motion, the Secretary was instructed to cast the ballot and all were declared elected.

It was moved and carried that an amendment to Article VIII of the by-laws be presented at the next meeting, providing that no papers shall be presented by any person other than the author except on vote of the Academy.

It was moved and carried that a committee of five be appointed in the Academy to study the question of the improvement of high school courses in botany, zoology, biology, and physiology, along the lines suggested in the papers of the symposium on Science and Education.

It was moved and carried that the Council of the Academy be given power to act in the matter of bringing about an affiliation of the Academy with the Division of State Museum, of the Department of Registration and Education of the State government.

Following this business session the remaining papers offered by members were presented and discussed, and the meeting adjourned at 4:20 P. M.

J. L. PRICER, *Secretary.*

Reports of Officers and Committees

REPORT OF THE SECRETARY

A meeting of the Council of the Academy was held at Urbana on April 7th, 1917, with all members present. The first item of business transacted was the acceptance, by unanimous vote, of the invitation extended to the Academy, by the mayor and other prominent citizens of Joliet, to hold the present meeting in this cty.

Next, the general character of the present program was determined, and the working out of details of the program was left in the hands of the President and Secretary. Several other matters concerning the general policy and welfare of the Academy were discussed, but no definite action was taken on any of them.

On June 29th and again, on July 5th, the Secretary was informed by Dr. A. R. Crook, of the Committee on Legislation, that House Bill No. 853, containing a provision of a thousand dollars a year for the publication and distribution of the Academy Transactions, had been passed by both houses of the legislature and signed by the governor. The second letter from Dr. Crook contained a copy of the bill, with the Academy appropriation set forth plainly in black and white. This convinced the Committee on Publications that the money so much needed by the Academy was at last within reach and they proceeded to arrange for the publication of Volumes IX and X of our Transactions, the manuscripts of which were in our hands.

I should say here that no meeting of the Committee on Publications was held to discuss the policy to be followed under this supposed new order of things. The business was carried on by correspondence and the policy adopted, was in the main, projected by the Secretary and consented to by the other members of the committee. In projecting the policy which was adopted by the committee, I was influenced by a firm belief that there was little liklihood that such aid from the State would not be continued in the future, since it had been granted us this time in a time of great national stress, and under a policy of the strictest economy on the part of the governor.

Since we thus believed that we were assured of $2,000.00 for the biennium, and in that time would have three volumes to publish, I thought it best not to attempt to publish the two volumes already in hand with the $750.00 available for printing the first year, but to borrow a little from the amount available the second year, when only one volume would be published. I also felt that one of the surest ways of guaranteeing State aid in the future was to make the publications of this year as valuable as possible, so as to be able to convince the State authorities that our publications are worthy of the aid granted. Consequently I made a special effort to make the volumes as complete as possible.

Early in August a contract was made with the Miller Printing Company, of Bloomington, for the publication of the two volumes in editions of 2,000 copies each. When the galley proofs were ready they were sent to the contributors for correction, with the statement that the Academy would furnish each contributor with fifty free reprint copies of his article, and that additional copies, in lots of fifty, might be had at a cost of eight cents per page. According to our contract with the printer, the first set of fifty reprints were to cost the Academy thirty cents per page. All contributors, except Dr. Hessler, accepted the offer. Perhaps the offer should now be recalled.

I favored offering the free reprints, first because it would lead to a much wider dissemination of the papers, second because it would attract better papers to our programs, and third because I felt that it was due the contributors.

So matters proceeded until the last week of last December, when Volume IX was about ready for distribution and would soon need to be paid for. Professor Hankinson, the Treasurer, wrote to the Auditor of Public Accounts, asking about the procedure necessary in order to make payments out of the fund provided by the State. We were all astounded by the reply, which was to the effect that no such fund existed; that the governor had vetoed the Academy item in the bill.

The 2,000 copies of Volume IX were printed when this discovery was made, and Volume X was all up in type. Volume IX consists of 262 pages and will cost, in the 2,000 edition, $660.65. Volume X will consist of 358 pages and in a 2,000 edition would cost $902.10. The printer, however, is willing to cut the edition to 1,000 copies and this will cost $605.70. These costs are exclusive of the cuts for the two volumes, which amounted to $207.25 which has already been paid out of the Academy Treasury. The printing bills in connection with the present program, and for envelopes for mailing out proof, and copies of Volume IX and X, amount to $88.60. The Secretary has a bill for postage on proofs, on copies of Volume IX, and for general correspondence amounting to $30.17. This makes a total of outstanding bills to date, of $1385.12, assuming that Volume X is to be published in a 1,000 copy edition and that the offer of free reprints be recalled. It will cost about $25.00 to mail out copies of Volume X to the members. This will make a total of $1,410.12, which would be needed at the present time to clear us of debt, aside from some small expenses connected with the present meeting.

I had been promised that Volume X would be ready for distribution at this meeting, but heatless Mondays and a few other causes of delay made that impossible, but I am now promised that within a week or ten days I shall be able to send it to the members.

J. L. PRICER, *Secretary.*

REPORT OF THE TREASURER

February 18, 1918.

RECEIPTS

Feb. 23, 1917, Balance on hand	$ 33.81
Feb. 18, 1918, Dues and Initiation fees to date	327.43
Feb. 18, 1918, Life Membership Fees to date	159.00
Feb. 18, 1918, Donations to date	59.00
Total receipts	$579.24

EXPENDITURES

Traveling expenses of officers to date	$ 75.19
Printing, (Including plates for Volumes IX and X)	243.94
Postage, stationery and sundries	37.18
Balance on hand, Feb. 18, 1918	222.93
Total expenditures	$579.24

T. L. HANINSON, *Treasurer.*

REPORT OF ECOLOGICAL COMMITTEE

To the State Academy of Science:

I have first to report the reorganization of the State work heretofore carried on by the State Laboratory of Natural History and the State Entomologist's Office, these being now united under the name of the Natural History Survey of the State as a division of the State Department of Registration and Education. The functions of this Survey are the same as those of the offices which it supersedes, except that they now cover both the botany and the zoology of the state comprehensively, and that the term botany is made to include forestry and plant pathology, in which no state survey work has heretofore been done. The management and staff of the Natural History Survey remain as before, but its work is placed under the control of committees made up of the director of the Department, the chief of the Survey, the vice-president of the University of Illinois, Professor John M. Coulter, of the University of Chicago, and Professor Wm. Trelease, of the University of Illinois. The whole field of the biology of the state is thus covered in all its aspects and bearings, scientific, educational, and economic.

The current work of this Survey during the past year has been largely a study and organization of our recently accumulated chemical and biological data from the Illinois and the Des Plaines rivers and from the Sanitary Canal, brought into comparison with the biological and chemical data obtained before the opening of the canal with a view to an analysis of the effects of that revolutionary event upon biology of the Illinois River system. This work is still in progress, but some of the principal conclusions reached concerning spring and summer conditions can now be stated.

We find that the original sewage load of the upper Illinois has been somewhat more than doubled since 1899* as measured in kilograms of chlorine per second carried by this stream in its downward flow, but that the sewage in the upper river is now much more dilute and very much fresher than in the earlier period. These latter differences are largely due, of

*The Sanitary Canal, it will be remembered, was first opened in January, 1900.

course, to the greater volume and more rapid movement of the stream since Lake Michigan water was introduced into it through the Sanitary Canal.

We also find that the river in its middle course, as at Havana, now carries a larger store of nitrogen in combinations which make it available as food for the river plankton than before 1900, but that a very much larger volume of these food materials now passes on into the Mississippi unused. In other words, the Illinois is now receiving a much larger food supply than it can digest and assimilate within its own course, and these processes are consequently carried forward in the Mississippi to a much greater extent than formerly.

Quite consistently with the foregoing, the successive steps of the self-purification process, evidenced by the appearance of a green plankton and an increasing saturation of the water with dissolved oxygen, occur now much farther down the stream than before 1900. It is important to notice, however, that the biological conditions of the river become normal much farther up-stream than the chemical conditions. In respect to the plankton forms, Averyville (just above Peoria) is now about as La Salle was before 1900; but the former chemical conditions at La Salle are now scarcely reached at Grafton, at the mouth of the river. We also find that the return to normal conditions, both chemical and biological, progresses more slowly downstream in the bottom sediments of the river than it does in the water over them—that the bottom mud of a given area in the upper river is relatively fouler than the water which flows over it.

This whole subject is very complex and difficult, but Mr. R. E. Richardson, one of the biologists of the Survey, has given his entire time to its study for a little more than a year, and we hope to have a detailed report in print before the summer is over.

Since the last report of the committee, Dr. V. E. Shelford, serving as one of the biologists of the Natural History Survey, has completed and published an investigation of the effects of coal gas on fishes. A preliminary summary of the results of this work was, indeed, printed in the Academy Transactions for 1916. The equipment of the new vivarium has now been brought into working order, and a series of experiments has been made upon the effects of weather conditions on the rate of development, number of individuals, and general success of several species of insect pests. The work to date shows that in addition to temperature, which is well known to have marked effects, air movement (wind) and humidity have effects which indicate that the relation of weather to insects is more complicated than is commonly supposed. These experiments have been made on cabbage butterflies, chinch-bugs, and pupae of the codling-moth. Those on the last are now being repeated under very carefully controlled conditions, with a view to determining the optimum humidity for each temperature. The chinch-bug, one of the most destructive Illinois pests, is so sensitive to all sorts of conditions, such as kind of food, too little moisture, too high temperature, too rapid air-movement, and the like, that it is extremely difficult to breed it in captivity. The length of time required to enable this insect to pass from the egg to the adult is modified by external conditions to a greater degree than in most other species. These experiments have been carried far enough to show that the chinch-bug can reach the enormous numbers in which it sometimes appears, only under certain very limited conditions. It is hoped that by means of further experiments, these conditions may be more precisely determined than has been possible with field observations alone.

Dr. W. B. McDougall, of the Botanical Department of the University of Illinois, began, during the summer of 1917, a study of the vegetation along the Vermilion River in Vermilion county. The area covered includes bottomland, upland, and much eroded land between. The region is all underlaid with coal, and any study made there necessarily involves important questions concerning the relation of the mining industry, forests, and the practice of agriculture to each other. It is proposed to study the physiographic ecology of the region and at the same time to give as much attention as practicable to the biotic factors involved. It is hoped that a comprehensive report may be made at the end of the season of 1918.

Mr. T. L. Hankinson reports progress in field studies on the fish and associated aquatic forms in the streams about Charleston.

Mr. A. G. Vestal has made minor studies of local inclusions of prairie within forest on south-facing ravine-slopes, and upon invasion of prairie into forested areas in the rights-of-way of railroads. These studies are being reported for the present meeting of the Academy.

An experiment is being started in the planting of an artificial assemblage of prairie plants upon the campus of the Eastern Illinois State Normal School. Some are transplanted and many of the more quickly growing plants are being started from seeds. Favorable opportunities exist and are being used for the study of mixed associations of forest herbs and prairie plants.

Mr. Vestal is preparing to map a township near or at Charleston to show original boundaries between forest and prairie. These boundaries can be made out in many places, and an attempt will be made to map a sample area.

Dr. F. C. Gates reports upon plant collections made by students of Carthage College, leading to a better knowledge of the plant life of Hancock county, and upon the bird work of a class of college students, the product of which has been published as the April (1917) number of the Carthage College Bulletin. Miss Mary A. McMillan has made a comparison of the trees found in cemeteries within the county with those of the natural vegetation, and Mr. J. R. Peters has studied weeds in relation to crops in Hancock county.

Preparations are now being made for a survey of existing forests of the state, in which the members of the Ecological Committee will participate, their traveling expenses being paid by the Natural History Survey. An emergency survey of the plant parasites of important crops has also been undertaken, in cooperation with the U. S. Department of Agriculture, as a piece of war work. All the field agents of the Survey and the members of the Ecological Committee will participate in this inquiry, which is under the general control of Dr. F. L. Stevens, professor of plant pathology in the University of Illinois.

Respectfully submitted.

STEPHEN A. FORBES, *Chairman of Committee.*

Addresses

THE ROLE OF SCIENCE IN MODERN CIVILIZATION

JOHN M. COULTER, UNIVERSITY OF CHICAGO

At the present time science is being called upon as never before to help this country meet a great emergency. This is merely public recognition of the relation between science and the public welfare that has always existed, but has not been realized.

When President Wilson, in 1916, asked the National Academy of Science to appoint a National Research Council, it was because of his conviction that the aid of science was necessary to develop the national resources to their maximum. Ever since that time scientific men have been called to the assistance of the government in increasing numbers. In consequence, the practical men of affairs are beginning to realize the debt of civilization to science, a debt incurred during the times of peace in much more fundamental service than in meeting the emergencies of war. Such men understand now that all they have been able to do in the past, and all hope of future material progress depends upon the results of scientific research. It is high time that the service of science should be more generally understood. not so much that science may be appreciated, but chiefly that it may be enabled to render a still greater service. Now that science has come into public notice in connection with war, it is a fitting time to call attention to its more fundamental service to a civilization at peace.

The service of science expresses itself in three general ways which are not mutually exclusive, but complementary. Opinions may differ as to the relative importance of these three kinds of service, but there is no difference of opinion as to their value. I wish to present them in what I conceive to be the order of their importance.

I. The first service of science is to extend the boundaries of human knowledge. It sets up as its goal to understand nature. We speak of "conquering nature," and of making her a servant to minister to our needs, but this first service contains no such thought. To such an investigator nature resembles a huge unexplored continent, whose secrets are gradually discovered. Something of the enthusiasm of the original explorers of our great western territory takes possession of him. Every advance into the new territory impresses him with the fact that it is far more extensive than he had dreamed. Every trail is worth following, for it means additional knowledge. Some trails may lead to rich farm lands and gold mines, but in exploration these are only incidents. To understand the new country, all trails must be followed and mapped. The figure has suggested the fact that this service of science is the service of the explorer, the service which makes all exploration worth while. Without it this nation would have had the Alleghanies for its western boundary. Without it nature would have remained a region of mystery, prolific in superstition, and of no service to civilization.

This general exploration of the unknown was once more appreciated than it is now. The original explorations of nature appealed to the wonder instinct of a people to whom the new territory was a revelation; but after the new territory became mapped in its rough outlines, the wonder instinct subsided, and people turned their attention to the farm lands and gold mines; and began to demand that exploration should stand primarily for these things.

Recently, however, the tide has turned and exploration in science is coming into its own again. This is indicated perhaps most significantly by the change of attitude in the scientific work of the government. Using my own subject as an illustration, the Bureau of Plant Industry, under the Department of Agriculture, has recently been adding to its staff scientific explorers. The reason for this has been a realization of the fact that practical application is sterile unless there is a continuous discovery of something to apply. Practice in an old territory is useful, but the discovery of new territory that demands new practice is far more valuable. If it had not been for exploration of territory we would have been farming in New England today instead of in Illinois; and if it had not been for scientific exploration, our practice would have remained that of a century ago.

This attitude of the government is expressing itself also in the developing ideals of agricultural experiment stations, which were formerly merely schools for apprentices, but which are now rapidly becoming schools of science. Furthermore, the general growth of this ideal is being felt in the universities, those notorious hot-beds of pure science, in the increasing attendance of practical students who have discovered that they must know science and must be able to explore.

A remarkable illustration of the incidental advantage that often follows scientific exploration for its own sake may be obtained from the work of the National Research Council. Through that Council a large number of emergency problems have been referred to the various sciences. In the great majority of cases the necessary information has been available because of previous exploration. Even plant taxonomy, often regarded as a subject most remote from the public welfare, has come into prominence as our surest guide to necessary raw products whose ordinary source of supply is no longer available. To know that a given plant yields a certain product is regarded as practical knowledge; but to know the relatives of that plant and their geographical distribution has proved to be far more valuable knowledge.

That scientific exploration is entering upon an advanced stage of its development is shown by the fact that it is proceeding in its methods from analysis to synthesis. Until recently progress in science was marked by an increasing segregation of subjects, so that scientific men were distributed into numerous pigeon holes and labelled. A man in one pigeon hole knew little of the work of his colleague, and cared less. This segregation was immensely useful in the development of the technique of science, by which results are secured, but now we realize the fact that nature is not pigeon holed, but is a great synthesis; and we know that to understand nature, which is to synthesize our results, all of our so-called sciences must focus upon the problems.

This first service of science, therefore, is that of exploring the unknown, and the result upon civilization is the development of the human race into greater intellectual efficiency, and incidentally the extension of civilization by occupying and using new territory.

II. A second service of science is to apply the results of science to human welfare. It sets up as its goal the service of man, and expresses itself in what has been called "applied science," in contrast with "pure science," which is science at the work of exploration. The public has begun to recognize the fact that pure and applied science are not mutually exclusive fields of activity, but complementary, and therefore public support for pure science has been growing, and as a consequence of the practical achievements of pure science in connection with the war, it bids fair to enter upon its own in public estimation and support.

The idea, however, that there are two kinds of science, pure and applied, not only exists in the public mind, but also is reenforced by published statements from colleges and universities. An analysis of this impression that there is such a difference uncovers the fact that pure science is thought to be of no material service to mankind; while applied science has to do with the mechanism of our civilization. The distinction, therefore, is based upon material output. In other words, pure science only *knows* things, while applied science knows how *to do* things. This impression, rather than distinction, has been unfortunate in several ways. The public, as represented by the modern American community, believes in doing things, and therefore pure science seems to them useless. The reaction of this impression upon opportunities for the cultivation of pure science is obvious.

On the other hand, the universities, as represented by their investigators, believe in knowing things, and therefore applied science seems to them to be a waste of investigative energy, and its devotees appear very unscientific; very useful, but not to be acknowledged as belonging to the scientific cult, the cult of explorers. The reaction of this sentiment sometimes has been to avoid the investigation of problems that have an obvious practical application. In recent years, however, the spirit of service has invaded the universities. The university is no longer conceived of as a scholastic cloister, a refuge for the intellectually impractical, but as an organization whose mission is to serve the public in the largest possible way.

The actual relation between pure and applied science can be discovered by tracing the history of any notable advance in human practice, which is usually regarded as an advance in civilization. It will be found that credit for the material results of science must be shared by those engaged in pure science, those engaged in applied science, and those not trained in science at all. The distinction, therefore, is not in the result but in the intent. In fact, the difference between pure science and applied science in their practical aspects resolves itself into the difference between murder and manslaughter, it lies in the intention. So long as the world gets the practical results of science it is not likely to trouble itself about the intention. In every end result of science that reaches the public there is an inextricable tangle of contributions. Between the source of energy and the point of application there may be much machinery, and perhaps none of it can be eliminated from the final estimate of values, and yet the public is in danger of gazing at the practical electric light and forgetting the impractical power house. In fact, schemes of what is called education in science have been proposed which would instruct in turning on the switch, and say nothing about the power house.

It is becoming obvious also, that all application must have something to apply, and that application only would presently result in sterility. There must be perennial contributions to knowledge, with or without immediately useful intent, that application may possess a wide and fertile field for cultivation.

The conclusion is safe that all science is one; that pure science is often immensely practical; that applied science is often very pure science; and that between the two there is no dividing line. They are like the end members of a long and intergrading series, very distinct in their isolated and extreme expression, but completely connected. If distinction must be expressed in terms where no sharp distinction exists, it may be expressed by the terms fundamental and superficial. They are terms of comparison and admit of every intergrade. In general, a university devoted to research should be interested in the fundamental things of science, the larger truths, that increase the general perspective of knowledge, and may underlie the possibilities of material progress in many directions. On the other hand, the immediate material needs of the community are to be met by the superficial things of science, the external touch of more fundamental things. The series may move in either direction, but its end members must always hold the same relative positions. The first stimulus may be our need, and a superficial science meets it, but in so doing it may put us on the trail that leads to the fundamental things of science. On the other hand, the fundamentals may be gripped first, and only later find some superficial expression. The series is often attacked first in some intermediate region, and probably most of the research in pure science may be so placed; that is, it is relatively fundamental; but it is also relatively superficial. The real progress of science is away from the superficial, toward the fundamental; and the more fundamental are the results, the more extensive may be their superficial expression.

A notable illustration of this connection between fundamental science and its superficial expression is that given by the study of organic evolution. Before the beginning of the 19th century evolution was a speculation, which was as old as our record of human thought. During the 19th century it came to be based upon observation, and thus became a science, but its appeal was simply to those who wanted to understand nature. At the beginning of the present century it became a subject for experiment, for observation had reached its limit, and it was necessary to know through experiment whether one kind of organism can produce another kind. This experimental work began to uncover the laws of inheritance, or of heredity, as we have come to call it. The discovery of these laws suggested methods of securing practical results in plant-breeding never dreamed of before, and a revolution in agriculture was the result. It is a far cry from speculation concerning evolution to a solution of the problem of food production, but the continuity is unbroken.

It is the proper balance between the two ideals that must be maintained. The physical needs of man, great as they may be, must never obscure the intellectual needs of man; especially as the trained intellect is the speediest agent in meeting physical needs. On the other hand, the intellectual needs of man, noble as they may be, must never lose sight of the fact that the speediest results are obtained by the enormous increase of experimental work under the pressure of physical necessity.

III. A third service of science is to develop a scientific attitude of mind. It sets up as its goal a more effective citizen, and expresses itself in the results of science in education. It is not necessary for me to consider the relation of the different sciences to education. This will be presented in the program of tomorrow by those who are in a position to know. Each science may hold its own peculiar relation to the needs of the student, as an educated person and a citizen. I wish to consider, however, the contribution of science in general to education, and through education to civilization. Any substitution of practice for scientific training is substitution of manipulation for knowledge, and is not to be regarded as science. The contribution of science to education is the development of a scientific attitude of mind, which means a way of looking at things rather than a way of doing things. The recognition of this factor in education has been shown recently by the numerous calls for men with scientific training; that is, not apprentices who have learned to do something; but students who have learned to understand something, which will enable them to do many things. It is this attitude of mind which has revolutionized modern thought and resulted in a new type of civilization. It has banished superstition as a controlling motive, and is the hope of our further progress.

It is important for teachers that this mental attitude be analyzed and the method of its attainment realized. There is much teaching in the name of science which does not secure it, and for this purpose there is no substitute for science. The scientific attitude of mind is probably nothing more than trained common sense, but a fuller definition will indicate more clearly the significance of this ideal.

In the first place, it is a spirit of inquiry, which recognizes that we are surrounded by a vast body of established beliefs that need a thorough going over to distinguish heirloom rubbish from the priceless results of generations of experience. It is also a spirit that demands a close connection between a result and its claimed cause. Failure to develop this spirit provides the soil in which political demagoguery, destructive charlatanism, and religious vagaries flourish like noxious weeds. It is a spirit that keeps one close to the facts. One of the hardest things in my teaching experience has been to check the tendency to use one fact as a starting point for a wild flight of fancy. Such a tendency is corrected somewhat, of course, when facts accumulate, and flight in one direction is checked by a pull in some other direction. Most of us, however, have the tendency, and the majority are so unhampered by facts that flight is free. There seems to be abroad a notion that one may start with a single well attested fact, and by some machinery of logic construct an elaborate system and reach an authentic conclusion, much as the world imagined for more than a century that Cuvier could do if a single bone were furnished him. The result is bad, even though the initial fact has an unclouded title, but it too often happens that great superstructures have been reared upon a fact that is claimed rather than demonstrated.

Facts are like stepping-stones; so long as one can get a reasonably close series of them, he can make some progress in a given direction; but when he steps beyond them he flounders. As one travels away from a fact its significance in any given conclusion becomes more and more attenuated, until presently the vanishing point is reached, like the rays of light from a candle. A fact is really influential only in its own immediate vicinity; but the whole structure of many a system lies in the region beyond the vanishing point.

Such "vain imaginings" are delightfully seductive to many people, whose life and conduct even are shaped by them. I have been amazed at the large developmnt of this phase of emotional insanity, commonly masquerading under the name "subtle thinking." Perhaps the name is expressive enough if it means thinking without any material for thought. An active mind turned in upon itself, without any valuable objective material, seems to react upon itself, resulting in a sort of mental chaos. In short, the scientific spirit is one that makes for sanity in thought and action, a spirit which is slowly increasing in its influence, but which as yet does not control the majority of citizens. Of course, the methods introduced by science are now being developed in connection with other subjects, but science gives a training peculiar to itself, and it is this contribution which expresses the service I wish to emphasize.

I shall assume that any peculiar result of science in education must be obtained, not through information in reference to the facts of science, but through contact with the materials of science. However valuable information may be, it can hardly be regarded as a substitute for knowledge. Information is always at least second hand; while knowledge is first hand. The real educational significance of personal experience, which is a better name for what we call the laboratory method, is very commonly overlooked, even by teachers of science.

We were first told that science teaches the laboratory method, the inference being that the content of science is of no particular educational advantage of itself, but is merely useful in teaching a valuable method. Of course this method holds no more relation to science than do algebraic symbols to algebra; they both represent merely useful machinery for getting at the real results.

Then we were told that science cultivates the power and habit of observation. Of course it does, but this is not peculiar to training in science, for it belongs to any subject in which the laboratory method is used. Then it was claimed that the study of science trains the power of anaylsis. This is certainly getting the subject upon higher ground, for the power of analysis is of immense practical importance; but to imagine that analysis is the ultimate purpose of science in education is not to go very much further than to say that the ultimate purpose is the laboratory method. The latter is the method, the former is but the first step in its application, and is by no means peculiar to science.

Beyond analysis lies synthesis, and this certainly represents the ultimate purpose of science. The results of our analysis are as barren as a bank of sand until synthesis lays hold of them;

but even synthesis is not peculiar to science. To pass by the incidental and the temporary, and to reach the real and permanent contribution of science to education is to discover that it lies, not in teaching the laboratory method, in developing the power of observation, in cultivating the spirit of analysis, or even in carrying one to the heights of synthesis. It is in the mental attitude demanded in reaching the synthesis. In this regard the demands of science are diametrically opposed to those of the humanities, for example, using this term to express the great region of literature and its allies. The general effect of the humanities in the scheme of education may be summed up in the single word appreciation. They seek to relate the student to what has been said or done by mankind, that his critical sense may be developed and that he may recognize what is best in human thought and action. To recognize what is best involves a standard of comparison. In most cases this standard is derived and conventional; in rare cases it is original and individual; in no case is it founded on the essential nature of things, in absolute truth, for it is likely to shift. It is the artistic, the esthetic, which predominates, not the absolute. The whole process is one of self-injection in order to reach the power of appreciation. If the proper result of the humanities is appreciation, whose processes demand self-injection, the proper and disinctive result of science is a formula, to obtain which there must be rigid self-elimination. Any injection of self into a scientific synthesis vitiates the result. The standard is not a variable and artificial one, developed from the varying tastes of men, but absolute, founded upon eternal truth.

Two such distinct mental attitudes as self-injection and self-elimination are not contradictory, but complementary. The exclusive development of either one must result in a lopsided development. Persistent self-injection tends to mysticism, a confusion of ideals or even vagaries with realities, a prolific source of all irrational beliefs. Persistent self-elimination narrows the vision to a horizon touched by the senses. The two processes and the two results are so distinct and so complementary, that any scheme of education which does not provide for the definite cultivation of both of these attitudes is in constant danger of resulting in mental distortion.

You have now the reason for the statement that the scientific attitude of mind is trained common sense, and also for the claim that this service of science is related to the better equipment of the race for meeting its increasingly complex problems.

To summarize the whole situation: the service of science is, first to understand nature, that the boundaries of human knowledge may be extended, and man may live in an ever-widening perspective; second, to apply this knowledge to the service of man, that his life may be fuller of opportunity; and third, to use the method of science in training man, so that he may solve his problems and not be their victim. Such results suggest that science, through exploration, through practical service, and through education, is to be regarded as the most important factor in developing civilization.

SCIENCE AND PATRIOTISM

John C. Hessler, James Millikin University

The business world may still adhere, in its formal correspondence, to the beginning of the Christian era as the year 1; the National Government may still date its documents as of such and such a year of the Independence of the United States; but the unconscious, yet none the less real starting point for this generation will be, for many a decade to come, "August of 1914." For in that fateful month and year the whole easy-going nation of us: business man, labor leader, religionist and scientist and all of those who spoke glibly and dreamed idly of the "parliament of man and federation of the world" were pushed up against reality and saw the world as it is, not as we wish it to be. The sensation we had was like that of a friend of mine who parted some leaves along his path through a tropical jungle and looked into the face, not of a rare flower, but of a crouching jaguar. Of all the phases of reality that we saw in those August days none was so rude and abrupt as the bristling, brutal word "Kultur." Since men heard that word, life for us has never been quite the same. It was laughable, if one could laugh when his heart (to misquote the poet Lowell) "was going pittypat, when it wasn't going 'pity the Belgians' ", to note the way in which the press of our country got to work to define "Kultur." The obvious equivalent was, of course, culture. We all knew something of what that meant, by reputation at least. It meant ease and enjoyment and discernment and appreciation and all that. But as an equivalent for Kultur, culture was always a failure: for Kultur has a boom in it—a Krupp boom, perhaps—that culture lacked.

You will pardon yet another attempt to describe, if not to define "Kultur." There was once a little girl who was studying Geometry and had a great deal of difficulty in understanding the definition of a line. She was told that it was something without breadth or thickness, having only the quality of length. She finally got another conception of a line: the kinetic conception; that is, that a line is a point in motion. In the same way the mathematician thinks of a solid as formed by a plane in motion. Now the American idea of culture has been, not a kinetic, but a static conception of a plane, or a stratum, if you please, of society. Like a plane, it is very, very thin; it can be used for a veneer; it can be slipped in anywhere without taking up any room; two such cultures can easily occupy the same space without seriously interfering with one another. But with Kultur it is different; for Kultur is a culture in motion. It has length and breadth and thickness and its sides are on the move; it generates a material solid; and two such solids cannot occupy the same space at the same time. The question we have been asking ourselves since August of 1914 is whether there is enough force behind the planes of German culture to expand the solid until it fills the earth.

There is not the slightest doubt that the kinetic idea of culture is the one put forth by our great enemy overseas. She felt for decades that her civilization was superior to all others; hadn't all the world said so? Why then shouldn't all the world be eager to embrace its beneficent, all-inclusive, all-pervasive sway? The vision of what this powerful Kultur may mean, how it may obliterate all man's other efforts at civilization, how it may engulf the aspiration of mankind for life and liberty and individual culture, these things we have seen with our eyes until we have grown sick at heart. Louvain, the Lusitania, Scarborough; these are but points—incidents—in the advancing plane of Kultur; if we are to believe the Teuton, they and others like them are justifiable and right. But the world remains unconvinced and asks: "Has all the struggle of the ages been only for the purpose of bringing us at last to a material civilization that has in it all the elements of moral barbarism?"

There were three great bonds that men had hoped would hold the Western world together and that should have operated against the break of 1914. The first of these was the internationalization of labor. How big and mighty this seemed to us just before the war! How well we remember the threatened strike at Paris against the war declaration itself. How well we remember, too, the boasting of the labor leaders of Western Europe that they had the power to hold the working classes together against the efforts of chancellors and premiers to bring about a general war. With what assurance public speakers told us of the impossibility of world strife because the world's labor interests would not produce the sinews of war. On that thin, negatve reed men leaned for support, then wondered that it failed them. Yet every one who wished might have known that for years German factories were making munitions one month out of every year and were at all times ready to go upon a complete war basis. What reason had labor to expect that the munitions it helped to make for the Prussian war lords would never be used by those lords for their own sinister purpose? Even as war broke out, it seems to us, German labor might have saved the day had it felt the pull of international gravitation. But instead it felt the stronger, closer, centripetal whirl of the national Kultur. Like Lee in '61 it turned aside from the greater, newer union to respond to the old appeal of a native state. Does America now believe, or must she still be taught, that we may not depend, for a long time yet, upon the negative weapon of an international strike to keep us out of war?

A second great bond that men hoped would hold the nations together is their common religion. Nothing has so indicated the growth of real Christianity as the enlarging meaning of that exclamation of Peter's; "Of a truth I perceive that God is no respector of persons (or nations)." And, conversely, nothing so fully convinces us of the thinness of Teutonic culture as its gross, brazen appeal to its tribal Gods. It makes the heart ache to read of the studied, cold-blooded indorsement of all the crimes of Pan-Germanism by a servile Teutonic ministry and religious press. All that Christianity stood for as the permeating, unifying force of mankind was brushed aside by the military lord. The appeal to the higher sentiments of men, like the appeal to the unification of labor, was felt to be only another bond that made for the solidarity of a conquering nation and the impenetrability of its Kultur.

Internationalism in labor we may reject as leading to the state of the Bolsheviki, but the universality of the religion under which all men are brothers must survive; it must not be swallowed up in the conception of any national Kultur. To be sure, when the war is over, and when men in Teutonia may again speak out, we shall learn that in this modern Israel, as in that of the days of Elijah, there will be found 7,000 men who have not bowed the knee to Baal, nor kissed his golden image. But they are gone as effective agents in this war. So far as we can see, only the Social Democrat speaks out, and he less and less clearly, as fraternization with the Bolsheviki grows less and less useful to the purposes of the military party.

A third agency, which we had thought would make impossible such an estrangement as came in 1914, was that of the intellectual fraternity of our Western world, including the brotherhood of the men of science. We can see why religious leaders might forget the universal faith, when we remember that in all the contending countries, men's aspirations have become embodied in historic churches, rites and creeds. But none of these existed in Science. Science, we were told, is too young, too practical and too intellectual to be swayed by historic statecraft and by outgrown governmental systems. Men even thought a bit archaic and in poor taste the stalwart patriotism of Pasteur, who because his beloved Strasbourg was alienated in 1871, refused to hold or to accept any honors which the Teutons sought to confer upon him for his priceless discoveries on the origin of disease. Yet in spite of this feeling, when the coup of 1914 was to be sprung, we have no record of any attempt by German science to stay the hand of the militarists by an appeal to the brotherhood of science and learning, as a reason for peace. We still think with horror of the reported arguments used by German scholars, including her foremost scientists, in favor of, not against the war. With glib tongues, they talked of manifest destiny and the right of might. Yet these were the men who had met with us in our conferences, at whose feet some of us had learned science and history and criticism, who had vowed the unity of learning as a permanent force for peace and brotherhood and universal understanding. Was any apostasy so great as that of the scientist who knew the futility of force, and yet throttled with brutal phrases the faith he had once embraced? Or were any lips so false as those of the man of learning who spoke not the word of truth, but only the false testimony that radiated from Potsdam? Too late we learned that German science, like German labor and religion, was only a phase of the great national Kultur and only useful to its countrymen as it aided, abetted and defended that Kultur in its stroke for world mastery.

There is no great need to stress the fact that this war, as no war that came before it, is a war of science against science. Even above the cry; "To your tents, O Americans," was heard the call, "To your laboratories, O, Scientists." For the submarine was transformed all at once from a scientific toy into the wasp of the sea; the dirty coal tar became in an instant a precious possession, for it became the raw material of munitions. From submarine detectors and depth bombs and gas masks to substitutes for rubber and platinum, from the manufacture of optical glass to the preparation of aniline dyes and antiseptics, everywhere the scientist has been asked to give his knowledge and his methods to the national defense. We need only call the roll of the research laboratories of the country, commercial as well as educational, to realize how many are in the service and what a war of science it is. We are arrayed against a nation of scientists, and brain is fighting against brain even more than arm against arm. We had toyed with the airplane; the Germans, the scientific as well as the military aggressors, soon made our efforts look like child's play. Speed and range and stability took on a new aspect, for they now meant not the plaudits or shudders of gaping crowds at Long

Beach, but success or defeat on the Western Front. Gases which the chemists had worked with cautiously in his laboratory, fully protected by fume chambers and ventilating systems, were liberated on the battle field in such volumes that they transformed whole companies of "first-class fighting men" into gasping, writhing wretches. How sorely has the science of the allies been tried to meet such infernal devices of destruction. Of the consecration with which our American men of science have given themselves to the defense of our democracy we can speak only with the highest praise. May their every effort be crowned with success!

But what of the days after the war? Shall we again seek to save the world with the prattle of a culture that has no body in it, that is disconnected from reality, or shall we give ourselves, as a people, to a Kultur that has three dimensions. Is an American Kultur possible that can satisfy the everyday needs of men and yet be strong enough to compel respect? In the hour when danger threatens, shall we have the means of defense organized, or shall we go back to our desire for individual, uncontrolled selfishness? Shall the relation of German science to our own be restored as an autocracy or as a real democracy of science, founded on reciprocal respect for achievement? We may respect German science, but it is more important that we respect our own, which is another way of saying that America must have a real science as the basis of its national life. America has too long been the humble imitator, feeding to German science the "pap" of a flattery that has raised it to its present status of the foe of mankind. It is not too much to ask that we have a science that will not merely engage in private research, but also in the organization of business, that will take not simply a subservient attitude toward constituted authority, but the role of the ruler himself.

The progress of the war is showing us more and more clearly that America has been all along the target at which the Teuton plans have been aiming. These plans included an acquiescent United States, so that there might be a subservient South America. A United States which flattered itself that the seas kept off the danger of an invasion, while it hid securely behind the British fleet. A United States that deluded itself into believing that it could raise armies over night and that it need only blow the tocsin and its sons would spring forth fully armed and in battle array. A nation that loved peace and thought that it would be left alone forever to pursue its solitary way. A nation also that has had no conception of the price men must pay for a worthy peace or an honorable "place in the sun." A happy-go-lucky nation that has been too busy picking golden apples to care much for the slow, painstaking methods of science. When the whole story of the war is written, we may see that the fatal error of German strategy (an error based upon its own narrow view of things) was the failure to launch its first attack, not on little Belgium, but on the impotent United States. No alliance would have compelled any European power to raise a hand to help us. With that score settled, the starvation of England would have been easy. If we have another war, Germany will not make this mistake again.

Even now, before the American army has been made fully ready, certain interests are talking of a quick return to the easy, irresponsible days before the war. Loud-mouthed patriots are already crying that they want to eat, buy, and sell what they want, when they want it, in whatever quantity they want it, without regard to the future of democracy in America or anywhere else. Even those of us who are more far-sighted are not yet through with the delusion that everlasting peace can be had for asking. Even while we are talking of such a peace, the German is talking of the next war. There is no hope of permanent peace for this country until we have developed an effective, unified, organized Kultur for ourselves. As a nation having a body of ideals, habits, achievements that can be respected we shall make ourselves powerful for peace. We can then accomplish something for world democracy. As a nation unorganized and uncontrolled, we cannot possibly save ourselves, to say nothing of making a real contribution to the peace of the world. As there is a Kultur formed to destroy nationalities, so there must be a Kultur dedicated to saving them; as there is a Kultur planned to sow discord, so there must be one just as efficient and far more powerful, planned deliberately to promote peace and understanding. As the one is bound to make itself feared, the other must make itself respected and loved. The call is for the consistent development of an American Kultur, of a unification of all our aims, ideals, methods, with the purposive intent of producing a democracy as efficient as any autocracy, yet with space for the growth of individual initiative.

Can we organize our democracy for an "offensive" peace? To develop such a democracy we need at least two things; first, the knowledge, and second, the "will to live" as a free people. This brings me to the point of this paper. We need *scientific knowledge* in America. We need it most, not as a knowledge of the past, but of the present, for the rules of the past help us very little today. We need to know our world as it is today. We need that knowledge as a basis of our common life, of our national culture, of our world plans. The idea of working together for a great future purpose is almost unknown to us; must such a possibility exist only for an autocracy? When conservation is called for, we as a people need to know science, or we cannot conserve wisely and cheerfully. When we wish to engage in a new manufacturing enterprise we need to have science, not that it may stand as a wage servant at our elbow and merely register our will, but as the forerunner and pioneer to blaze the trail. As we cannot raise armies over night, so we cannot make our people scientific by wishing them to be so. Scientific knowledge must not simply be diffused among our people, but *ingrained into* our people, so that they can act as an intelligent unit toward a common purpose. The conviction of this need rises paramount to every other; to achieve this end should be the aim of our national policies, the goal of our popular education. Science is not analyzing bugs, or making oxygen, or measuring the distance of the stars, or guessing the age of a trilobite. Greater than these individual products of science, are the methods of science. To ascertain the facts, large and small; to eliminate the non-essential ones; to draw conclusions; to realize the limitations of these conclusions, yet to derive a working philosophy from them; and to determine upon a line of action based upon the facts and the conclusions —these are the ways of science. It will need two generations, at least, of scientific, devoted, patriotic thinking to make us a scientific nation. We cannot learn the principles of science by lectures when we are grown up, or in the frenzied effort to drive off an enemy who is knocking at our doors. We must play with the means of science as toys in our childhood, must grow up with them, watching them expand as we grow, until they change from toy to playmate, and from playmate to counselor and friend.

We believe American civilization has in it something worth living for and worth dying for, but the living and the dying will alike be in vain if the experience of this war does not teach us the need of consistent scientific solidarity, and push us rapidly into it. Instead of praying for the extension in length and breadth of an idealistic culture, that cannot be realized short of the millennium, let us work as well as pray for a three-dimensional American culture; a Kultur in action. It is well to have the clouds of idealism on which the setting sun may spread the rainbow of hope, but it is not well for present-day men to dwell in the clouds. The ways of science bring us down from the clouds to the actual world in which we and our children must live. Today, the greatest science in the world is linked with the greatest autocracy. Is it to continue so? Science as the handmaid of autocracy may give us a fetish, a superstition, like the "Ich und Gott" cult of the Hohenzollerns; democracy and science will give us *faith*. Have we the "will to live" strong enough within us so that we will subject ourselves to self-denial and self-control for the future good, or is this power of foresight and preparation to remain only in the hands of an autocracy? On her answer to this question hangs the future of America, if not the destiny of the world.

This paper was prepared between the birthday anniversaries of Washington and Lincoln. Never, we believe, have the ideals of these two great Americans meant so much to us as this year. Each of them, we now see clearly, stood like a great rock of the ages between the clamor of the unharnassed idealism on the one hand, and of the gross materialism on the other hand. As we think of their lofty ideals and unselfish patriotism, we also think of their sturdy common sense. For, when you come down to it, this is true science, as it is also enlightened patriotism: *trained common sense* as applied to our world, our country, and to ourselves.

Symposium on Science and Education

THE STUDY OF ZOOLOGY AS A FACTOR IN SOCIAL AND ECONOMIC PROGRESS

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One of the real functions of the high school should be the training of men and women to live. In the secondary schools a large percentage of our population find their training and mental equipment for life. A realization of this state of affairs is bringing about a complete reorganization of the high school curriculum. Fortunately, most people have ceased to consider the primary function of the high school that of preparation for college. The modern trend of vocational education is a manifestation of the extreme point of view in this reorganization. No longer is any subject or group of subjects retained in the curriculum because of some hypothetical cultural value. Utilitarian values are constantly being more stressed. This, with the addition of new subjects to the curriculum, necessarily leads to a sort of competition between subjects. Values are constantly being weighed one against another with the result that many subjects are on their way toward elimination.

Few administrators stop to ask the question if the basis for rejection of any subject is the intrinsic value of the subject *per se* or rather a valuation which has become attached to the subject because of unfortunate conditions and circumstances entirely foreign to the subject but usually associated with it, I believe in the case of zoology in the high schools it can be shown that the materials selected for study and the methods of presentation are responsible for the decline, where such has existed, rather than any intrinsic weakness in the fundamental subject matter as a factor in directing human activity.

A decade or two ago men like Spencer, Huxley, and Forbes convinced the educational world concerning the values of biology with the result that the study of biology was given a considerable impetus and prestige as a subject of instruction in the schools. At that time the number of subjects offered in the high school was relatively small. Competition between subjects for a place in the curriculum had scarcely begun. Biology secured entrance to the list of studies through the demonstration of the fact that the study of it contributed utilitarian, intellectual, aesthetic or emotional, and moral values to the education of the student. With the increase in our scope of knowledge and the development of new sciences there are now numerous courses offered in the secondary schools all of which contribute to the intellectual, the aesthetic, and the moral or ethical phases of life. Consequently the final struggle for supremecy, or in some cases existence, is to be fought out along the lines of relative contribution of direct practical value in human life.

The past generation has brought forth few educators in the field of zoology. Tremendous progress has been made in the addition of new facts to the bulk of zoological knowledge, but unfortunately no successful effort has been made by the leaders of this science to meet the popular demand for emphasis upon the practical values in teaching. Zoology as taught in the high schools is still chiefly that of the older morphological type in spite of the fact that the more recent advances in the science have frequently possessed more strictly practical sides. This failure to appreciate the necessity of incorporating the practical applications of zoology into the course of the secondary schools is due in large measure to the feeling that the value of zoology had been given full recognition upon its adoption following the efforts of the educators mentioned in the last paragraph. As a consequence of these combined factors no significant advance has been made toward the production of a text-book which would incorporate zoological materials of such importance to social progress as to demand general dissemination.

The prime object of a high school course is not the training of zoologists. In fact any attempt at correlation with later work in university or college course might interfere with accomplishing the very object of such a course, namely that of equipping the individual with a fund of knowledge concerning and attitude toward living organisms and his relations to them. That attempted correlation between high school and college courses has in the past failed is evidenced by the general feeling among university teachers that students who have had work in high school zoology are but little, if any, better prepared for the intensive courses in the university than are those who have never had such previous training.

Elementary work in a university course of zoology usually takes up the morphology of a series of types as a foundation upon which the study of the higher branches of the science may be built in later courses. Students coming from the secondary schools with a smattering of morphology, superficial, to be sure, but leaving them with the idea that they know the structure of animals, enter their university work with the handicap of self-complacency. At least in some instances this is due to the selection and preparation of the high school teachers of zoology. Frequently persons are required to teach zoology when their preparation consists in nothing more than an elementary course in a university or normal school. The lack of appreciation of the subject and of the problems involved in the teaching of students of high school age permits such a teacher to attempt, with very few modifications, a repetition of the course which he had in college. The result is the cultivation of an abhorence for zoology on the part of the students. Administrators are naturally inclined to attribute this result to weakness in the subject itself for the chances are that the teacher has been a success in teaching subjects for which he has been more thoroughly trained. On every hand there seems to be ample justification for a sharp differentiation between high school and university courses in zoology. Whatever line this differentiation may take it must be kept in mind that there are facts and principles in the science of zoology an understanding of which are vital to the interests of the individual and of society. The dissemination of these must find a place in the program of our secondary schools.

Many teachers have laid especial emphasis upon the value of the study of science as a training in approaching the problems of life and reaching valid conclusions through a grounding in the application of the methods of science. The whole question of the transfer of training is much in dispute but we are led to believe that not much is carried over directly except in case of rather closely related fields. For this reason the study of zoology offers opportunities unique among the sciences because of the possibilities of direct transfer of methods and content to the problems of man himself. The study of the structure, habits, functions, economic relations, reactions to stimuli, carried out in the field and laboratory upon various animals finds direct application of methods in the study of man himself. The origin and meaning of sex, relations of individuals within a community, degeneracy as an adaptation to conditions of life, are all purely zoological problems capable of direct transfer in the study of the identical problems concerning the human animal. Not all these things can find full explanation in a high school course in zoology, but the student may there be started to thinking along the right lines and to that extent his whole attitude toward life may be modified.

Let us look for a while at some of the problems of every day life, an approach to which can be best made through a properly organized course in zoology for high school pupils. As indicated in an earlier part of this paper practically no one questions the intellectual, the moral, and the aesthetic values of zoology as a subject of instruction. On the other hand these values may well be assumed to be associated in varying degrees with all subjects of instruction. As far as these alone are concerned, one subject probably serves as well as another for training students of high school age. There are, however, phases of zoological knowledge which hold peculiar values for the individual and for society. Were these to cease being matters of common knowledge among so-called educated peoples much of social and economic progress would be retarded. Conversely any agency tending toward the wider dissemination of such knowledge is distinctly opening the way to the solution of many of our economic and social problems.

No one questions the value to mankind of the knowledge of animals in their relations to disease, and the numerous problems associated with this phase of zoology. These have been cited so often that it seems hardly worth while to more than mention a few specific examples. A few generations ago a scourge like typhoid fever was looked upon as a problem which was to be solved by the members of the medical profession. Today it has in addition assumed a distinctly social significance. Little can be done in any community toward the prevention of a disease like typhoid without the education of all persons in that community in the reasons for exterminating the fly, based upon a study of the structure and habits of that animal. This in turn demands some knowledge of the life history of the fly, for effective measures toward extermination all presuppose such knowledge. Studies of this sort give to the individual more than the training in powers of observation and reasoning which frequently are considered the goal of zoological training. The pupil is not only given possession of facts which, put into practice, make him a better citizen, but at the same time he is given a distinct advantage over those who are not possessed of this kind of zoological knowledge.

Few persons lead an existence which does not at some time or other bring them into contact with insect pests of household, crops, domestic animals, or of man himself. All effective means of combating and controlling such pests find their solution in the feeding habits and life history of the insects. Simple problems in development and in the structure of the mouth parts of the insects, which are correlated directly with the feeding habits, are studies which may be taken up to good advantage by the average student of high school age.

The enactment of fish and game laws, and laws for the protection of song birds all have as their aim, directly or indirectly, the conservation of the resources of our country. Persistent violators of these laws are, on the whole, the ignorant classes of society for whom the claims of personal liberty are stronger than the demands of social obligation. Bird protection laws would have much greater effect if more people had definite knowledge of the economic importance of our birds in holding insect pests of fruit, grains, and other crops in check. Game laws would cease to be looked upon as infringements upon personal rights if greater numbers of our citizens were informed upon the breeding habits of our game animals and understood the severity of the struggle for existence among such animals as population becomes denser over the entire continent. State and federal officials would find not only support in enforcing existing laws but demands for more effective legislation if the reasons underlying such laws were more fully understood. This would unquestionably be the case if more general knowledge of such matters were given in our public schools. The final success of the United States in constructing the Panama Canal has often been heralded as more of a biological than of an engineering accomplishment. Other nations starting the task failed, not because of insufficient knowledge of the engineering problems involved but because of the lack of appreciation of the biological phases of the problems of sanitation and transmission of disase. Huge accomplishments of this kind, if they were numerous enough, would convince the most skeptical persons of the values in applied zoology, for the most of us are influenced by the spectacular. However, it may be asserted without fear of contradiction that extension to all persons of fundamental knowledge concerning animals as agencies in disease with means of controlling such relations would stand for more, economically, to the nation than any number of spectacular achievements such as the one just mentioned.

It is difficult, if not impossible, to place a correct monetary estimate upon human life yet the most conservative of figures show that the economic loss to the people of the United States through what are termed preventable diseases is appalling. Many of these diseases do not involve animals other than man directly, so it may be claimed that a knowledge of zoology has no bearing in coping with them. But on the other hand the study of zoology in its relations to problems of sanitation and medicine furnishes a point of departure from which these topics may be reached in dealing with high school classes. The instance of hookworm in its bearing upon the economic problems of the South finds direct application at this point. A few years ago no one would have guessed that a small intestinal parasite could have produced such pronounced direct effect upon the economic status of a community as have been demonstrated in the case of the hookworm. Thousands of non-producing individuals throughout the South constitute an incipient reserve to our economic situation awaiting the application of zoological knowledge and establishment of sanitary conditions to transform them from physical and mental abnormalities into productive citizens. Outside agencies, such as the establishing of commissions for the extermination of such a pest, are effective but their influence cannot be equal to that of a general dissemination of knowledge concerning such animals through a well organized course in zoology.

The savage goes to the medicine man for a charm and an incantation to keep off disease. To by far too large a percentage of the civilized world vaccination, administration of antitoxins, and similar preventive measures of the modern physician are regarded with a supersition differing from that of the savage only in degree. Our whole system of modern medicine is destined to be built more and more upon the foundation of the development of immunity and preventive medicine. It is not sufficient for the welfare of society that men and women in our colleges be trained in the general methods of the preparation of sera, antitoxins, vaccines and the like, for they constitute by far too small a percentage of our total population. The pity is that some knowledge of these intensely interesting and vital relations of man to other animals in the prevention and control of disease cannot be given to all classes of society. If future generations are to be prepared for the reception of the advances which are bound to come in the practice of preventive medicine, it is essential that the general public be educated along these lines. Otherwise advance in this line would suffer the same fate as that accorded the practice of vaccination when it was first introduced into this country. History is replete with the records of social and economic revolutions which, once started, have failed because of the fact that the people had not been prepared to accept them. The logical place for the preparation of the general public for the advances in medicine which have been outlined above rests with our high schools and more specifically in connection with the courses in zoology.

Our public press in the past few years has conducted several campaigns against the quacks operating under the disguise of the medical profession. Occasionally we read sensational articles upon the apprehension of a few miscreants and the exposure of their methods of operation. The vast majority of the tribe remains unmolested and stands as a stigma in most communities. Most thinking people if asked for an explanation of why these conditions exist are free to confess that ignorance rests at the bottom of the whole system. It is not, however, the ignorance of illiteracy for many of the victims are of what we might call the educated class. The ignorance that plays into the hands of such imposters is the ignorance of the human body which prudish persons frequently mistake for a type of chastity. Any person ignorant of the structure of the human body and its normal functions is just as much an obstacle in the path of social and economic advances of a community or nation as is the quack who preys upon such ignorance.

Turning now to some of the other phases of zoology which might be emphasized as of direct human value, the much discussed problems of heredity and those of sociology growing out of the operations of heredity can have little significance to the individual who is not acquainted with the fundamental concepts of the animal cell and its structure. Not that I claim an extensive study of the cell by students of this age is desirable or even possible, but the concept of the cell as the unit of bodily structure with at least a brief knowledge of the reproduction of the cell and the functions of the chromosomes as bearers of the determiners of hereditary qualities constitute a type of knowledge possession of which is essential to right thinking and to the abandoning of superstition regarding the genesis of life and the hereditary relation of parent and offspring.

A full realization of man's place in the universe can come only after a careful study of man's relations to other animals. In its entirety, this is a problem too deep for the adolescent mind to grasp. However, it has been well said that primitive man *felt* rather than knew his relationship with other animals. In much the same way the child with his inherent interest in animals offers a foundation already prepared upon which to build a knowledge of those animals and a beginning of an understanding of his relations to other organic beings. Here is a field where the study of zoology alone can direct the primitive instincts of kinship between man and other forms of life toward the formulation of a rational concept of man's place in the universe.

Some practical knowledge of organic evolution must be behind every move in the progress of man. The facts of evolution may be recorded on the printed page but some facts standing alone have little true significance to the individual who has not had some first hand knowledge of the structure of a graded series of animal forms. Further, in the study of the varieties of domesticated animals we find material which is able to impress the high school student with the idea of plasticity of animal form and the responses of the organism to the factors of evolution even though they are here manipulated to great extent by man. It is but a step from this conclusion to a realization that these same laws of evolution are operative upon the human being. True, not all high school students would grasp the significance of such a conclusion; not all would be able to take this final step; but the chances are that many would sooner or later be able to think the problem through for themselves and arrive at the conclusion that since man is subject to these same laws of change, man and his creations must participate in the endless march of time. If his progress is not upward it must be in the opposite direction for the progressive change of evolution works equally in either direction. Such a conception is an absolute essential for a social or economic leader of men. For that reason it seems imperative that the background against which such concepts may be formed should be presented to as many of the future leaders as possible. The high school is none to early to begin training along such lines.

THE NEED OF A MORE GENERAL KNOWLEDGE OF AND TRAINING IN BOTANY

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Recent developments in the field of botany have been so remarkable that botanists may justly feel proud of the knowledge, the great material prosperity, and the improved living conditions made available, by the contributions of their particular science.

The subdivisions of the mother science have become so vigorous and have penetrated so far into their respective fields that it is impossible for the members of any one group to be thoroughly cognizant of the achievements of the others. There is, however, a common ground on which all botanists may meet. There is likewise a stock of knowledge which must be not only the possession of botanists, but which must become the inheritance of the average citizen if botany is to fulfill the important mission allotted to it by nature. It is chiefly in the interest of botanical education that I wish to speak.

Genetics as we know it at present in its application to plants youngest member of the botanical family. Since its rebirth less than two decades ago, it has held the spotlight of the scientific stage, and the workers have done much to deserve the attention they have received. Definite methods of procedure have been formulated by which cultivated plants may be modified almost to suit the fancy of the producer. By an intelligent manipulation of the normal reproductive processes of plants, new varieties may be produced, desirable characters accentuated and objectionable qualities removed. Yet genetics, mendelian inheritance, and eugenics are terms which have but little vital significance to the vast majority of college graduates, while to the great rank and file of citizens educated in the public school they are meaningless symbols.

All botanists know that phytopathology has passed from the pioneer stage. Its importance to all phases of plant production is now so well established that colleges and universities everywhere have departments wholly devoted to this branch of botany. Conclusive evidence to justify the formation and maintenance of these new departments at public expense is to be found in the results obtained by the corps of active practitioners associated with every experiment station. But to what extent has the great body of knowledge accumulated by the experts become effective in the practices of the average man engaged in growing plants? My observations in this particular field have been somewhat extensive, ranging from the large commercial nurseries to the back woods farmer. It has been found that the producer who treats his seed wheat for smut or his potatoes for scab, or who in any way modifies his practice to prevent the infection of his crops or to control the spread of contagious diseases is the very rare exception. The resultant losses are measured in hundreds of millions of dollars.

In bacteriology the contrast between the valuable knowledge extant and the portion functioning among the people is greater than in any other field of botany. And since many of the edicts of the bacteriologists are laws of health nonconformance to them through ignorance is all the more disastrous. City ordinances calculated to protect public health are for the most part dead letter laws. No law can be inforced against an indifferent or antagonistic public opinion. Ignorance when not antagonistic is usually characterized by indifference. Instead of our public schools being places where specific and effective instruction is given on the nature and control of contagious diseases, they are more often places where contagious diseases are disseminated. It is truly pathetic to hear well meaning parents rejoice because Willie got the whooping-cough or Johnie the mumps, measles, chicken pox, scarlet fever or what not, while he is young. Their theory is, and to our disgrace it is the prevailing theory among the masses, that people must have these diseases and therefore the sooner it is over with the better for all concerned.

It would be ludicrous if it were not so serious to witness the attempts to prevent infection when the information goes out from the health officials that the city water supply is contaminated. City folks are not the only nor even the worst offenders against the laws of sanitation so well known to the botanists.

Down on the farm where everything is supposed to be so pure, fresh and healthful, we more often find filth resulting from garbage undisposed of, open privies, and other sources, so that one is continuously exposed to typhoid, hookworm, and diarrhea through the well known channels of infection.

These conditions it seems to me are directly chargeable to the lack of an educational policy intended specifically to overcome them.

The agriculturists are doing more and succeeding better in disseminating the facts which we hope are destined to transform farming from an empirical practice to a scientific procedure.

As the result of state and national aid the agricultural experts have gone directly to the adult population and with much tact and persistency have demanded a hearing. No such inclusive campaign has ever before been attempted in American education. The results, in so far as the results of an educational campaign can be judged, have justified the effort and the expenditure of public money. There is, however, much remaining to be done. There are legions of farmers living contentedly in their sins. They plant their crops by the moon, operate on their stock according to the signs of the zodiac, and carry buckeyes to ward off disease. Many of these individuals have been in contact with the truth, but they have passed the formative period of their lives and their habits have become fixed. They may even assent intellectually to the teachings of the experts, but they have not the power to adjust themselves to the new methods. They go calmly on doing as their fathers did while the average yield of crops thruout the country is only from one-third to one-half what it would be if the average farmer knew and applied the available knowledge on plant production. As propaganda the course which has been pursued by the agriculturists has produced wonderful results, but as a fixed educational policy it has many elements of weakness. The greatest good has come, not from the regeneration of the adult population, but from the number of young people who have been influenced to enter the schools and take up a systematic and thorough study of agricultural science.

I have included this statement on the conditions in agriculture because as Dr. Gager recently said, "Most botanists have never been able to shake off the superstition that somehow or other the successful growing of crops is in part at least a botanical problem."

Suppose we turn our attention from applied botany very briefly to the pure science side of the subject without which there could be no applied science worthy of the name. Suppose we were to select some of the big and vital things which have been done recently in plant physiology or morphology, in taxonomy or in ecology, in cytology or evolution, and go before the public to find out what is known in these fields of plant science. We should learn not only that the so-called educated public knows nothing of the facts, but also that the individuals are extremely scarce who know that the field of botanical endeavor has become so large as to include any such subdivision of subject matter.

The facts which I am endeavoring to emphasize are: (1) that there is a large stock of extremely valuable knowledge in the botanical storehouse. Knowledge which has as many points of contact with the lives and practices of the people who compose the average community as can be established by any of the fundamental sciences. It is knowledge which applies directly to sanitation and maintenance of health, to the production and preservation of foods, and to increased efficiency wherever there is involved an intelligent control over plant life or plant products. (2) Just as obvious as the preceding and to those of us interested in public education equal to it in importance is the fact that there is but a very small portion of this knowledge that is being used by the people to whom it is most applicable and by whom the funds have been contributed which has made it available. Through the lack of judicious advertising and efficient salesmanship there is but little public dmeand for our goods and our most valuable stock is lying stored in the libraries unused.

Live contact has not been made between the research laboratory and the public mind. As a result the current which should transport the new knowledge to all the people and which should ever carry a fresh and vigorous supply of new workers back to the laboratories is not functioning effectively in either direction. The public is not receiving just returns on its investment and it is only natural that the condition should be met by indifference and the withdrawal of support.

The U. S. Commissioner of Education tells us that the number of high school students taking botany decreased 45% between 1910 and 1915, and that less than 8% of the *total* enrollment studied the subject.

Botanists must decide if it is desirable for the present movement to continue. It means that in the near future botany will be studied only in the colleges and the universities, and that knowledge of plant life from the scientific point of view will gradually disappear from the people who receive their entire education in the elementary and the secondary schools. If this is considered desirable then the present course which is a sort of intellectual isolation is the correct one to pursue.

Any one who knows the subject matter of botany and who is interested in public education will look upon such a result as a calamity both to the science and to education.

The attempted solutions which have been presented recently under the names of Civic Biology—Elementary Agriculture, General Science, and other popular names have for the most part been unsatisfactory to the botanists. We feel as if we were trying under a camouflage of popular phrases, to teach our students a little botany without them knowing it. A rose by any other name may be as sweet, but the botany which has been offered under these assumed names has in most cases been so dilute that it is well nigh valueless. It perpetuates none of the valuable history of our science, meets the present needs only in the most superficial way, neither does it have any elements of promise in it for the future.

There is, after all, a good deal in a name and it is very unfortunate that botany has become a synonym of uselessness in the public mind. The name seems to stimulate about the same round of emotions in the average individual that the term Nature Study creates among the scientists, except, perhaps, that the latter are a little more violent. I believe that the good name of botany can and will be cleared of the unjust indictment of being useless. I also believe that science will soon form a part of the elementary school course, but I doubt if it can go in under the name of Nature Study.

The work done by the advocates of general science has, I believe, been done in good faith and it has served at least one excellent purpose. It has put the case squarely before us in a way that demands immediate attention.

It is not a simple problem. Many factors have contributed to the condition so tersely expressed in the report of the Commissioner of Education. It seems to me that the discussions of Dr. Gager and Prof. Jordan before the sections of Botany and of Agriculture respectively of the American Association for the Advancement of Science point us in the right direction. What these men have said I believe is in perfect harmony with what Prof. John M. Coulter has been preaching in season and out of season for the past five years or more. The apparent harmony of thought and purpose coming from what in the recent past have been considered rival camps is evidence that progress is being made. I believe that the time should come and I have faith that it will come, and that soon, when the agricultural courses both in the secondary schools and in the colleges will require a preliminary knowledge of botany. The agriculturalists need it and the botanists can do the job. *When agreement can be reached on what the content of such a course should be a big step will have been made toward the solution of our problem.*

I do not believe, however, that botanical courses in the secondary school should exist entirely or even primarily, as a preliminary to agriculture or horticulture. There are too many students who by the very nature of the case cannot continue in that direction and botany can be made to serve them in a more effective way.

I would like to see the courses in botany prepared for the high schools and for beginning work in college so that the points of application to the lives and interests of every one would be so numerous and so evident that there would be no question as to why they should be required of all, no matter what occupation might be chosen in the future.

In the administration of these elementary courses I would remove the handicap of extra hours which has been arbitrarily imposed on high school science and which is one of the chief causes of its unpopularity with students. I believe that five hours a week under a good science teacher will contribute as much to the education of a high school boy or girl or of a college freshman as an equal numbers of hours spent in any other subject even though two or four of these hours are spent in the laboratory. The extra hour requirements in the elective sciences have caused the courses to be shunted into almost inaccessible places on the schedule and to be handicapped in numerous other ways. Botany as well as the other sciences would be greatly benefited if more men educated in science would sacrifice their personal interests and seek administrative position.

The best time for the training of a botanist to begin is while he is still at his mother's knee, and the more agencies which can be made to contribute to the desired end the better. Much effort may well be spent in general appeal and instruction by the press and from the stage and platform, but in the last analysis the regularly organized educational institutions will have to be held responsible for the job. Surely there is no place in the public school system where in this so-called scientific age the teaching of science should be neglected.

There is a rich fund of material related to the knowledge of, and control over, plant life which is admirably suited for the needs of all the children in the elementary school. The big reason why Nature Study has been a failure up to the present time is that the scientists have not given it the attention it deserves. Adverse criticisms have been and are abundant, but constructive cooperation has been almost lacking.

There should be a direct and definite course of science teaching which should proceed in regular sequence through the elementary school, and the high school into the university. I would direct no one into such a course simply because it led into the university, but because the lives of those who traveled in that direction would be enriched and enlightened every step of the way. It should make no difference whether an individual went but a short distance along the route or whether the entire journey was completed. He should be given direct and immediate values for the time and effort spent.

Other sciences have established the connection between the fundamentals of their subject matter and the daily lives of the people without material loss in scientific value, and I believe that botany will not longer lag behind in the process.

THE NEED OF A MORE GENERAL KNOWLEDGE OF AND TRAINING IN CHEMISTRY

W. A. Noyes, University of Illinois

Before we can discuss properly the place of chemistry or of any other science in a scheme of education we must have a basis in some true philosophy of education and back of that must be a sane philosophy of life. Very many of the present tendencies in High School education seem to imply that its primary purpose is to develop men and women who are money making and money spending machines and that life consists chiefly of the externals, food and drink, and clothing and recreation and material resources. The poet Tagore gives a quite different view —to him the ideal of life is not acquisiton, but *realization* and our greatest teacher has said, "The Kingdom of God is within you." For three and a half years of terrible war, Germany has been fighting because the masses of her people have believed that she is surrounded by hostile nations which threatened to destroy her civilization and because her leaders believe, with some show of justification, that their civilization is the best in the world and that it is their duty to impose it on others. Our allies have been fighting that the principles of justice and humanity may not perish from the earth and they are slowly coming to see that international cooperation and mutual helpfulness are better than selfish national aggrandizement. On both sides the nations of the world are demonstrating that they are willing to sacrifice a million lives and the material accumulations of a generation for ideals which are of greater value than life tself.

The dominant purpose of our education should be, therefore, to prepare our pupils for a rich and varied intellectual and spiritual experience in life. To secure such an end we should not have a series of disconnected science courses filled with interesting information which the pupil can safely forget as soon as he has passed the semester examination, but a graded course in science running through four years arranged in such a manner that each part rests upon that which precedes. The natural sequence might be physiology, botany, zoology, physics, chemistry. I place chemistry at the end because it is better adapted than any other science to bring, with its own special contribution, a correlation of all the scientific knowledge which precedes it. It would be well to give an examination at the end which should cover in a comprehensive manner the work of the four years. The older education secured such a consecutive, graded course by the study of Latin. Scientific studies will never satisfactorily replace Latin in genuine educational value until we secure some such graded work as I have outlined. I think that some of our smaller schools, with a limited program, follow a better pedagogical model than the large, strong schools with their hodge-podge of electives, often administered without demanding a proper sequence of subjects.

In the presentation of chemistry or of any other scientific subject the attempt should not be made to give merely interesting information about a series of disconnected facts but rather to develop scientific habits of thought and the ability to understand clearly those simple, fundamental principles which are our most valuable heritage from the past. Above all the pupil should learn that these principles are not to be taken on authority but are logically connected with facts easily understood, some of which he can reproduce for himself. While the laboratory work should doubtless begin with experiments which illustrate the facts of general inorganic chemistry, qualitative analysis, if properly taught is better adapted than any other subject with which I am acquainted for the development of accurate, scientific methods of thinking.

The opinion is all too common that no study is "practical" which does not directly minister to the student's ability as a money-getter. If we accept the ideal which I have put before you—that our purpose should be to prepare the student for a rich and varied experience in life by suitable intellectual training in habits of accurate thought—courses which give some real knowledge of the science are certainly more practical than courses which give a great variety of interesting but disconnected information.

In vocational courses, however, the information important for the vocation which the student is preparing to follow finds its proper place. The ideal, as it seems to me, would be that each pupil before leaving school should have some vocational training. If he is to leave at the close of the eighth grade, at least a part of his work should have a direct bearing on his future vocation. If he is to go out into life from the high school he should be trained in school for some definite vocation. The same is true of the University if his education is to close there. But the amount of time given to training for a vocation should never be so great as to crowd out the more important training for life and for citizenship.

PHYSICS IS A FACTOR IN A LIBERAL EDUCATION

Fred D. Barber, State Normal University

As an instructor in physics in a Normal School and Teachers' College, I conceive it to be my chief duty to give such instruction in physics as will enable my students most successfully to teach that subject in our public schools. With this end in view I feel it my duty to study constantly: First, the prevailing curricula of our public schools, especially our high school; Second, the service which our public schools can render the people of this state and nation; Third, the choice of subject matter and the methods which will best accomplish the desired results. In this paper I shall, therefore, briefly indicate some conclusions bearing upon these points so far as physics is concerned.

In thus confining my discussion to these points I beg you not to suppose that I am unmindful of the importance of research in physics. Without the fruits of research in physics nearly all lines of engineering, as well as the application of physical principles to many trades, to agriculture, even to housekeeping in the modern home, in fact to nearly all occupations of life must to greater or lesser extent stagnate. To the research worker in physics we must ever look for inspiration and for the further mastery of the physical forces which makes progress along many lines of life's activities possible. All honor to the research worker in physics and his co-workers in allied sciences for the knowledge of the physical world and physical forces which is making possible the engineering achievements in the great world conflict which is upon us. If the United States and her allies shall finally triumph in this greatest of all human struggles, that of democracy in resisting the tyranny of autocracy, and we all believe that we will so triumph, the victory will largely be due to the achievements of research and the inventive genius of the Anglo Saxon in utilizing those discoveries in our defense. And if at the end of this gigantic struggle this war-wrecked earth shall be able again to gather its wasted power and forces together and again become a peaceful and comfortable abiding place for mankind, with humming industries and thriving commerce, with food in abundance, with the common comforts of life and a reasonable measure of life's pleasures available to the masses, the achievement will largely be due to man's mastery over the physical forces about him. We shall ever look to the research worker and his revelations for the knowledge which gives man an ever increasing supremacy over his environment.

It seems certain, however, that the field of research in physics is in little or no danger of neglect. Capital and gigantic industrial organizations hold forth mighty inducements for research work in physics. Moreover, our great universities, many of which are liberally supported from state treasuries, gather together many of our best prepared research workers and place at their disposal abundant means for the prosecution of their work. Even though I thought it desirable, but which I think is quite unnecessary, yet no word I could utter would in the slightest degree stimulate or accelerate research in physics.

It is, therefore, not to the problem of research in physics but to the problem of the dissemination of the fruits of research among the masses to which I wish to call your attention. This, it seems to me, is the great need of the hour. If the value and significance of scientific research is not revealed to and appreciated by the rising generation there will certainly be fewer research workers in the next generation. Also, if the masses come to regard science instruction in our public schools as of little importance, much of the service which research in science might render humanity will be lost. It is my purpose to point out the fact that at the present moment there is great danger that such an attitude towards science may become prevalent not only among the masses but even that the authorities in charge of our public schools may also assume that attitude. This Academy of Science cannot afford to be indifferent regarding the position in which science finds itself today in our public schools. The attitude of the nation towards science in the years to come will largely be determined by the attitude of our public schools towards science tomorrow.

THE DECLINE OF PHYSICS IN OUR PUBLIC HIGH SCHOOLS

During the past twenty years there has been a constant decline in the *percentage of students* in our public high schools who enroll in physics classes. In the United States as a whole, according to the reports of the Commissioner of Education, the percentages of high school students who enrolled in physics has declined from 19.04 per cent. in 1900 to 14.23 per cent. in 1915, a decline in fifteen years of 25 per cent. In Illinois, during the same fifteen years, the percentage enrollment has declined form 17.40 per cent. to 12.73 per cent., a decline of nearly 27 per cent. While this decline in percentage enrollment has been vastly less marked in physics than it has been in some of the other high school science subjects it has been sufficiently great to cause us to pause and seriously reflect upon its cause and its significance. It should be noted that this decline in the percentage of high school students who enroll in physics has taken place during a period when the control of our physical environment was rapidly increasing as a factor in our national development. That the decline in percentage enrollment other high-school science subjects is still greater is no consolation to the physicist, but rather an added source of alarm. That the decline in percentage enrollment in physics was only between 3 per cent. and 4 per cent, during the five years from 1910 to 1915 affords some consolation. One can not resist the temptation of asking, however, whether it is probable that the decline in percentage enrollment and apparent appreciation of physics as a high-school subject is about to cease. Can we reasonably expect at the present time to see a reaction set in and to see physics soon regain its former position as a high-school subject? I have been asked to speak of physics only, but what I say concerning physics as a high-school subject today could be reuttered in much stronger terms regarding other high-school sciences.

I regard it as most timely that this Academy has at this meeting turned its attention to a consideration of science as a factor in our common school educational system. A wide-spread spirit of unrest and a prevalent dissatisfaction with our school curricula coupled with a strong popular demand for efficiency and conservation in all life's activities are making new demands upon common school education. Nor, in my judgment, will this demand cease with the close of our present struggle for the maintenance of our national freedom. On the contrary, I believe, that the period of reorganization which will follow the close of the war, if the perpetuity of democratic institutions is guaranteed, will demand that our system of public school education shall be thoroughly reorganized with a view of making it more efficient and of greater value to the masses.

THE SMITH--HUGHES ACT

The demand for greater efficiency on the part of our public schools, so far as it relates to the training of the masses of young people who will of necessity, in a large measure, become the producers of the next generation, is clearly shown by the passage by Congress of the Smith-Hughes Bill. By the terms of this act many millions of dollars will be available as federal aid for the promotion of strictly vocational training to be given within our public high schools. This act seeks to encourage the public high school to provide technical training for boys in agriculture and the industrial trades and for the girls in domestic economy. Moreover, this technical training is to begin with the entrance of the pupil into the high school, that is, at the age of about fourteen.

No one can today safely predict to what extent this act by the federal government will have upon the public high schools of Illinois and of the nation. Nothing is more certain, however, than the fact that when the federal government holds out a substantial bonus to the high school which will conform to the curriculum prescribed many high schools will conform and the act will be a large factor in the reshaping of high-school curricula in the immediate future.

To appreciate the possible effect of the Smith-Hughes Act upon science in the high school we need to recall some of its provisions. In order to receive federal aid, as I understand the law, every student in the class must devote one-half of his time to strictly vocational studies, the announced purpose of which is strictly the mastery of some industrial trade, or of agriculture, or of home economics; one-fourth of his time may be devoted to closely allied subjects, such as "applied mathematics" or "applied science"; the remaining one-fourth of the pupil's time may be devoted to what are commonly called culture studies. Detailed statements regarding the conditions under which federal aid may be secured are given in the Educational Press Bulletin, No. 124, issued by the State Department of Public Instruction for February and several bulletins issued by the Federal Government.

My only purpose in referring thus briefly to the provisions of the Smith-Hughes Act is to point out the fact that in order to enjoy federal aid the curriculum of the high school, or at least the portion of it which will receive federal aid must be intensely practical. For instance, there is no place provided for cultural science; the science taught must be applied science and have a direct bearing upon vocation chosen. Listen to some of the terms used to describe the character of the science which may be taught: "Prerequisite science", "agronomy", "soil physics", "soil fertility", "animal husbandry", "horticulture", "general science", "applied science", "household physics", "household chemistry", "science essential to competency in the trade or industry which the pupil is preparing to enter". To be sure, the teachers of these courses are required to have training in "related science work such as botany, zoology, chemistry, physics, geology, and mathematics" or as stated in another place "trade mathematics, trade science, and trade drawing from the standpoint of methods of teaching and teachable content of the trades".

In this statement we have a view of the outlook for high-school science under the provisions of the Smith-Hughes Act. This law as I understand it has the approval of Governor Lowden and of the Department of Public Instruction. Three weeks ago today the Schoolmasters' Club of Illinois was in session at Decatur. As is well known that organization is representative of the school administrative forces of the state. The topic under discussion at both sessions was the Smith-Hughes Act. Its provisions were explained by those who will have its administration in charge. Not a single superintendent present raised his voice to ask whether it is to be the chief function of the public school to give technical training to boys in agriculture and the industrial trades and to girls in domestic economy. On the contrary, to all appearances, it was a scramble on the part of superintendents to learn the exact conditions with which their schools must comply in order that they may share in the distribution of federal funds.

I have long felt that the physics taught in our public high schools has not been well adapted to the needs of the masses. I have long felt that the decline in the percentage of students enrolled in physics was largely due to that fact. From long experience with students coming from our public high schools I speak with positive certainty when I say that physics as usually taught in the high school is both distasteful and uninteresting to a majority of high-school students, especially the girls. It does not appeal to them as worth the effort required to secure the passing grade. It has been, to a large extent, a misfit in the curriculum if it is the purpose of the public school to develop the boy or girl by natural and psychological instruction into men and women who shall appreciate science and shall be able to apply its principles to their own environment. I have long felt that not only physics but all high-school science needs reorganization. If high-school science is to be saved, in my judgment it must be reorganized and adapted more closely to the immediate appreciation and the ultimate needs of the masses. But it also seems to me that the present tendencies in public school education, if those tendencies are truly represented by the shifting enrollment in high-school subjects and by the provisions of the Smith-Hughes Act, are based upon a misconception of the real immediate appreciation and the ultimate needs of the masses.

To me it is unbelievable that the primary function of the public high school is to start our boys and girls at the age of fourteen upon a strictly vocational training. I can not bring myself to believe that boys and girls of that age are ready for any kind of specialization in education. I believe that at least the first two years of high-school training should be devoted chiefly to the acquisiton of knowledge concerning their social, economic and natural environment. If democracy is to survive is it not evident that to the largest possible extent a common pabulum of environmental understanding is essential? The very hope of democracy rests upon the possession by the masses of a common pabulum of understanding. Surely we are not ready to concede that the capacity to earn ones living is a sufficient qualification to assure good citizenship in a free democracy; the possession of superior skill in a certain trade is no guarantee of good citizenship. I cannot believe that the American people are ready to cast aside the long cherished conviction that general education, general enlightenment is the foundation and bulwark of real democracy.

If narrow vocational education of the type indicated by the provisions of the Smith-Hughes Act shall become the prevailing type of our public school education there will practically be no place in the high-school curriculum for physics or for any other special science. The cultural element of science, the historical element of science, the general enlightenment of science—all these elements of a scientific education must go. The common pabulum of knowledge concerning our natural and physical environment must go. The Spencerian idea of science as a foundation for all solid and substantial education must go. Social solidarity will go. Society will tend more strongly towards stratification for we shall then be turning out from our high schools a body of specialized wage earners lacking social conscience and social coherence. Can democracy survive such a condition?

I believe that a violent reaction is bound to come against this extreme type of vocational education if it is ever accepted for trial by the American people. But I also believe that the present inclination to accept for a trial this extreme type of vocational education is a well-merited rebuke, at least so far as physics is concerned, for the kind of science instruction we have been dealing out to our high-school students. We shall have our rebuke, I fear, in good measure. May we profit by it but at the same time I trust that we may never agree that the narrow, scanty, purely mercinary training in science, a training intended merely to meet the demands of a specific trade, is an adequate training in science for the coming citzenshp of America. Such a training in science can no more prepare the masses for citizenship in a democracy than did the abstract, so-called logical training in science, which we have indulged in so largely during the past quarter of a century, prepare the masses for earning a living.

Somewhere between these two extremes must lie the happy mean. The high-school course in physics almost universally offered in the past has consisted of some two hundred or three hundred physical principles, abstractly stated and inadequately illustrated. Many of those principles have no essential relation to the daily life of the pupil. The laboratory work has generally consisted of blind and often unsuccessful attempts to manipulate with manual dexterity certain apparatus the like of which was never seen outside of the laboratory. The hundreds of set problems have usually been equally remote from the pupil's life experiences. The physics possible under the provisions of the Smith-Hughes Act will be found in limited quantities in the course in general science and possibly in some additional cases where physical principles are clearly required for an understanding of some process in a trade or occupation. No opportunity will be offered for the study of physics for the purpose of giving the student an understanding of or a mastery over his physical environment.

I deem it quite unnecessary that any argument be made before this body to show the necessity of disseminating as widely as possible knowledge concerning the fundamental principles of physics. If any one of the sciences is more fundamental than the other sciences, if any one has more universal application to human welfare than the other sciences, that science is universally acknowledged to be physics. A fair knowledge of the fundamental facts of physics is important to the farmer, to the industrial trade worker, and to the housewife in the modern home but is no less important as part of the equipment of the citizen for national, state and municipal government is nowadays largely a matter of applied science. I conceive it to be a part of the work of every high school to give something like an adequate training, not only in physics, but also in all the fundamental sciences to all the pupils in that high school.

Somehow, in some manner, we must so modify our science instruction so that it will appeal to school authorities as being of vital importance; science must be made to appeal to the pupils much more strongly than it appeals to them today. Only in this way can we hope to check the declining percentage enrollment in the sciences in our public high schools.

Science in the high school is today in a precarious condition. The seriousness of the situation is not easily overstated. This Academy of Science can certainly, it seems to me, do no better work in behalf of science than to study the high school situation. We should realize that the public high school is the chief medium for the dissemination of the fruits of scientific research and the chief source of future research workers. And above all this Academy should take a stand squarely upon the proposition that the first duty of the public high school is to train up our boys and girls into highly intelligent, public spirited citizens, with lofty social ideals and clear-cut social consciences that they may form the bulwark of democracy. Only secondarily shall our public high school be devoted to the task of producing skilled artesans.

THE NEED OF EARTH SCIENCES IN THE PUBLIC SCHOOLS

R. D. Salisbury, University of Chicago

1. VOCATIONAL BEARINGS (ABSTRACT ONLY)

This paper discussed the bearing of earth sciences on the many vocations in which knowledge of the earth plays an important part. The value of the knowledge of geology to farming, mining, oil production, and all industries concerned with the production of building materials and road "metal", was pointed out. A large proportion of the active men of our country are engaged in industries which have to do with soils, ores, fuels, and structural materials. In view of this great fact, it clearly is not right that boys be placed under a heavy handicap at the outset, by having the knowledge which affects their future productivity, withheld from them. Manifestly they should have a chance to gain the knowledge which will stand them in good stead, in all their future work.

In commercial life, knowledge of geography is as important as knowledge of geology. Where commodities are, where they are or are to be needed, how they are to be transported from the one place to the other, are primary matters of geography and fundamental matters in commerce. The location of power, of fuel, of raw materials, are parts of geography, and knowledge of them is a part of the equipment of every successful factory. These are but illustrations of the general fact that knowledge of geology and geography is of vital importance to the industrial life of most men. This being the fact, public schools cannot justify their action, if they do not make adequate provision for these subjects.

2. NON-VOCATIONAL ASPECTS

There is quite another aspect to geology, which does not concern itself immediately with income or with industry. The study involves the contemplation of things which are enlarging and ennobling, in a spiritual sense. No education which leaves out training of the imagination is properly enlarging or ennobling; and where, outside of science, is there such opportunity for developing and training the imagination, and where in science, a better field than geology? The time conceptions involved, the force conceptions involved, the results involved in the operations of time and force, are among the greatest with which the student has to deal. They strengthen the mind by exercise of a sort which few other subjects afford. In space conceptions, astronomy surpasses it; in their appropriate spheres, physics and chemistry are equally effective for the educational ends here emphasized; but on the whole, no science surpasses it.

No subject affords a better field for the development of that sort of attitude of mind which seems especially to fit men for life. While there are phases of the subject which deal with facts and principles which lead to inevitable conclusions as certainly as mathematical reasoning does, there are other phases in which reasoning of another sort is called for. In most of the affairs of life, decisions are based on a preponderance of evidence. In few momentous decisions is the evidence so clear that there is but one side to the question. Rarely is the evidence 100:0; it is 75:25, or 60:40, or 51:49. And training in weighing evdence which is not overwhelmingly one-sided, is one of the most important functions of education, for most of the important decisions of life are reached by the balancing of conflicting evidence. Thorough training in geology must lead to the balancing of seemingly conflicting evidence, for there are multitudes of questions to which the student of even the elements of the subject is introduced, concerning which evidence must be weighed, and a tentative decision reached, with a full recognition of its tentative character. The recognition of this character of a conclusion opens the way to a revision of judgment when additional facts warrant, and this attitude of mind is the attitude to which good education should lead, in connection with all questions where evidence is inconclusive, and this means in connection with many of the affairs of life.

No claim is set up that no other subject does the same thing. As a matter of fact, some do and some do not; but the claim is set up that the type of subject which works on strictly mathematical lines cannot, by itself, afford the best preparation for the solution of the average problems of the average man.

Neither can other types of subjects which do not involve the balancing of evidence, and the development of the power to separate what is weighty and relevant, from that which is light and irrelevant.

One of the great lessons which the world needs most to learn, is that progress comes from cumulative achievement. If every individual could be made to realize that even his tiny contribution to the sum of useful work is really moving the world along, it would add grandeur to life and dignity to all human endeavor. This is a frame of mind that should be developed in every young person, and cultivated till it becomes a habit. Where can this be done better than in connection with such a subject as geology, where the stupendous results of processes which, day by day, seem insignificant, are constantly under consideration? Nowhere else in the whole range of subjects in our ken, is the majesty of the cumulative results of seemingly slight processes more sharply emphasized, and more constantly reiterated.

Processes are at work on the land which, by themselves, would in time destroy it utterly. They have been in operation so long that they would have accomplished this result eons ago, if nature had not provided counter activities which defeat this end. Nowhere is the inter-play of constructive and destructive forces, using these terms in their bearings on man's life and welfare, more pointedly studied.

One of the chief functions of education is to put man into sympathetic and appreciative touch with his surroundings. His physical surroundings are an important part of his environment, always and everywhere, and he who does not understand, is cut off from one of the great resources of life. It is of course true that one may enjoy a landscape, even if one does not understand geology; but he will enjoy it more if he does. A man may enjoy pictures and music without understanding much about them, but he will enjoy them more if he understands. And just as some education in music and art is to be desired because it increases a man's capacity for enjoyment of the things which he sees or hears occasionally, so education with reference to the landscape, which the average man sees much more than he sees works of art, and much oftener than he hears music, is a desideratum. To go about the earth blindly, unintelligent as to the meaning of its surface configuration, is to cut off one of the great pleasures of life, and especially one of the great pleasures of travel.

Since all men are always in touch with at least a limited part of the land surface, and most of them in touch with enough of it to find lasting enjoyment in it if they are taught to see what it means, how can we justify ourselves, if we withhold this resource from this and coming generations?

Prompted by the attitude of mind which mountains inspire, I have repeatedly watched their effect on groups of students who, for the first time, live in them long enough to have their influence felt; and I have seen, or thought I saw, how littlenesses and meannesses drop away, and how the nobler qualities come to the fore. John Muir has made much of this idea in one connection and another, and I think he is entirely right. To many men, mountains are as inspiring, as uplifting, as soul-stirring, as great essays or great poems are to others. Is it not just as great a mistake to leave the one out of consideration, as the other? To the average young *man* at least, I suspect that the mountains are quite as much of an intellectual and moral tonic, as the best that he finds on the printed page.

What has been said of the mountains might be said, with modifications, of other parts of the earth. If there are those who think the landscape of an unrelieved tract like that about Chicago unlovely, I think this feeling would be changed completely, if the grand march of events which has made that surface what it is, were understood. While it can never have the charm to the eye that some other sort of surface has, it has its own elements of attractiveness, its own beauty, to the eye which really sees. When men belittle the attractions of the level prairie, they advertise their ignorance. One may not choose to read poetry all the time. With equal education in the two, I am confident that the normal man could live contentedly with the plains longer than with poetry—even of the best.

The sea has a charm for almost every soul, but he who gets only what the eye records of color and movement, fails of the larger meaning, which, to beauty, adds grandeur. What does the salt of the sea mean? What is the period of time of its accumulation? What volumes of rock—many times all that is now above its surface—have been destroyed in its production? What range and volume of life of which the voyager has but a glimpse, does it harbor now? What of the life of which it has been the home in the time which has passed since life was, and what of the great evolutions that have taken place within it? And what is yet to come? The great panorama of events, of processes, of changes, all of which are involved in the history of the sea, add a meaning larger than the eye, unaided, sees. To see the ocean merely as it is, is like seeing the social fabric of today, without reference to what has been in the past, or what is to be in the future.

Our period of school is all too short to give us an intelligent look into all the fields with which it would be profitable to have acquaintance, but is this field on which we live and move and have our being, one we can afford to neglect?

There is one other aspect of both geology and geography, which gives them great educational value. Neither science is completed or nearing completion. There are great things ahead in both. As an organized science, geology is older than geography, at least older than geography in its modern sense, and is the mode advanced. While geology has made phenomenal advances in the last half century, the problems ahead are so numerous and so interesting that even an elementary course in the subject, properly developed, opens up great vistas for the future. I believe it to be fundamentally important that young people should be led to see visions, and inspired by the allurements of future development. Nothing is more conducive to a right attitude toward life in general, than the feeling of the possibility of participation in the progress of the future. In this, geology is not peculiar. Only as it is less advanced than some other sciences, has it the advantage over them in this respect. In saying this, I am not losing sight of the fact that but few of those who give attention to geology in their student days, will ever go farther; but a comprehension of what is likely to come, stimulates an abiding interest, and abiding interests in various lines of work and thought, are important elements in a good education.

In modern geography the promise is perhaps even greater, since less has been accomplished. Perhaps no science touches human life and interests more closely, or in more ways. There is, I am confident, no science which, properly developed and utilized educationally, will do more for the development of good citizenship. Its substance perhaps touches the essence of material life, especially on the human side, more intimately than any other science. No other science and no other subject, unless it be sociology and possibly modern history, is likely to do so much to promote sympathetic understanding between the nations of the earth, and this is one of the greatest desiderata not only of this day and generation, but of all days and generations. For this reason, if for no other, promulgation of the knowledge of modern geography should be furthered wherever possible.

When geography and geology, and subjects which have similar advantages, occupy larger places than they now do in our educational system, I believe that our young men and women will be better equipped than they are now, to do their part in transforming a contentious world into a world of righteousness, based on mutual consideration.

WHY TEACH AGRICULTURE IN THE PUBLIC SCHOOLS?

Eugene Davenport, University of Illinois

This question is honestly asked by many thoughtful people who regard education from the traditional point of view as a kind of mental training quite distinct from the exigencies of existence.

Education is all this to be sure, but it is much more than this. The mental training represents the results, the fruitage of education, not its methods, its material, or its processes.

Constructively education implies two parties, the *teacher* who represents the older generation and the *pupil* who is getting ready to live. If the older generation is to help the younger it must have suitable *material* to work upon, and as nobody knows the future the material must be drawn from what lies at hand and from the knowledge and experience of the present and the past.

The first reason for including agriculture among the materials employed for the training of the next generation is that it is *useful*—the very reason which some would advance for its exclusion.

Historically, utilty has always been the basis of education. The non-utilitarian is a later, a very valuable, but a far less fundamental consideration than is the useful.

The primitive teacher is the father and the medicine man. Whatever the medicine man may teach of stoicism, of superstition, of religion, it is the father who teaches how to trail, to kill, how to elude an enemy, how to build a fire in the rain, how to run and dive,—in short, how to live as living is defined among savages. And the chances of the pupils living are in direct proportion to his faithfulness and ability as a learner. Considered in the large, education is not different now.

If we omit the wandering philosopher, the first schools were employed to teach definite occupation—the practice of medicine, the knowledge of law, the teaching and advancing of religion. Latterly, we have recognized a longer list of necessary occupations in which learning may be useful, and among these is farming, which for our purpose may be defined as the using of the land for the scientific support of human life upon the earth.

It is manifest that the amount of human life which can be supported upon the earth and the happiness it may attain are in large measure determined by the skill and the scientific knowledge with which we use the soil. No apology is due therefore for advancing the *argument of utility* as the *fundamental reason* for teaching agriculture in our public schools.

A second reason for including agricultural courses in our curriculum is that thereby we *connect the schools with real life.*

This connection is hard to make and many a graduate has turned out useless only because the school failed to connect its its activities with the serious business of living and the student failed to make the connection for himself. For many years his board and bills have been paid automatically and without exertion on his own part; indeed, he has come to consider going to school as a kind of occupation,—why not after sixteen years of carefree experience? Such an unhappy result of universal education may and does occur in techincal courses, but far more rarely than in the non-technical.

Again, the materials and the applications of an agricultural course are concrete and close at hand. They lie within the student's personal purview and well within his capacity to understand.

Much of the material of education is of necessity abstract or else far away either in time or space. The concrete is clear and easy of apprehension. It is enticing, for its presents opportunities. It is exhilarating for the connection and the meanings are evident and world-wide.

Still again, agriculture provides something for the student to *do.* It enjoins performances. It threatens failure but it invites success. And all this is well worth while.

Much of the material and motive of education lie entirely beyond the ability of the student to exert the slightest influence upon the course of events.

He sorely needs opportunity for trying out his powers of construction as well as those of expression, and among all the subjects that offer this opportunity, agriculture is one of the best because it is concrete and because it lies close at hand. It is a man's job. It is tremendously full of opportunities and consequences. It provides good material on which the boy may whet his faculties. The prospect is eminently educational.

Incidentally, the field, the materials, and the philosophy of farming afford an almost infinite variety of engaging opportunity for meditation and for expression, and healthy intelligent expression is vitally connected with intellectual growth.

Agriculture in practice *is an art as well as a science.* As a subject of instruction it is a science. The content is eminently useful, leading to the proper conduct of the great business of production. Its study demonstrates that successful civilization must rest upon a successful management of the lands of the earth, because food provides the only source of energy for the support of human life.

The methods of the study and the teaching of agriculture are the methods of science, and one great reason for teaching science is to develop in the pupil the faculties of exact observation, precious conception, logical analysis, and correct conclusions.

To these ends the physical sciences are especially valuable; none more so than agriculture. For precise methods no science equals mathematics, although chemistry is a good second; but when observation, analysis, induction, and deduction are all involved, no subject equals in teaching power the physical sciences, and of all physical sciences agriculture is the most concrete, the most human in its applications, and the most fundamental in its results upon the welfare of man.

In general, science must not be relegated to the fringes and fads of our education, but it must constitute the background,—indeed the very warp and woof of a system of universal education. This is because science is only another name for facts that are definitely ascertainable, and of all the body of knowledge or supposed knowledge, facts of this kind studied in their relations and in their human meanings are eminently educative.

This is not decrying those forms of knowledge or of philosophy that cannot be definitely set down. They, too, are useful, but they have no presumptive rights. True, the soul of man needs food that is not tangible, just as truly as the body needs nourishment, but even here much of the material involved is purely secondary. For example, while literature is inspirational, language is mainly a tool for its expression and understanding.

The correct teaching of agriculture, too, soon leads the student into the field of obligation, of achievement, of usefulness, of contact with God's creatures, of partnership in His Plan, and of a wholesome philosophy of life in living. No consistent student of agriculture can be either an atheist or a loafer. He cannot sleep well nights unless he does his duty day by day and works with the Lord in the feeding of His people.

When once the higher view and possibilities of agriculture are more generally understood and taught, then will universal education begin to be able to fully justify its existence and the time and the money spent upon it.

General Papers

IS THE STATE ACADEMY OF SCIENCE WORTH WHILE?

J. L. PRICER, STATE NORMAL UNIVERSITY

In these days of flux and change, when everything is taking on new values, and when new calls are being made on all of us for time and energy and sacrifice, it may be well to scrutinize almost any existing institution as to its worthwhileness.

The Illinois Academy of Science had a most propitious beginning, enrolling as it did, almost every scientist of any prominence in the State, as a charter member. It seemed to give promise at the time of its birth, of becoming at once, one of the strongest organizations of its kind in the country. But of course, there was in this promise of vigor and usefulness, and in the plan of organization, as laid down in the constitution, a confident expectation that the State would soon recognize the value of the organization and give it the aid it needed to to function properly, in the service of the commonwealth. We seem to have been possessed of a perennial hope that the State would ultimately recognize our worth and bestow upon us the financial aid necessary to vitilize our organization, and to carry over to the point of effective service, the energy, and time and money that we as members could afford and were willing to put into it. While this hope which has been kept alive by a small bit of realization in the form of a small grant from the State Treasury for the biennium of 1911-12, and by repeated passage of an appropriation for us by both houses of the legislature,—while this hope has been a stimulating factor, during the eleven years of our history, doubtless some of us are beginning to feel that we can not continue to exist on hope alone.

Now, we are facing a large financial deficit, which we incurred under the delusion, that our hopes had been finally realized. While nearly every member from whom I have heard, seems determined to make what further sacrifices are necessary to raise money with which to meet our obligations and to put the organization intact once more and ready to continue its demands of the State, I have some intimation that a good many are asking more seriously than ever before: "Is the Academy worth while?"

I for one would be frank to confess, that if the Academy is to continue indefinitely to be the poverty stricken organization that it has been in the past, it would not be worth the sacrifice and the effort that its members would have to make for it. Thru lack of funds for printing, we have not been able in the past to do in any effective manner, either of the two fundamental things which we state in our constitution to be the purposes for which we exist as an organization. Most of our publications have been little more than mere apologies for what they might have been. They have consisted too largely of abstracts and have been published in such small editions that the papers printed in them have been quite effectively buried from sight. They have been neither an effective stimulus to scientific research, nor an adequate means for the dissemination of scientific knowledge. We have had some splendid programs, but we might have had much better programs, could we have offered a more attractive medium of publication. Money for the adequate publication and distribution of our transactions is the one thing needed to transform the Academy from a weak, struggling and ineffective organization, to a vigorous and effective organization that would draw all the forces of science in the State together and multiply their power for good.

So, in my opinion, the question as to the worthwhileness of the Academy resolves itself into the question: "Is there any liklihood that we shall ultimately secure the aid from the State that is necessary to make it worth while?" I am persuaded that there is absolutely no question about this. We have probably been too patient and long-suffering in this matter. We have probably urged our cause with a modesty and a timidity that may be becoming to men of science, but which is not calculated to attain success in some other fields of activity. The State is thoroughly committed to the policy of aiding scientific and educational organizations by paying for the publication and distribution of their proceedings, and the states of the middle west are most of them, committed to the policy of supporting state academies in this way.

The High School Conference at the State University publishes its transactions and pays the expenses of most of the speakers on its program out of State funds. In the same House Bill No. 853 in which our illfated appropriation was included when it passed both houses of the legislature, were included the following allowances for somewhat similar organizations: to the Bee-Keepers' Association, $2,000.00; to the Dairymen's Association, $5,000.00; to the Poultry Association, $2,000.00; to the Live-Stock Breeders' Association, $3,000.00, and to the State Horticultural Society, $11,000.00. It may be that we are not exactly in the same class with these organizations. It may be that the services that we could render to the State would be a little less direct, or a little farther to seek than those rendered by these other organizations, but they are surely none the less certain, and of no less magnitude. It only remains for us to convince the Authorities at Springfield that this is the case. It is my understanding, however, that Governor Lowden vetoed our item in the bill, not because he deemed our cause unworthy, but simply because it happened to fall in the class of new requests, and under the conditions of great national stress, he had determined to draw the line at that point. So, so far as the worthiness of our cause is concerned, in the judgment of the present State government, our battle has been already won. Of course, many good things must wait on the outcome of the present international crisis, and on this account we may be compelled to wait, but I can see no cause, at the present time, for ceasing to persist in our efforts to make the Academy what it should be, with firm confidence that if normal conditions do return after the war we shall succeed.

When we consider how faithful the original members of the Academy have been in clinging to the idea thru eleven years of discouragement and disappointment; when we consider how willing they have been to contribute valuable papers to our programs, only to have them tide up for two or three years, before being published, and then finally published in so small an edition as to give them no adequate currency, there seems to be no grounds whatever to doubt the abiding faith which the membership has in the value of the organization. But we are now put to a new and more severe test. We must meet this new financial deficit. We must pay more than we bargained for. Let us hope that this is the final test before we are admitted to the promised land. It is my hope that we shall meet this test in such a convincing fashion that the very manner of our meeting it will be a large factor in making it the final one. To this end, it seems to me to be of the highest importance that every member contribute something, even if it is only a dollar. This would show a solidarity of purpose, of devotion to the cause, and of faith in the value of the organization, that would not be shown should we raise the funds needed by a few large contributions. We should show our strength, and our devotion to the cause of science also by the amount we raise. We should not stop with paying the debts already contracted. We should provide also, and speedily, the funds needed with which to publish the papers of this meeting.

The special address by Dr. Coulter, and the symposium on Science and Education, were planned specifically for the accomplishment of a definite and very much needed piece of work, and it is obvious that very little will be accomplished in the direction intended unless these addresses are given wide circulation. If, with the aid of a few large donations from wealthy men, we can raise enough money, not only to pay for the two volumes already published, but to publish the papers of the present meeting, we will have in this accomplishment itself, an unanswerable argument to the effect that we as a body stand ready to do our part of the work for the State that can be done only by such an organization of the science forces within it.

This is a day of organizations. Hardly any cause can prosper as it should, in these days, unless it is backed by an organization. I would not underestimate the value of the individual worker in science. Science itself, is the sum total of what individuals have done, and yet, it is obvious that no one has given his full measure of support to science when he has served it merely as an individual. He must join forces with others for the accomplishment of ends that cannot be accomplished by individuals, working alone. The papers and discussions of this meeting will develop the fact, I am sure, that science is not functioning in society as it should. In fact, I am sure that it will be shown that if certain present tendencies in education are allowed to continue, science will function among the masses of people, in the future, to a less extent than at present. Now, who is to check these tendencies, if not the men and women engaged in science work? And how can we deal with such problems except thru some organization? We who, are devoting our lives to science, should know better than any other class in society, the great need of the further prosecution of scientific research, and of the wider dissemination of scientific knowledge among the people, and so because of this knowledge, we are charged with the responsibility of doing whatever lies within our power to further the interests of these things. If we do not do every thing that we can to create public support and demand for scientific research, such support is likely to be lacking. If we do not assume some guarding care over science education, it is likely to be neglected. Science, like everything else, is always in competition with other interests, and most of these competing interests are backed by active organizations. Hence, it follows that if science is to hold its place and perform its true mission in society, those who understand and appreciate it best must be organized and in a position to assert its rights and to advocate its cause at every turn, and in the most effective manner.

In conclusion, I would say, then, that this is no time for any member of the Academy to give even a single thought to withdrawing his support from the organization or to shirk his share of the responsibility in helping it out of its present difficulties. In this day of patriotic appeals, when young men on every side of us are making sacrifices which are out of all proportions to anything that most of us shall be asked to make, the present difficulties of the Academy should shrink to exceedingly small dimensions, and we should do with a generous hand, what is to my mind, plainly our patriotic duty, both to society at large, and to the State of Illinois. It would be a sad commentary on the men of science in Illinois if this Academy should be allowed to perish or even to languish in this time when it is needed as never before.

THE STATUS OF BIOLOGY IN ILLINOIS HIGH SCHOOLS

FRED HARTIN, RANKIN, ILL.

The present status of biology in Illinois high schools is shown by the accompanying tables, which need only a brief explanation. The data for these tables were gotten from the report of the High School Visitor of the University of Illinois and from 275 replies to a questionaire sent to each of the public high schools accredited by the University of Illinois.

Table I shows the sequence of subjects in 169 Illinois high schools. Fourteen different arrangements are being used. The most common order of subjects is physiology, zoology, botany, this order being followed in more than half of the 169 schools. Two reasons are commonly given for using this order; first, that physiology is a science with which high school pupils are already acquainted and for this reason can be more profitably taken up first; secondly, because physiology is required by law to be taught in the ninth year.

The second most popular sequence of subjects is botany, zoology, physiology. This order has been adopted by the Biology Section of the Illinois High School Conference as the most logical and most pedagogical.

Table II shows eighteen different arrangements as to amount of biological work offered. The features of interest shown in this table are the fact that the half year arrangements is quite prevalent, that seven schools offer none of the three biological subjects, that twenty-nine offer no botany, forty-nine no physiology, and forty-seven no zoology.

Table III shows the amount required in 250 schools. Schools requiring all three subjects are mainly small high schools in which no electives are offered. The ninety-eight schools that do not require any of the biological courses are mainly the larger high schools which offer two or more courses. The requirement of some biology in certain courses in these schools is quite general but the selection of the course by the student is essentially the same as having none of the courses required.

Table IV shows what percent. the enrollment in each course is of the total enrollment of the year or grade in which the course is offered. Generally speaking, each biological subject is taken by about one-half of the pupils in Illinois high schools.

Tables I, II, and III show a general lack of uniformity in the organization of biological courses in Illinois high schools. This lack of uniformity seems to indicate a diversity of opinions regarding the aim or value of biology on the part of biology teachers, high school principals, and superintendents. If this be the true state of affairs, the low percentage of enrollment in biological courses is not so surprising.

TABLE I.

SEQUENCE OF COURSES

Sequence	*Number of Schools*
Physiology, zoology, botany	86
Botany, zoology, physiology	39
Physiology, botany, zoology	19
Zoology, botany, physiology	5
Botany, physiology, zoology	4
Zoology, physiology, botany	3
Zoology, physiology and botany parallel	2
Zoology and physiology parallel, botany	1
Zoology and botany parallel, physiology	1
Botany, zoology and physiology parallel	1
Physiology, botany and zoology parallel	1
Physiology and botany parallel, zoology	1
All three parallel	1
Physiology, others optional	5
Total	169

TABLE II.

AMOUNT OFFERED

Courses offered— Botany. Zoology. Physiology.	*Number of Schools*
½ year, ½ year, ½ year	247
1 year, 1 year, 1 year	2
1 year, 1 year, ½ year	30
1 year, ½ year, ½ year	6
½ year, ½ year, 1 year	2
½ year, ½ year, 0 year	23
½ year, 0 year, ½ year	9
1 year, 1 year, 0 year	10
1 year, 0 year, ½ year	4
½ year, 0 year, 1 year	1
1 year, ½ year, 0 year	2
0 year, ½ year, ½ year	3
1 year, 0 year, 0 year	3
½ year, 0 year, 0 year	4
0 year, 0 year, ½ year	19
0 year, 0 year, 0 year	7
1 year of botany, 1 year of zoology and physiology	1
24 weeks of botany, 24 weeks of zoology, 12 weeks of physiology	1
Total	384
Offering no botany	29
Offering no zoology	47
Offering no physiology	49

The rise and fall of high school subjects during the past fifteen years.

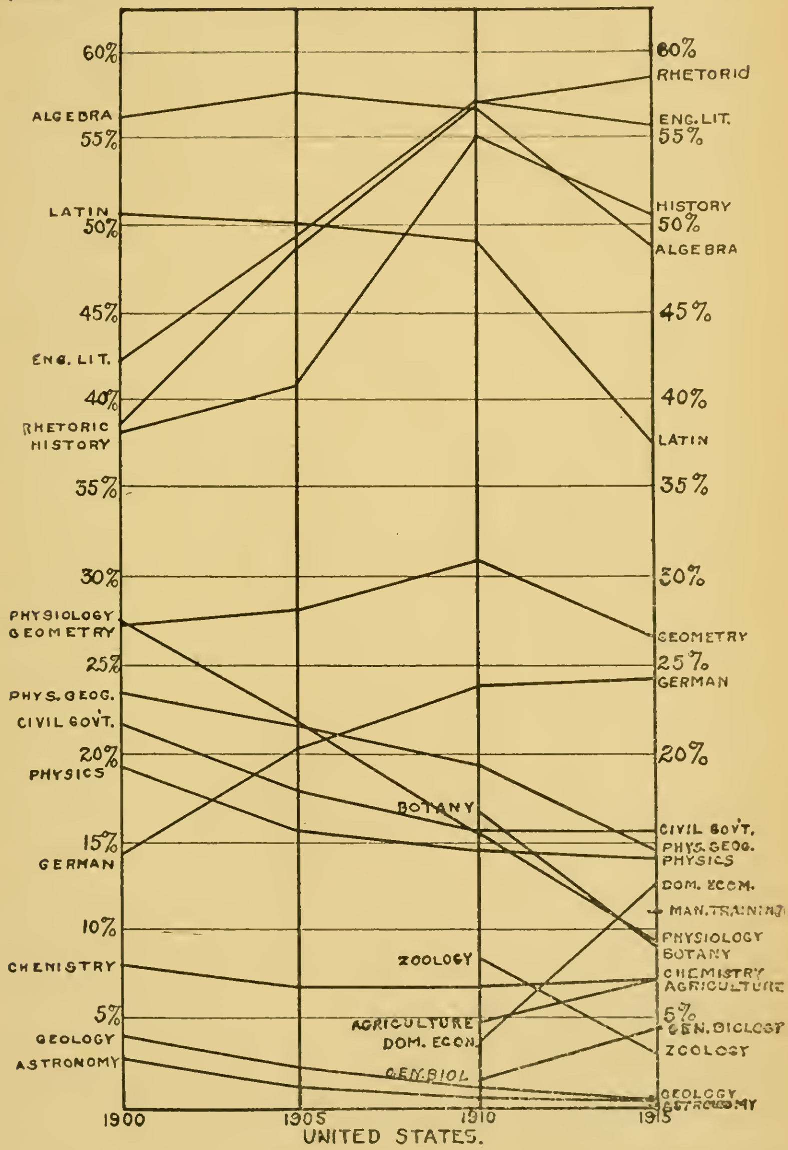


TABLE III.

AMOUNT REQUIRED

Courses required.	*Number of Schools*
All three	49
Physiology only	79
Botany only	3
Botany and zoology	13
Botany and physiology	5
Zoology and physiology	3
None	98
Total	250

TABLE IV.

PERCENT. OF STUDENTS ENROLLED IN BIOLOGICAL COURSES

	Botany.	*Zoology.*	*Physiology.*
Enrollment in courses	5407	4051	8487
Enrollment of grade	9951	9367	13247
Percent enrolled in courses	54.3	43.2	64.0

THE REORGANIZATION OF HIGH SCHOOL SCIENCE

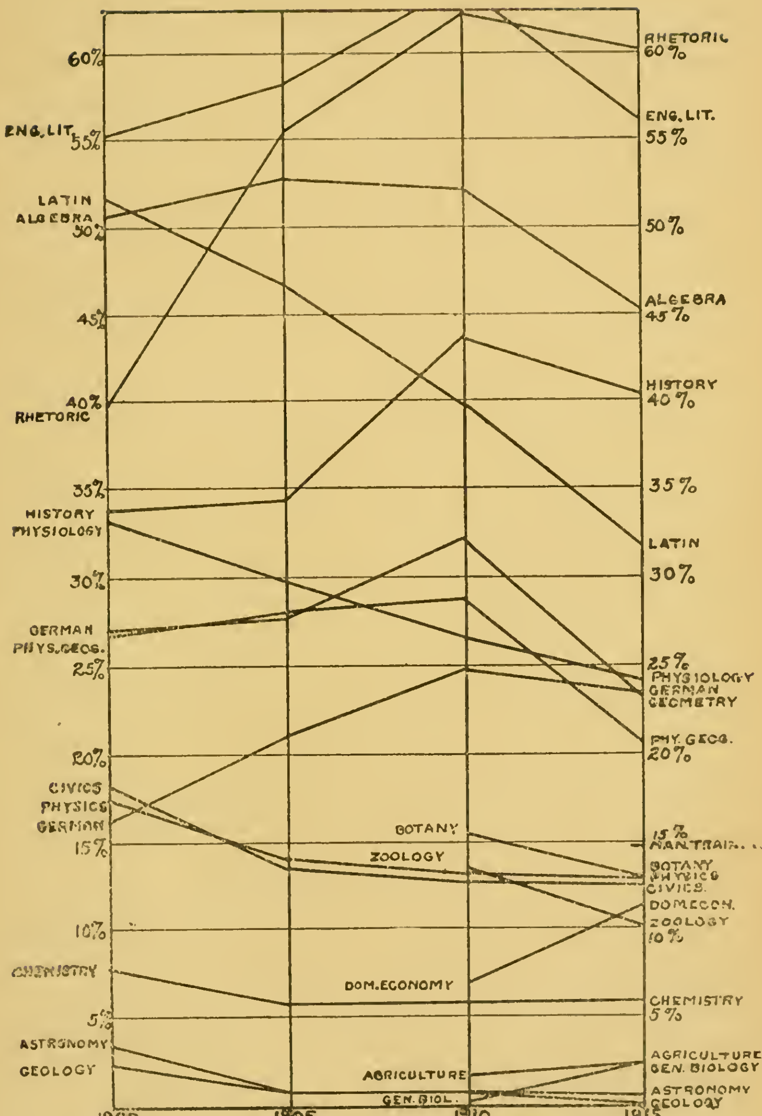
Fred D. Barber, State Normal University

THESES

1. The day has passed when it was pertinent to ask whether high-school science needs reorganization: high-school science is now being reorganized.

2. The *laissez faire* attitude of teachers of the biological sciences and of earth science, has been a large factor in bringing about the marked decline in those sciences in the high school and the substitution of agriculture, domestic economy and general science in their places.

3. The shift from "pure science" to applied science has occurred chiefly in the first two years of the high-school science curriculum. This shift has been the result of a wide-spread conviction that the science generally offered in the first two years was scarcely worth while.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ENG. LIT.
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ALGEBRA
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45%
40%
RHETORIC
35%
HISTORY
PHYSIOLOGY
30%
GERMAN
PHYS. GEOG.
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CIVICS
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GERMAN
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10%
CHEMISTRY
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ASTRONOMY
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BOTANY
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DOM. ECONOMY
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1900
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HISTORY
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PHYSIOLOGY
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PHY. GEOG.
20%
15%
BOTANY
PHYSICS
CIVICS
DOM. ECON.
ZOOLOGY
10%
CHEMISTRY
5%
AGRICULTURE
GEN. BIOLOGY
ASTRONOMY
GEOLOGY

ILLINOIS.

4. Standpatters in science are now face to face with a condition, not a theory; it behooves the adherent of "pure science" to wake up if they would have the best elements of the old regime preserved.

5. Reorganized science for the first two years of the high school should preserve the elements of historical significance and scholarship from the old and incorporate them with the elements of real worth and interest from the new.

6. The "ordinary" four-year high school is impossible of definition; it may have two teachers or it may have twenty teachers; it may be strictly rural, or it may be strictly urban in character.

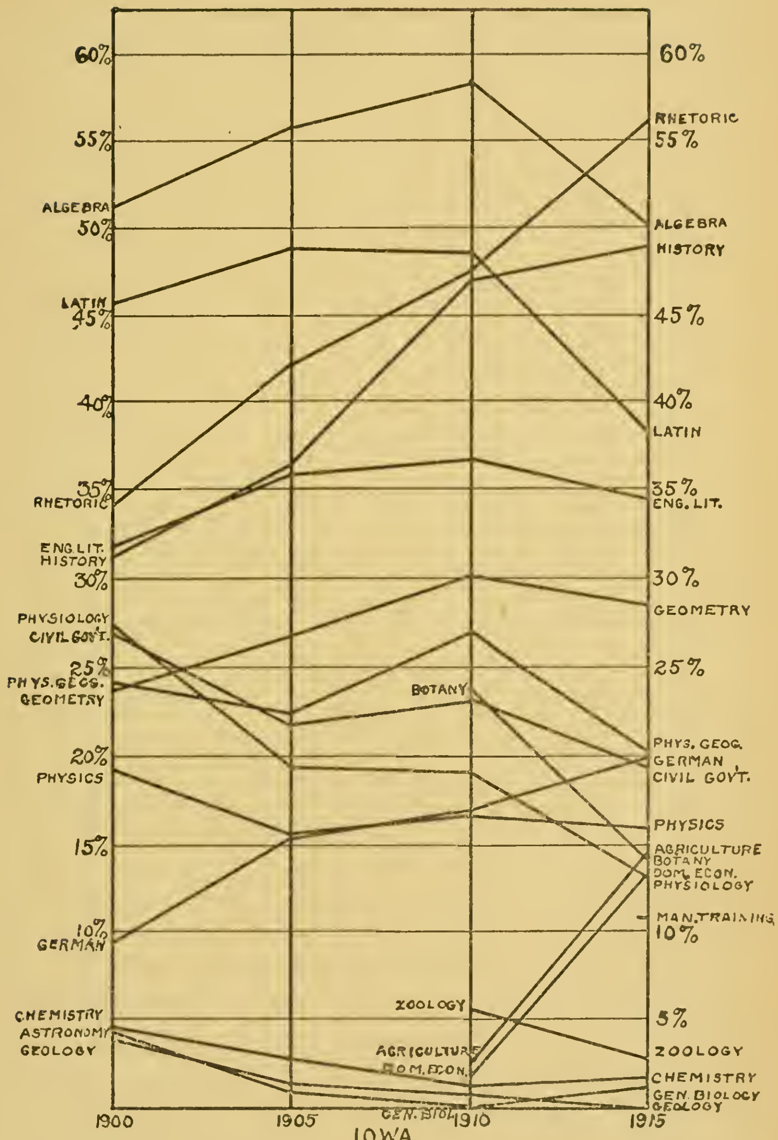
7. It is highly desirable that a nucleus of the science course shall be found which is equally applicable to high schools of every character; such a course must meet the needs of all classes of high school students.

8. Such a stem course is possible; it may as well be known as a two-year required course in general science. Such a course should be organized from the materials found in the pupil's environment; the first year's work should be found in a study of the home, the school and street leading from the home to the school and should be largely physical science material. The second year's work should consist of a study of an outer circle of environment, plant and animal life in the garden, the orchard and the field, together with personal hygiene and community sanitation.

9. In this stem course human welfare will be everywhere emphasized. Its purposes and methods will differ much from those of either the old special sciences or the new applied sciences.

10. This stem course must not be the only science offered in the high school; it must be followed by elective courses in agriculture and domestic economy and courses in the special sciences to the extent that the facilities of the school admits.

11. If the 6-3-3 plan is adopted the stem two-year course in general science may well be put in the eighth and ninth grades.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PHYSIOLOGY
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PHYS. GEOG.
GEOMETRY
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PHYSICS
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GERMAN
CHEMISTRY
ASTRONOMY
GEOLOGY
BOTANY
ZOOLOGY
AGRICULTURE
DOM. ECON.
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PHYSICS
AGRICULTURE
BOTANY
DOM. ECON.
PHYSIOLOGY
MAN. TRAINING
5%
ZOOLOGY
CHEMISTRY
GEN. BIOLOGY
GEOLOGY
1900
1905
1910
1915

IOWA

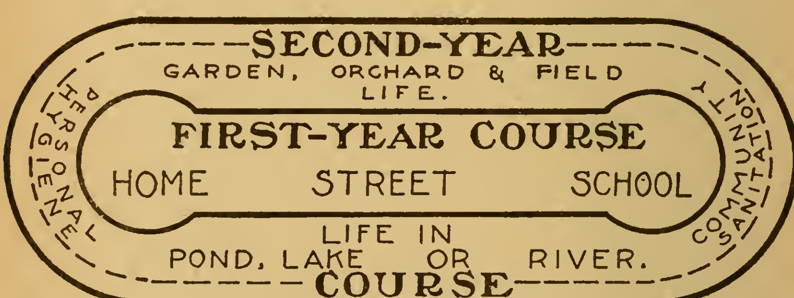
12. Teachers of science in the high school should wake up to the situation and exert every possible influence to bring high-school science out of its present chaotic condition. They should agree upon some sort of stem course which can be generally adopted.

TABLE I.

Table I. Showing percent. increase (italic face) or decrease, during the 5 years from 1910 to 1915 in the percentages of students enrolled in the various high-school subjects:

Subject	*United States*	*Iowa*	*Wisconsin*	*Illinois*	*Ohio*
Physics	3%	4%	*4%*	3%	8%
Chemistry	*7%*	*15%*	*17%*	4%	10%
Physical Geography	25%	35%	33%	24%	18%
Physiology	38%	31%	30%	8%	44%
Botany	45%	39%	30%	17%	28%
Zoology	59%	54%	50%	22%	49%
Agriculture	*54%*	*513%*	*24%*	*52%*	*231%*
Domestic Economy.	*241%*	*593%*	*237%*	*65%*	*340%*

The rise and fall of high school subjects during the past five years.



THE RELATION OF GENERAL BIOLOGY TO MEDICINE AND DENTISTRY FOR THE PEOPLE

V. A. Latham, Chicago

"It is characteristic of Science and Progress, that they continually open new fields to our vision." (Pasteur.)

Preventive Medicine, when viewed in its broad, general sense, indicates not only the prevention of disease and its consequences to the individual, but of still greater import to the mass of people. So does the Teaching Forces and Medical inspection of schools primarily concern themselves with the individual, thereby deserving a permanent place in the efforts being made to understand and eliminate disease and conserve health; and also in a far reaching way, it embraces the betterment of the masses both in its hygienic and economic aspects.

Organized beings are continually acted upon by their environment, and life is an expression of their continuous reaction. When reaction ceases, the organism becomes the passive prey to surrounding forces, life is extinct and has been succeeded by death. Living, the organism withstood the force of gravity and raised itself from the earth; maintained an equable temperature despite the surrounding alterations from heat and cold; retained the moisture of its tissues against the drying influence of the encircling air. In reacting against its environment, a living organism acquires its development, so that the endless struggle so bound up with life is not without advantages. So long as the organism is able to maintain the equilibrium of its functions, the condition is described as *health*. All creatures, however, are only capable of reacting against a special and very limited environment, hence a relatively narrow one. An Aviator succumbs to the rarefied air and cold before an altitude of 9,000 meters is reached, unless properly protected. Whilst the immense weight of water crushes in upon the Diver who dares brave the watery depths.

Civilization and disease go hand in hand, and the physician of today is to teach preventive medicine more than to treat disease. The glutton, the inebriate, the profligate will persist despite the Reformer; the clash from mailed fists will go in defiance of the Humanitarian; and in the world of trade, where misdirected commercial zeal racks the nerves and ofttimes blasts the mind, the physician's warning will go unheeded. Indeed, so lightly do we regard our health that while our Departments of War, Navy, State and Agriculture are considered essential, the safeguarding of the people's Health finds no place in the Cabinet—the Cabinet that conducts the affairs of our Nation. Fortunately, there is some improvement along this line, and Teaching and Diplomas are now being given in Public Health.

Our Marine Hospital Corps has done some excellent work in Malaria, Pellagra, Hookworm and water-borne diseases, and we feel an incentive to carry on this work. Several reasons exist for the apathy shown. First and foremost, a careful guarding of the Medical Practice Acts which at the present time are most unjust to the practitioner by limiting practice according to Statehood. This country is called United, but the laws are far from being unified according to the legislature of the State. It reminds one of the old question, "When is a man a man? When he is asleep!" The existence of faddists may be a help but are oftentimes a danger unless they are endowed with a broadly educated brain and a high sense of justice and equality. And to no one is this truer than to you as Biologists, who realize into what problems you may be drawn.

How soon set theories are overthrown by a simple wild plant or animal appearing in an area it seldom or never occurred in before! The Mounds so often regarded as Man's work have been proved as natural remnants of waterborne glacial materials.*

The question of pay to scientific workers in all countries has been a source of regret and only in Europe we have to look for government aid and appreciation of some student's discovery. Better give some encouragement now and not when a man has died! Problems of scientific education, the greatest discoveries and inventions have been made in the past by men with little

*Crook, Composition and Origin of Monks Mound. Trans. I. S. Academy of Sci., 1916.

formal scientific training, and in fields quite outside their ordinary vocations. Thus James Watt was a maker of mathematical instruments, Von Leeuwenhoek a Dutch spectacle maker; G. Stephenson, a colliery fireman; Arkwright, a barber; Edison, a railway porter; Cavendish, Boyle, Sir William Herschel and other great workers in the field of pure science might be described as gifted amateurs. No rigid distinction could be drawn between pure and applied science. Wireless telegraphy afforded a good instance of purely theoretical work leading to unforeseen but vast practical results. The telescope has revolutionized our conception of the universe; the microscope our conception of life. The significance and difficulties of correct microscopical observation must be believed to be very generally underestimated and that accurate observation is by far the most difficult art which mankind ever essayed.

The endowment of Institutes is a help but one, which if not carefully directed, becomes difficult to enter thru cliques, narrow portals or set opinions. Science knows no master, neither does she remain at rest. For cardinal principles of Living, we must know Biology (the science of life), together with the component sciences as given here, Palaeontology, Zoology, Morphology, Geology, etc., for otherwise the physician and dentist cannot grapple with the results of the deviations or deformities that come to his practice.

The scientific or professional branches require B. S. degrees rather than those of arts, for time and money spent is all too short for the foundations we *really need* in these rapid times. Formerly the classics held their sway, and it goes without saying, nothing should be excluded, for who does not need the languages for reading work, the chemistry rather than mathematics for basic reason, but the finality must be the test; and we find in this century, the Physician and Biologist are far more allied to each other and the Chemist and Physiologist with the Anatomist than the cultured classic or mathematician, or even the historian.

How is the relationship of Biology to Medicine and Dentistry borne out for the people? In so many ways, it is difficult to exclude them. First, a simple example may show a comparison between the truth and a theory or a fad, Medicine in its broad sense and Eddyism.

Take one of the lowest and simplest forms of life found everywhere in some type or other in the water, in the slime, in the soil. The Amoeba—Geology claims it and even adds to it; the Zoologist follows with many forms and places; the Biologist regards it as a simple type; the Botanist sees food for thought in its flow of protoplasm and its relationship to that monstrosity but wonderful ne'er do well, what is it and where is it "The Myxies"; the Chemist analyzes its chemical composition and the physiologist regards it as a complex animal and wonders at its food supply and vacuole. The Histologist stains its Protoplasm, Spongioplasm and other structures and endeavors to spot the nucleus. The Pathologist with his confreres, the Physiologist and Histologist squabble over its amoeboid movement and phagocytosis. The one that it is a Leucocyte or white blood cell, the other that it has a vicious habit and gets into the wrong environment, the intestines, liver or mouth.

That it is a food source, the Bacteriologist not to be outdone, endeavors to horticultural it by adding soup, salts and drugs and claims it as a fine inducement to growth for plant culture in soils; and again has a puzzle to grow some other sorts; whilst the Physician or Internist is busy hunting in the excreta with the laboratory worker to end those intense pains, and the Dentist, not to be outdone, says to his colleague "That's the cause of loosening and falling out of teeth, Pyorrhoea." "No, it's not," said his friend, "it's an 'Eater of Bone,' " and so helps the oral surgeon to get a case, when up comes the preventive man and says, "You're wrong. It's doing its duty; it's mostly a good scavenger and saves the youngsters some work."

Gentlemen, my story includes the *Amoeba Proteus, lobosa, radiosa villosa, verrucosa and Endamoeba Histolytica, Tetragonus, Buccalis and Endamoeba Coli of Panama and India, whether in the intestine, liver or mouth.

Amoeba of the mouth not a recent discovery as some writers describe, but the Entamoebae Buccalis Kartulis or Amoebae

*Endamoeba is parisitic for man, and the Amoeba a free living saprophyte.

Gingivallis of Gros 1849, and the Amoeboid action of the Leucocyte; each and all are known to you, each and all have taken years of study and lots of paper and printer's ink, each and all are nearly strangers even to you, eminent in your specialties, and we all need to follow Kipling when he said:

"It ain't the guns nor armament nor funds that they can pay
  But the close co-operation that makes them win the day.
It ain't the individuals nor the army as a whole,
  But the everlasting team work of every bloomin' soul."

The Physician and the Dentist should have a better knowledge of Biology and must of necessity be a trained Microscopist. How much we need a better teaching in this subject, in all its departments, the use of illumination and the apparatus for the purpose, the smattering in most of our schools and colleges is deplorable. We need a course such as Professor Gage's at Cornell. Year by year the interest which is taken in the world around us, in the unspoiled works of Nature, continues to increase. It is now recognized that to train the powers of observation is one of the most important necessities in general education, and that it is far better for everyone to train himself naturally through the interest aroused by the subjects considered, than to learn nothing but second-hand facts from others. Whatever line of study is taken up, if any real progress is to be made, some aid to vision must be sought to see the structure and minute facts of the life of the subject. Here it is that the microscope comes into play, and it is not too much to claim that besides being the source of additional interest the instrument is a great educator, that is to say, it trains without appreciable effort the hand to be skillful, the eyes to appreciate, and the brain to elucidate. There will be times when the most enthusiastic Nature-student cannot be out of doors long dark winter evenings, wet days, even in summer, when indoor work must take the place of outdoor. It is then that work with the microscope will prove such a fascinating hobby and lead us into regions where it is impossible to travel without it. The whole science of bacteriology and the discoveries of the minute fungi which cause disease and putrefaction, which give the taste to butter and the flavor to cheese, entirely depend upon skilled work and high powers of the microscope. It may be worth while to recall the address by Sir James Paget of England in 1880 on plant diseases and their relation to man; the oak-galls having been the favorite. The Crown-gall in both wild and cultivated plants is analagous to sarcoma in man. Dr. E. F. Smith has recently produced a complex tumor or embryoma. It may not be out of place to remind the members here that Prof. T. J. Burrill was, I believe, the *first instructor* in Bacteriology in the United States, for he gave Bacteria in his Fungi courses in the 70's and his paper on the Pear Blight in 1879.

The treatment of mouth and the gastro-intestinal tract is where we all work together, the internist, the chemist, the bacteriologist, zoologist, pathologist, and dietitian. Use here of Micro-analysis shortens time, is accurate, takes less material, fewer re-agents, and the results are the same. The sooner the Universities give a full medical standing in the 1st, 2nd, 3rd years for Dental students, or require the M. D. degree entire, the better it will be for all concerned; then specialize in the subjects desired as Occulist, Aurist, Dentist, etc.

To be able in this day and age to treat a case intelligently, medical and dental men must know germs, culturing, vaccines, serum-therapy, surgery, and even law in its medical and forensic aspects.

To the better understanding we need Biology in its broadest sense, the thorough mastery of the Microscope, its accessories, and we need to know and use the Polariscope and the selenites. Cheese yields various moulds and parasites. Aspergillus glaucus and Penicillium glaucum, cheese mites. Milw, water and all other foods and beverages require a good knowledge of biological studies even to the Textiles, for fibres yield errors and much amusement, as well as work to identify and tarce in disease and for Medico-legal examination.

Flesh foods are important to all mankind in one way or another as Food and even Dangers in their uses.

The Zoologist is required as well as the Botanist, Biologist, the Veterinarian, the Chemist, the Doctor and the Dentist. Hence closer co-operation with one another is much to be desired, for research, for disease and cure, and last but greatest of all for the welfare of the Country, the People and the Academy.

The Normal schools are amongst some of the largest factors in the educational scheme of this country and they must remember to include teachers who are trained in health work and a broad knowledge of dental study and the far reaching dangers of dirty mouths, which are so potent a factor in children. The time for dental examinations and treatment are unfortunately made too late; they need to begin at home and the kindergarten, when the teeth should be filled, the gums treated as well as the nose and throat; but today, I regard as one of the most vital helps for the race of mankind, the very early expansion of the jaws to make room for the development of the bones of the face and head, for about 60 percent. need it badly. It is easy to propound questions. It is often very hard to answer them. But when the answer involves the discovery of a principle, especially of a principle that can be utilized for the preservation of health, that answer is worth striving for.

Tropical Medicine has surely taught us to value all the group of sciences mentioned for the value of discovery has reclaimed barren tropical areas, drained Mangrove swamps, cultivated soils and marshes, saved thousands of lives from death by cholera, malaria, plague, leprosy, dengue, prevented smallpox, and for physicians no higher praise and tribute can be given than that paid Edward Jenner by Thomas Jefferson:

"You have erased from the calendar of afflictions, one of its greatest. Future nations will know by history alone that the loathsome smallpox has existed and by you has been extirpated." The discovery of wonderful seeds, plants and animals, and as for Economy and Colonization, the worth can never be estimated.

See. Importance of Biology as applied to Dentistry. Ch. F. L. Nord. Dental Cosmos. 1916.

Compare, if you will, the weakness of the new religionist who without a proof can question so formidable an array of thinkers, from the days of the Palaeontologist to the Physiologist of today even to that startling phrase, the immortality of the Protozoa (Weismann).

Are we and have we not proved that Nature buries her secrets deeply, not lightly or weakly for human eye to see? To those who dig and delve, her whims, her schemes may some day be unbared. To offer you to observe, reflect, compare, record, not one alone, but together prove that Nature is God's own Servant for the Truth.

Ten years after the Battle of Sedan, and thirty-three before the present war, the great French physician, Charcot, in his "Lectures on Senile Diseases", p. 20, (Trans. New Sydenham Soc. Lond. 1881. Trans. by Tuke) indulges in comment on French, German and English medicine that is perhaps more striking *now* than when first it was written. The pride of the Frenchman in Laennec and the Stethoscope is evident. Slow waking up of the German to modern scientific medicines and the influence of Schonlein, of Purpura fame, and of Rokitansky is charmingly described. For nobody should forget that Science owns no country and is the property of no race. His contrast of "the exclusive and illiberal ideas of the Prussian savant," (Virchow), with "the grand words of one of England's greatest physicians (Graves) is striking:

"The empire of reason, extending from the old to the new world, from Europe to the Antipodes, has encircled the earth; the sun never sets on her dominions—individuals must rest, but the collective intelligence of the species never sleeps."

A DEFINITION OF A STATE MUSEUM

A. R. Crook, State Museum

Meager, ill kept, uninteresting collections of various sorts housed in some museums have so often made such a lasting impression upon visitors that those persons ever after have had an improper idea of what a museum in the proper sense should be.

Such has been the experience of the Illinois State Museum which for many years was so poorly cared for that the impression which it made upon legislators was an unfavorable one. The definition which these men would give for a museum is totally different from the one which I would emphasize. And since they never visit this museum now and are unacquainted with any other, there is no hope of their ever bringing out a revised edition of their definition.

I would define a museum as an "institution designed for the collection, preservation, investigation and display of objects which illustrate in concrete and tangible form the knowledge and skill that men have in science, in art, in manufacture and in business," and a State Museum is an institution which illustrates in concrete and tangible form the things that men of science, of art and of business in the State know and can do. Thus it is a repository of ideas and of deeds rather than simply of objects. It illustrates at every turn the knowledge that men have. Instead of being a collection of things it is a collection of thoughts.

The various departments in such a museum would be designed to graphically illustrate what men have discovered in those departments. The division of botany would be more than simply a herbarium—a collection of dead plants. Instead it would be so fitted as to point out what our botanists know about all kinds of vegetation in the State—what they have learned concerning appearance, life habits, relationships, noxious qualities, medicinal values and possible commercial utilities of the three or four thousand plants which grow in Illinois. Artists in glass and wax would build groups to depict the leading regions of the State from sand dunes, lake shores, river bottoms, valleys, and prairies, to forest regions, and give tangible illustration of the excellent work being done by the Academy "Committee on Ecological Survey."

The tree exhibit would contain not only the trunks, leaves and fruit of the hundred and fifty kinds of trees growing in the State, but also fine illustrations of magnificent trees and samples of their products—boards, laths, shingles, clothes pins, wood pulp, paper and all the things made out of wood pulp even to car wheels. There would be a long list of things which illustrate what dendrologists know and what artists and manufacturers can do.

The zoological section would consist not simply of a great multitude of shells, insects, fish, birds and mammals, but would be a fascinating place where the visitor could delight in the varied and strange forms of insects and fish; the beautiful plumage of birds; the fine fur of mammals; the life-like groups, where artist and man of science combine to depict nature in her most charming and instructive forms and through cunningly devised arrangement of animal, flower, leaf and rock to explain what men know about the life habits, history, relationship and utility of the multitude of creatures which constitute the zoological world.

In the department of ethnology as well as that of zoology there is a great field for artistic group work. At the Illinois State Museum there is promise of remarkable work being done in the field of ethnology, thanks to a gift of three thousand dollars one week ago today by a generous friend of the museum and thanks also to the promise of another friend to give the museum in the near future one of the greatest archaeological collections of its kind in the country.

The amount of time represented by man on the earth is but a fraction of the years involved in the earth's history. If we go back of modern history, back of the art of writing, back of the stone age, back of the "psychozoic era"; back to reptiles, to fish, to the dim and nebulous times of gradual accretion of dust of the universe to form a world, each step is an interesting field not because of objects but because of what we know of them.

No department of the museum can exceed this in importance or fascination nor afford a better opportunity to show what men know and what they are discovering. These form the divisions of general geology, paleontology, mineralogy and petrography.

Similarly a successful museum represents what physicists and engineers know and can do. In such a museum instead of a constant repetition of signs reading "Hands off," "Do not touch the objects," etc., one reads such signs as this: "Turn on the light and see a magnificant spectrum," "Touch button to obtain view of axial figures," "When lighted these specimens show marked fluorescence," "Turn the button and start the machinery," etc.

No department of a museum could be more attractive than that which concerns itself with the knowledge and accomplishments of our physicists.

Very interesting, too, would be the departments of chemistry, of astronomy, of the manufacturing arts and of the fine arts. All of these and of those mentioned before have the common purpose of speaking in a voice perpetually audible and readily understandable concerning the ever increasing fund of knowledge of our investigators and artists in all departments of human endeavor.

A survey of these few points impresses us with the wealth of material upon which a museum can draw. If it is a poor uninteresting place it certainly would not be because of lack of subject matter but because of lack of energy, of imagination or of money on the part of the officers or workers in whose keeping the institution is placed.

A museum is then a voice announcing the valuable work of our men of science. It speaks with no discordant note, with no attempt to silence or minimize other voices, but to swell their volume and to add to them becoming an extra voice as of one crying in the wilderness, "Behold the attainments of science and the coming of the hosts of knowledge."

Papers on Botany

PRECOCITY IN A FURCRAEA

WILLIAM TRELEASE, UNIVERSITY OF ILLINOIS

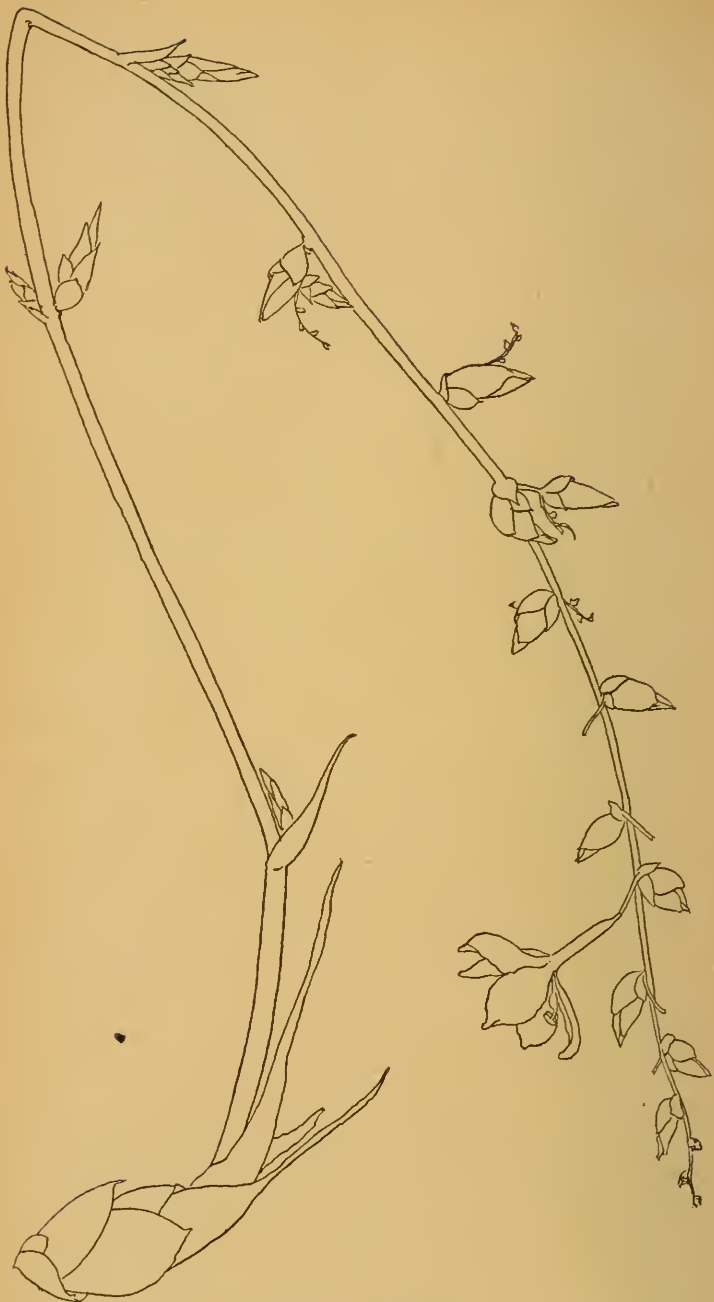
A number of cases are known in which seeds germinate in the fruit, either normally as in the mangrove, or exceptionally as in watermelon and citrus fruits. With these phenomena are connected, though not very logically, the many cases of bulbil production in flower-clusters,—often of unlike morphological character, such as *Poa, Polygonum, Allium,* etc., offer. In a way comparable with these, are the cases of flowering precocity on suckers, offsets, etc., of such monocarpic plants as *Agave* and *Furcraea,* where these diminutive derivatives of a mature plant flower when it does.*

Unlike *Agave,* the related genus *Furcraea* does not fruit as a general thing, but is propagated by bulbils that accompany or follow the flowers, as in the cases already referred to. Commonly, these bulbils fall from the parent stock when they have reached what may be considered normal development, and it is by their use that many of the Furcraeas, like the related Sisal Agaves, are propagated commercially.

To my observant correspondent Mr. L. J. K. Brace, of Nassau, I owe knowledge of a very striking and exceptional illustration of sexual maturity of *Furcraea* bulbils concurrently with the mother plant, which may be compared in its physiological meaning with the concurrent flowering of offsets in this and other genera. The case is that of a small plant of *Furcraea tuberosa* obtained from Mr. Joseph Chamberlain's estate on the island of Andros, and supposedly derived originally from Kew.

When already in pole and about to flower, the scape of this plant was broken over by a wind storm, and in this position, still connected with the rest of the plant, it went through the usual process of producing unfruitful flowers and abundant bulbils. The unusual part of its history is that many of these bulbils, remaining attached to the mother plant, and without

*Trelease, Ann. Jard. Bot. Buitenzorg. II. Suppl. 3: 909. (Furcraea).



FURCRAEA TUBEROSA

more than the customary leaf production of such bulbils, developed into slender scapes—in one case, at least, two feet long, as freely floriferous and bulbil-bearing as the usual ultimate branches of a normal inflorensence.

SOME PERCHED DUNES OF NORTHERN LAKE MICHIGAN AND THEIR VEGETATION

Geo. D. Fuller, University of Chicago

The sand dunes of the Lake Michigan shore may, for the purposes of our discussion be divided into groups according to their location. Those at the south end of the lake, situated principally in Indiana, differ in some respects from the sand areas scattered along the east shore upon the lower peninsula of Michigan. The formation of the Indiana dunes is in general more recent and is to be referred to that period during which the waters of the lake have stood at approximately their present level. A smaller portion of the area was developed during the later stages of the glacial Lake Chicago.

In contrast with this the dunes of the lower peninsula of Michigan are to be associated with a more remote origin connected with bodies of water or ice belonging to former ages.

It is the purpose of this paper to record a few of the phenomena connected with the occurrence of various dunes found upon the islands in the northern part of Lake Michigan and upon the adjacent mainland.

Nearly all the dunes of this and similar regions are of *lacustrine* origin, being formed from sand thrown upon the shore by the waves and then caught up by the wind, carried inland, and piled in characteristic mounds and ridges. Some of these lacustrine dunes have accumulated upon the existing beach and may therefore be called *beach dunes,* while others are developed upon substrata elevated some distance above the beach and may be termed *perched dunes.* They may have been formed either by a wind eddy at the top of a short cliff, or have travelled inland from the beach over higher land. The term is also applied to dunes formed upon an old beach which from the subsidence of the lake level finds itself much above the level of existing waters.

The beach dunes are characteristic of depositing shores and to this class are to be referred those of the southern end of Lake Michigan, while perched dunes are more characteristic of eroding shores and are frequent along the east shore of Lake Michigan, ranging from 10 to 400 feet above the present level of its waters.

While it is evident that the greater part of the shore dunes of Michigan belong to one or other of the types just mentioned, it is conceived that dunes may also have been formed from sandy material deposited by the action of ice and water about the margin of the Pleistocene ice sheet and afterwards worked over by the wind. Dunes of such an origin may be termed *terrestrial* in contrast to those of lacustrine formation that derive their material directly from the lake. It seems probable that some of the interior dune areas of Michigan are of this type and recently evidence has been obtained that at least a few of the shore dunes are terrestrial rather than lacustrine in their origin.

THE NIPISSING BEACH DUNES

The beach developed by the water of the Nipissing Great Lakes has been carefully traced by Leverett and Taylor.[1] Upon portions of this beach sand dunes have been subsequently deposited, although on account of the comparatively recent date of its development, they are nowhere very extensive. At a point near the north end of the bar separating Portage Lake from Lake Michigan, a gravel ridge between 15 and 20 feet above the present lake is partially uncovered just back of a low fore-dune and again just north of Point Betsie lighthouse is a similar ridge. From their height and general character it seems probable that these beaches are Nipissing. On either side of the mouth of the Platte River the Nipissing beach does occur, extending for several miles, covered in many places by low grassy dunes, but none of these appear as interesting as some development upon the Fox and Beaver Islands.

[1]Leverett, Frank, and Taylor, F. B. The Pleistocene of Indiana and Michigan and the history of the great lakes. U. S. Geol. Surv. Monograph *53*: 447-463. 1915.

On South Fox Island the lighthouse stands upon an isolated mound of sand at the extreme south of the island. This mound is a dune some 70 feet high and 200 yards across, standing upon a gravel bar some 400 yards long and half as broad, and connecting it with the main portion of the island. From the ridges of the island to the lighthouse dune the ridge is swept bare for more than 200 yards and its surface is seen to be about 20 feet above the lake and this agrees so well with the elevation of the Nipissing beach that it seems probable that it was actually formed by those lakes.

Upon the Beaver Islands the beaches have been traced by Taylor and there is no doubt as to the identity of those occupied by the dunes under consideration. Upon the west shore

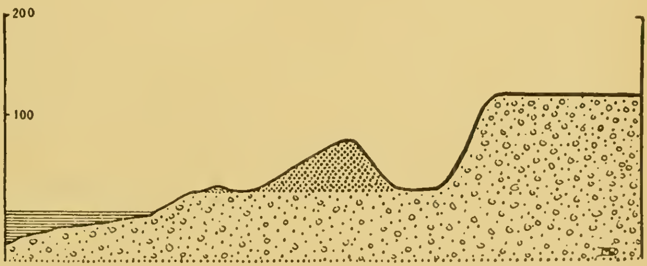


Fig. 1. Diagramatic east-west cross section of a dune perched upon a wave-cut terrace of Nipissing age. Beaver Island, Mich. Vertical height in feet at the left of diagram. Horizontal scale one-half the vertical.

of High Island the dunes form a crescent about the inner side of a bay about two miles across. The shore is gravelly throughout and just back of the fore-dune a well developed beach is seen, partly covered with partially fixed low dunes. An exactly similar area about 100 yards broad is to be seen on the west shore of Beaver Island. At the northern end of the west shore dune area of Beaver Island this low complex of beach gravel and small superimposed dunes merges into a sand cliff of higher sand ridges, but farther south it passes to a strong wave-cut bench from 100 to 200 yards wide with a steep cliff 50 to 100 feet high (Fig. 1). Upon this bench, the most striking development of the Nipissing beach upon the island, a dune ridge 20 to 50 feet high has been built up and in some parts strengthened by a grassy fore-dune. The ridge is completely fixed and was evidently formerly covered by a mesophytic forest of maple, beech, and hemlock, with a small amount of *Abies balsamea, Picca canadensis,* and *Populus balsamifera* at the outer edge. This has been cut off, and the dune cover now consists of a few remnants of trees and coppice from the former forest, together with such pioneers as *Betula alba papyrifera, Prunus pennsylvanica, Populus grandidentata, Ostrya virginiana* and *Acer spicatum.*

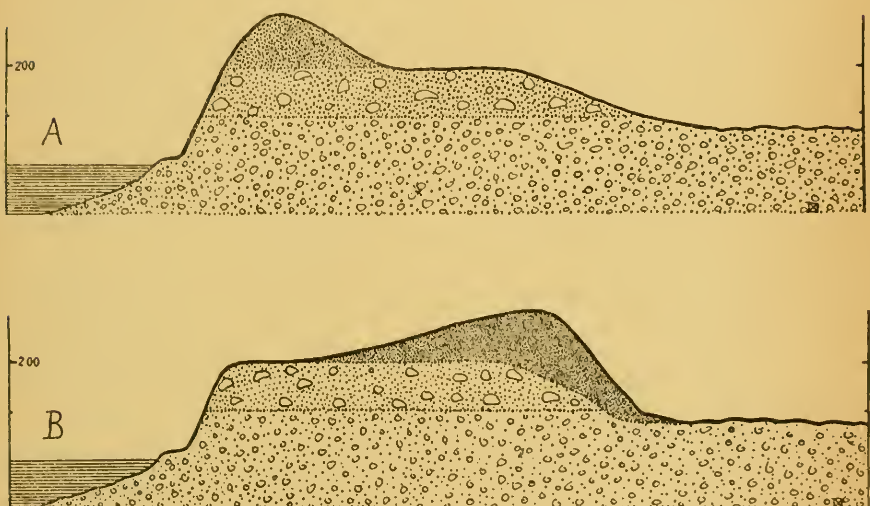
A most distinctive shrub association has developed upon the gravel of the Nipissing beach as well as upon the low dunes which are developed before or are percehd upon it. It occurs both upon High and Beaver Islands, and is characterized by low growth, small thick leaves, a large amount of vegetative propagation from buried stems and by a decided scarcity of grasses. On Beaver Island a scanty sprinkling of *Agropyron dasystachyum* is almost the only grass present, but on High Island there are in addition small amounts of *Ammophila arenaria,* and *Calamovilfa longifolia.* The effect of exposure to the strong winds of the west and south-west seems to be the cause of a decided dwarfing in all the larger shrubs. Species that upon other dune habitats attain a height of 3 to 6 feet or even more are here reduced to a foot or less. *Prunus pumila, Cornus stolonifera* and *Salix* spp. afford examples of such dwarfing except when they occur within the shelter of the succeeding border zone of forest. The same thing is true of *Populus balsimifera* which is seldom more than a yard high among the shrubs, although it occurs rather freely within that association.

The composition of this association varies somewhat, although generally its dominant members are *Arctostaphylos Uva-ursi, Prunus pumila, Salix longifolia, S. syrticola, Populus balsamifera,* and in some localities *Potentilla fruticosa* and *Cornus stolonifera.* With these broad leaved shrubs *Juniperus horizontalis* and *J. communis* mingle freely and in places become dominant with the gradual elimination of the willows, cherries, and poplars. Either the broad or needle leaved shrubs may be succeeded by the trees of a marginal shore forest in which *Populus balsimifera, Betula alba papyrifera, Abies balsamea, Thuja occidentalis* and *Picea canadensis* are most abundant. On the more open portion of these low dunes there are mingled with the shrubs such herbaceous plants as *Artemisia canadensis, Cirsium Pitcheri, Zygadenus chloranthus* and *Lithospermum Gmelini.*

HIGH PERCHED DUNES

The rapid erosion along the east shore of Lake Michigan has developed many stretches of steep shore cliffs cut in the

Fig. 2. Diagramatic east-west cross sections through a shore



cliff near Frankfort, Mich., showing stratified clays and gravels upon which is perched a sand dune. Vertical height in feet at the left of diagram. Horizontal scale one-half the vertical.

morainic material. These cliffs very much in height and are frequently surmounted by dunes of considerable size. Only a few of the most notable of those recently examined are here described.

A half mile north of Frankfort the eroded shore shows distinct stratification of morainic clays and gravels while upon the moraine there is perched a dune, the top of which, according to the maps of the U. S. Lake Survey, reaches the height of

320 feet above the lake, about 100 feet being sand (Fig. 2A). This dune area is about half a mile long and about half that width, and has recently been mapped and described by Waterman[2]. The upper stratum of morainic material is largely composed of boulder clay, giving when eroded a number of "razorback" cliffs. The dunes have been fixed and forested but through them has cut a complex of wind-sweeps ending in a semicircular blow-out popularly known as "The Crater" (Fig. 2B). The wind-sweep throughout the greater part of its channel has cut quite through the sand and has exposed the surface of the morainic plateau. The sand of which this perched dune is composed may well have been derived from the waters of the former Lake Algonquin, although there is nothing to show that they are not of terrestrial origin. In this connection it may be recalled that the moraine upon which the dunes are perched are at least 150 feet above the supposed level of Lake Algonquin or of the Nipissing Great Lakes.

A second example of even more remarkable perching is found four miles north of Empire in the Sleeping Bear dunes. Here the morainic substratum is in the form of a kame-like ridge with its long axis parallel to the Lake Michigan shore and its flat top about 400 feet above the lake. At the north and east of this plateau the gravelly surface is much lower, while an east-west section through the ridge just north of "The Bear" shows that a peak (Fig. 3A) of gravel near the eastern side projects above the sand which has been swept from the plateau and is moving towards the east. That the greater part of this plateau was formerly well covered with perched dunes is evidenced by the great banks of sand on the west side where they present a great advancing lee front over a mile long with a maximum height of over 300 feet (Fig. 3A). Upon this wind swept plateau the most conspicuous dune remnant, perched on the edge of the shore cliff, is the isolated mound some 90 feet high and four times as broad, known as the "Sleeping Bear" (Fig. 3B). The north and east slopes are still well covered with the remnants of a mesophytic forest in which *Thuja occidentalis, Sorbus americana, Acer saccharum* and *Tsuga canadensis*

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[2] Waterman, W. G. Ecology of Northern Michigan dunes: Crystal Lake Bar region. Rep. Mich. Acad. Sci. 19: 197-207. 1917.

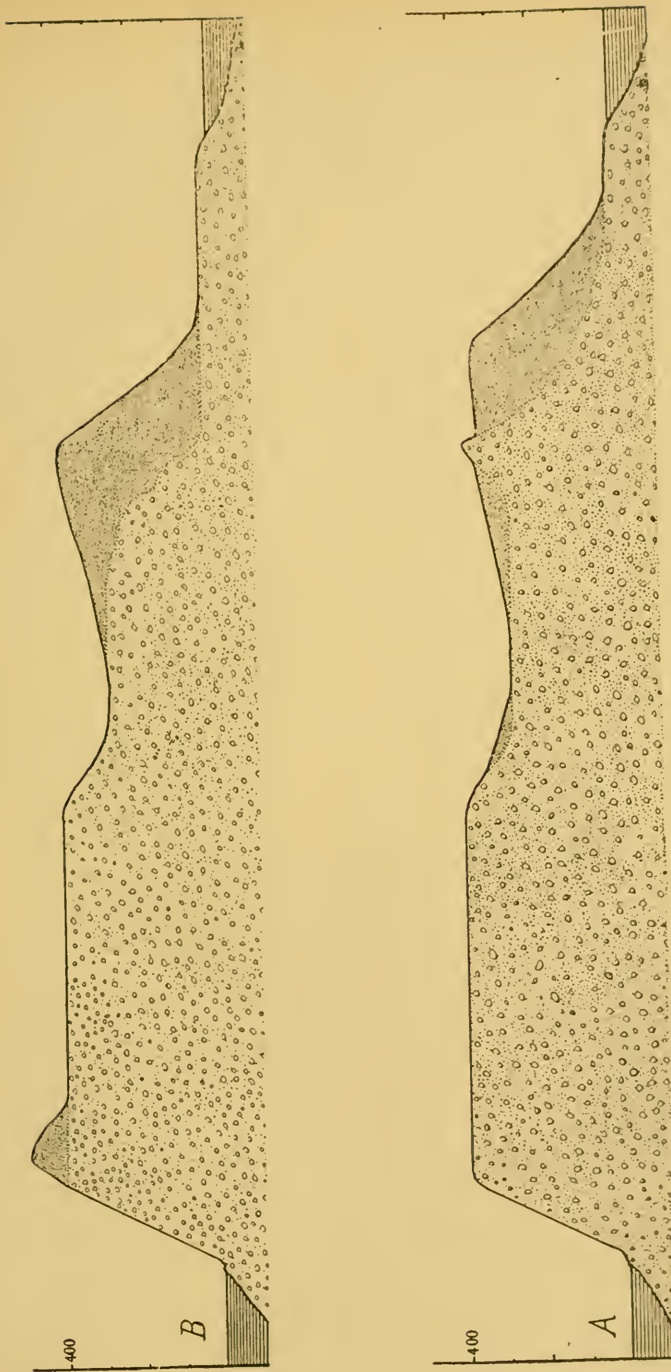

Fig. 3. Diagramatic east-west cross sections through the kame-like gravel ridge and the perched dunes at Sleeping Bear Point, ich. The section extends from Lake Michigan on the left to Glen Lake on the right, section *A* being just north of the Sleeping Bear Dune and section *B* directly through the Sleeping Bear Dune. Vertical height in feet at the left of diagram. Horizontal scale one-half the vertical.

are conspicuous. The other sides are being eroded but show signs of having been covered with forest.

It seems quite probable that dunes of the size of Sleeping Bear or even larger could have been formed at the top of a high shore cliff, but it is difficult to imagine that the great mass of sand that has been swept from the morainic plateau and forms the great moving dune advancing towards the east could have been so brought up from the lake at least 300 feet below. The hypothesis of a terrestrial origin for the sand would on the contrary seem more suited to explain the situation if it could be supported by adequate data. Such data have not been obtained in the Sleeping Bear area but appear upon one of the islands to the north.

South Fox Island, lying in Lake Michigan about 35 miles north of Sleeping Bear Point is about 5 miles long and a fourth as wide, the long axis of the island running some 30° west of north. The chief topographical features are a continuous ridge of morainic material capped with dunes, varying from 200 to 325 feet in height, and from 200 to 400 yards in width, running along the western side and a gravelly plain of low elevation which occupies the eastern side of the island (Fig. 4A).

The western shore is being rapidly eroded and the cliffs rise abruptly from a very narrow beach strewn with pebbles and glacial boulders. The cliffs are composed of mixed morainic clays and gravels while a distinct horizontal line separates the lower more stony mass from the upper more sandy material. This line has an elevation running from about 125 feet at the south of the island to somewhat more than 200 feet at the north. This upper stratum of sandy material has been somewhat worked over by the wind and at least one large wind sweep has developed, the trough being floored with glacial gravel and the whole terminating in a bald dune, about 325 feet high, forming the highest elevation upon the island (Fig. 4B). Much of the sandy stratum, however, presents evidence of having been deposited by agencies other than wind. The evidence consists in an admixture of pebbles, bits of rock, and particles of soil both larger and smaller than the grains of wind-blown

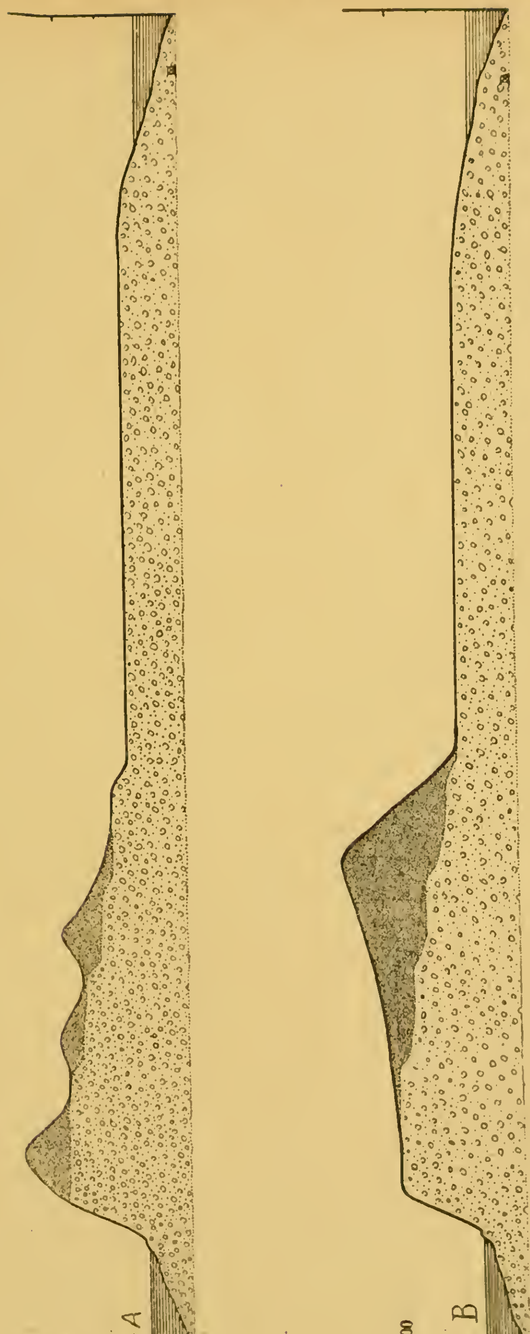

Fig. 4. Diagramatic east-west sections through South Fox Island showing gravel ridge and perched dunes. Vertical height in feet at the left of the diagram. Horizontal scale one-half the vertical.

sand. It seems most probable that this sandy soil was deposited simultaneously with or immediately following upon the formation of the kame-like ridge upon which it rests, and that it is due to similar combined action of ice and water. The exact method of its deposition may be more definitely explained upon further investigation, the main point of interest at the present time, however, is that the sandy mounds which cap the ridge are not composed of lacustrine sand piled up by the wind, but have an origin connected more immediately with the former ice sheet. It is evident that this material being largely sand and lying in an exposed situation has been subject to disturbance and working over by the wind. Dunes have been and are being formed from it and these dunes may be termed terrestrial in origin.

If it be granted, as the evidence seems to demand, that these perched dunes of Fox Island are terrestrial, it seems highly probable that many of those of the Sleeping Bear area had a similar origin, for the topography of the two regions is so extremely similar. The large mass of material in the advancing dune swept from the plateau upon which the Sleeping Bear dune rests would present no difficulty when explained by the hypothesis of terrestrial origin.

Without extensive investigation it is impossible to say just how many of the sand hills upon South Fox Island are dunes and how many are made up of glacial sands. It is certain that the high bald dune in the center of the island is composed of wind-blown material and is still slowly moving across the island, but it seems highly probable that many of the peaks which immediately surmount the shore cliff were, in their deposition, intimately related to some phase of glacial activity. The hills at the east of the shore ridge probably are in part dunes, and in part glacial sand hills, the two showing no difference in plant covering.

The variations in the plant associations of the various dune regions mentioned will be discussed elsewhere but it seems worth while to call attention to the climax mesophytic forest as developed upon the sand hills of South Fox Island. Although less than 25 miles from the mainland, where these species abound, the island is entirely without any *Pinus* or *Tsuga* nor was any *Acer pennsylvanicum* seen. *Salix* spp. were also represented by very few individuals, as were also *Picea canadensis* and *Quercus rubra.*

The mesophytic forest has covered all but a very few of the highest peaks and doubtless formerly extended over all the plain which forms the eastern half of the island. Less than 100 acres of the island have been completely cleared and cultivated, but more than three-fourths of its surface has been more or less cut over although there is little evidence of damage by fires. The higher hills being less easy of access, have had less of their timber removed and are covered with a rich growth of *Acer saccharum, Thuja occidentalis, Fagus grandifolia, Abies balsamea,* and *Tilia americana,* the three first being most abundant, the *Acer* dominating the gentler slopes and the *Thuja* the narrow valleys and steeper hillsides. Occasional trees of *Betula luta* and *Fraxinus americana* are found and where cutting has occurred *Betula alba papyrifera, Populus grandidendata* and *Prunus pennsylvanica* have come in. Among the shrubs are *Sorbus americana, Sambucus racemosa,* and *Taxus canadensis,* the latter being particularly abundant, while among the herbaceous vegetation were found such decidedly mesophytic forms as *Trillium declinatum, T. grandiflorum, Hepatica triloba, Actaea alba, Mitella nuda,* and *Mitchella repens.* Perhaps the most conspicuous fern was *Cystopteria bulbifera,* but *Botryhium virginianum, Aspidium marginale* and *A. spinulosum* were also fairly abundant.

In concluding, it may be mentioned that a similar mesophytic forest with *Thuja* as a conspicuous member is to be seen along the marginal shore dunes at Frankfort, while "forest graveyards" of *Thuja* upon the dunes of the Sleeping Bear complex as well as the remnant of forest upon Sleeping Bear dune itself would serve to indicate their former development in that region.

The writer wishes to acknowledge the courteous criticisms of Messrs. Frank Leverett and F. B. Taylor who were good enough to read his manuscript. He also wishes to state that

he assumes full responsibility for certain portions of the paper that are not entirely in accord with the views of these distinguished critics.

LOCAL INCLUSIONS OF PRAIRIE WITHIN FOREST

Arthur G. Vestal, Eastern Illinois State Normal School, Charleston

The accounts of early settlement in Illinois and neighboring states mention frequently the occurrence of small openings or glades in the forest, covered with prairie vegetation. Probably most of them were small patches of upland prairie, surrounded by xerophytic oak forest which had slowly spread from nearby stream valleys. These small prairies, and most of the forest which surrounded them, are now destroyed by cultivation. But there may also have been prairie openings of a second type, which because of their small size and scattered distribution, have escaped notice, and are practically unknown today, although they are still fairly numerous. Probably they would be regarded as mere open places in the woods, without being recognized as prairie. These small prairie inclusions were first noted in 1916 in the neighborhood of Charleston. It is generally known that at the present time forest tends to encroach upon treeless areas where cultivation does not prevent, but it is not generally known that in many places local exceptions to this tendency may be found. Probably the greatest interest which these prairie inclusions may claim lies in the fact that many of them seem to be holding their own against forest invasion, and that in places prairie vegetation has even replaced forest, in recent years.

The commonest topographic site for these small areas of prairie is the windward crest of a valley or ravine running down to the east, southeast, or south, and the side-slope beneath which accordingly faces to the south, southwest, or west. The essential condition is the great insolation and exposure to the dry summer winds from the south and southwest, making for local xerophytism. This is apparently a static rather than a dynamic feature of the environment, since both habitat and xerophytic vegetation may persist indefinitely, even though there is a slow lateral migration as the valley widens. It is probable that the dryness occasioned by the slope to the south is in most places not in itself sufficient to preserve the prairie from forest encroachment, for forest is able to establish itself in quite xerophytic habitats in the vicinity, and has in fact done so over most of the south-facing ravine slopes. Other physical factors aid the original exposure afforded by direction of slope. One is instability of surface, due partly to steepness, partly to the meagerness of protection against erosion afforded by the open and sparse ground-cover.* Others are accidental and artificial factors which destroy or check forest growth, such as fire, cutting, grazing, and trampling. These operate in places only temporarily, but in other places recur frequently enough to permit the continued existence within the forest of small but rather numerous patches of prairie, with more or less shifting boundaries, wherever the basic condition of southward exposure is fairly extensive. The spur-tops and other small upland areas adjoining the slopes may also show prairie vegetation, especially in those ends and corners of uplands which are too small or too narrow to tempt the farmer to invade them with the plow, even if there are no trees. This type of situation is a distinct geographic or topographic entity and should have a name. *Upland salient* or simply *spur-top* might answer this need.

The locality which shows these local prairie inclusions best is hardly more than a mile east of the southern part of Charleston, along a large ravine ("Endsley's ravine" or "Endsley's Hollow") which runs east and a little south to the Embarras river. A topographic map showing some of these patches of prairie was made so that situation and extent could be quite definitely shown (Fig. 1). Most of the prairie is below the crest

*It is of interest that even in flat areas like east-central Illinois, the topographic diversity of the broken country of the valley-slopes and ravines results in vegetation-diversity, in a manner entirely comparable to that which prevails over the general area in a mountainous region. Thus in the rock exposures along the Embarras river three miles east of Charleston, and in the various slopes and valleys of the district, there can be found many of the types of physical habitats common in mountain areas. One thus can learn much of the relations of topography and vegetation as developed in mountains without visiting the mountains themselves.

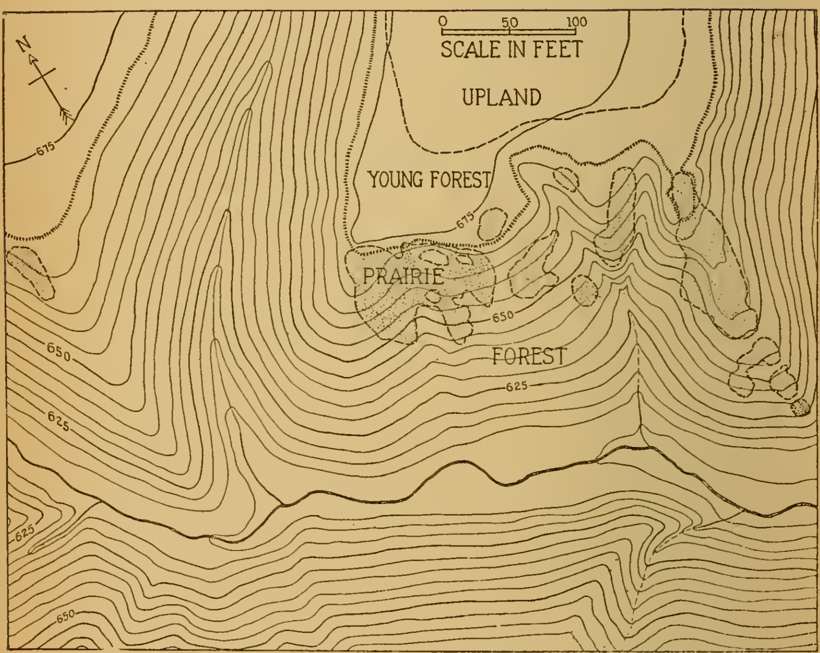

Fig. 1. Map of a ravine area with prairie inclusions, near Charleston, Illinois.

Fig. 2. Part of the largest patch of prairie shown in map. Leaves of Silphium in foreground.

Fig. 3. A very small opening about 15 feet across, near Embarras river, almost entirely enclosed by forest. Grapevines on trees, border of sunflowers at right and in back. Silphium, Parthenium, and several prairie grasses are found even in some of the smallest patches.

Fig. 4. Andropogon furcatus in gravelly clay on spur overlooking Embarras. The treeless area is about 15 feet on either side of the trampled path, and there are numerous prairie species.

or edge of the upland, shown by the line of short hachures. Forest had at one time spread about a quarter-mile from this edge, and had since been cleared for cultivation. New forest growth near the edge has come in since about 1911. Prairie and forest herbs occur in mixture in open spaces between saplings. The largest prairie patch has almost luxuriant vegetation, in which grasses, and Parthenium integrifolium, and the coneflower Brauneria purpurea, are conspicuous. There are also a few long-lived perennials, such as Silphium terebinthinaceum (Fig. 2), which are commonly absent from prairie that has not been established for many years. The invasion of forest seems to be upward, because the shade falls on the part of the slope just above the position of the trees. The boundary between prairie and forest vegetation is in places somewhat ragged and indefinite, partly because prairie and forest herbs intermingle along the border, where also occur the forest-border sunflowers, Helianthus strumosus and H. divaricatus (Fig. 3), and the bushy legume Baptisia leucantha, and the half-shrub Ceanothus americanus. The badly washed spur at the right in the map is mostly bare clay with scattered bunches of Andropogon scoparius, and a few interstitial annuals, including two small species of Lespedeza, which are typical in new growths of clay hillsides. The taller bunch-grass Andropogon furcatus is common in places (Fig. 4). A long, narrow spur-top just east of the area mapped is covered with prairie of apparently recent development from forest.

Small prairie patches in the woods are common also along the Embarras river, especially on the south-facing flanks of spurs, on both sides of the stream. Figures 3 and 4 illustrate two of these patches. One extensive south-facing hillside, once forested, is now part of a large pasture. Many kinds of prairie plants persist on this hillside, due to the topographically determined dyness and instability of soil, which keep the bluegrass from driving out the native plants, as it does in level or in well-watered pasture.

In conclusion, it appears that these small enclaves or openings of prairie in forest must be of fairly general occurrence, that they deserve to be generally known, and some of them set aside as natural history preserves. They illustrate admirably the influence of topography in control or modification of vegetation-distribution and vegetation-development. They show that while forest invasion of prairie is general, it is by no means universal.

INVASION OF FOREST LAND BY PRAIRIE ALONG RAILROADS

ARTHUR G. VESTAL, EASTERN ILLINOIS STATE NORMAL SCHOOL, CHARLESTON

The Big Four, Clover Leaf, and other railroads in central Illinois, in crossing the numerous and generally forested stream valleys, make treeless paths through many wooded areas. The rights of way in these cleared areas become vegetated from nearby plant populations, which are of three types, forest, prairie, and ruderal. The forest immediately adjoins these cleared areas, and would in most cases quickly reproduce itself if the railroad companies would allow seedling trees to reach tree size, which they do not. However, many forest herbs and certain forest shrubs, including sumac, blackberry, hazel, and Symphoricarpos, make up the dominant vegetation in such places, especially on the east side of streams, where the forests are more extensive, having there been well protected from former prairie fires, as shown by Gleason.

Certain other cleared parts of the rights of way are not far from areas of prairie vegetation, and have received abundantly the seeds of prairie as well as forest plants. In numerous small areas one finds mixed communities of prairie and forest herbs. It is probable that these mixed growths may in places be relatively enduring. The new growths of mixed forest and prairie plants which must have followed the original felling of the trees were probably unstable, as many of them now are. Their development either into forest growth minus the trees or else into typical prairie, probably depended, as it does now, upon a number of factors. Among those which favor the development into prairie are: coarse well-drained soil; considerable exposure to wind and sun, as presented by certain topographic situations; deficiency of rainfall during one critical or several successive growing seasons; and the destructive effects of burning or of mowing, both of which are common on rights of way. The opposites of these influences would favor development into forest.

The ruderal plants are in too many places able to get in and successful in establishing themselves, forming pure weed growths or ruderal components in forest or prairie.

The forest clearings most likely to be successfully revegetated by prairie plants are those to the west of streams, since there the prairie is better preserved, and the forest fringe is narrower and broken. The right of way approaches a stream on a down grade through broken country dissected by ravines. In

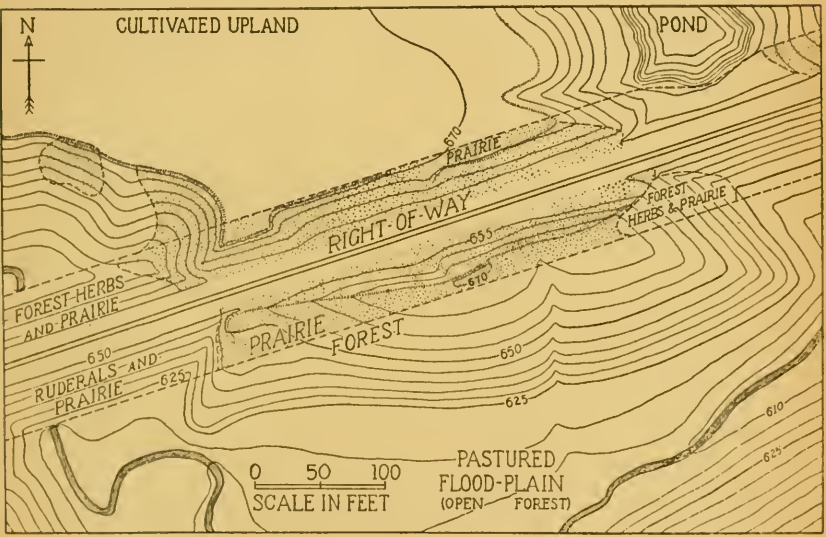

Fig. 1.

most places the original boundary between prairie and forest on the west side of streams was at or near the edge of the flat upland, but there were usually tongues or islands of prairie even in the broken country near the stream, within the general forest area. These have spread into the rights of way, occupying them almost continuously from the prairie upland to the end of the embankment which runs to or part way over the flood-plain, thus making a narrow lane of prairie through the forest. In a few places it appears that prairie vegetation is established on the east side of the stream as well.

A sample area in the broken country a quarter-mile west of the Embarras river was mapped (Fig. 1). The originally forested area, much of it still wooded, extends a third of a mile west of this area. The upland shown was probably entirely forested; it is now a cultivated field. Its steep southwest and west side-slopes are partly forested; there are rather well-developed patches of prairie also, and prairie plants among scattered trees. The Big Four railroad makes a cut eighteen feet deep through the end of this upland, and its right of way is now all prairie, both over what remains of the original surface and on the steep clay banks of the cut. Of the numerous prairie species, Andropogon furcatus, Brauneria pallida, Parthenium integrifolium, and Euphorbia corollata, are conspicuous. The hillside just over the fence from the prairie in the right of way is closely covered with trees; the boundary at the fence is quite sharp.

North and northeast-facing slopes in the right of way have the mixture of prairie and forest herbs previously mentioned. Notable plants are Smilacina (two species), Polygonatum, Taenidia integerrima, Specularia, Gillenia stipulata, and in one station, Pteris aquilina.

If the prairie growths remaining along railroads are to be of use as typifying former conditions of prairie vegetation, care must be taken to distinguish areas of original prairie from those recently developed on forest land. The rather frequent occurrence of such new growths, established as they seem to be, makes it necessary to reconsider the fairly common notion that prairie vegetation, once destroyed, is gone forever, and to realize that in its struggle for survival against cultural, ruderal, and forest plants, the prairie, in some areas at least, is putting up a not altogether losing fight.

PLANT SUCCESSION ON AN ARTIFICIAL BARE AREA IN ILLINOIS

W. B. McDougall, University of Illinois

The opportunities that botanists have had for studying the revegetation of bare areas of great extent have been few. The island of Kracatoa, laid bare by its volcanic explosion in 1883, has become a classic example. The Salton Sea area in southern California which is being so carefully studied by Dr. D. T. MacDougal and his collaborators bids fair to become as great a classic. The region laid bare by the eruption of Mount Katmai in Alaska, which is being made famous by Dr. R. F. Griggs, is a still more recent example. But this nearly completes the list. It is, therefore, of interest to note that we have in Illinois several bare areas of no mean proportions some of which are being left for nature to reclothe.

The areas to which I refer are those bottomland areas that have been "stripped" by coal mining companies in the practice of surface mining. Aid received from the Illinois State Laboratory of Natural History enabled me to make several visits to the properties of the Missionfield Coal Company, situated about five miles west of Danville, Illinois, during the summer of 1917. These properties which cover some thirty or forty acres are of special interest because they consist of three distinct sections which were worked at different times and therefore represent different stages of revegetation.

The area under consideration was originally covered with the bottomland forest characteristic of the region in which the sycamore is one of the dominant trees. This vegetation was all destroyed of course by the operations of the mining company and the land was left as a bare area consisting of alternating ridges, and furrows, the ridges varying from three or four feet to twelve or fifteen feet in height. I am indebted to Mr. W. G. Hartshorn for information concerning the time that has elapsed since the various parts of the area were worked by the coal company. The facts brought out by him are that the east section was operated about eighteen years ago and the middle section about three years later, while work on the west section was started about six years ago and finished four years later.

The west section because of its recent abandonment is still largely occupied by the pioneer ruderal plants. Because of the nature of the surface (Fig. 1) both hydrarch and xerarch secondary successions are represented. In the bottoms of the furrows the two knotweeds, Polygonum aviculare and Polygonum persicaria, are the dominant and often the only plants. In the shallower furrows Echinochloa crusgalli, the barnyard grass, takes the place of the Polygonum or occurs along with it, and often scattering individuals of the giant ragweed, Ambrosia trifida, also are present.

The ridges present somewhat more variety in their floras although some of them are almost exclusively occupied by the sweet clover, Melilotus alba. Others, however, are covered with such plants as the wild aster, Aster ericoides; sunflower, Helianthus hirsutus; ragweed, Ambrosia artemisiifolia; evening primrose, Oenothera biennis, and occasional individuals of black mustard, Brassica nigra. On those parts of the section that have been longest abandoned one finds also patches of venus's looking glass, Specularia perfoliata, and of partridge pea, Cassia Chamaecrista, and occasional individuals of pokeweed, Phytolacca decandra.

The middle section of the area under consideration has been subjected to artificial interference which has not made it less interesting but has greatly retarded its revegetation. The interference is due to the fact that the mining company is almost constantly pumping water into it so that it is largely flooded as shown in Fig. 2. The shallow parts of the water are occupied almost exclusively by the cat-tail, Typha latifolia. Just above the water on the sides of the ridges there is usually a zone of cocklebur, xanthium commune. On some of the lower ridges the willow, Salix nigra, has become established in considerable numbers, while the higher ridges are in most cases still occupied by sweet clover, melilotus alba, and black mustard, Brassica nigra.

In the eastern section the xerarch and hydrarch successions mentioned in connection with the western section have become

Fig. 1. The west section of the Missionfield Coal Company grounds showing the alternating ridges and furrows which result from "stripping" the coal. Ruderal vegetation becoming established.

Fig. 2. The middle section of the Missionfield Coal Company. Explanation in text.

Fig. 3. The east section of the Missionfield Coal Company. The larger trees are cottonwoods.

merged into one, and we find the vegetation well on its way toward the re-establishment of the bottom-land forest (Fig. 3). The trees consist of the willow, Salix nigra, which was probably the first to appear; the cottonwood, Populus deltoides, which occurs up to eight inches in diameter; soft maple, Acer saccharinum; red elm, Ulmus fulva, and sycamore, Platanus occidentalis, the last three all being small. The undergrowth is such as would be expected in such a situation and need not be described here.

As previously stated eighteen years have elapsed since this eastern section was abandoned by the mining company. Since numerous small individuals of the sycamore, one of the very characteristic bottomland trees, are already present it is probable that twenty-five or thirty years will be sufficient for the complete re-establishment of the typical bottomland forest.

ON THE FOLIAR TRANSPIRING POWER OF TILIA

J. E. Cribbs, College of Emporia, Kan.

ABSTRACT

Studies on the foliar transpiring power of *Tilia* were conducted during the summer of 1916 and 1917 in the dune area of northern Indiana. *Tilia* was chosen because of its unusual ability to surmount the dunes which move upon and cover large areas of mesophytic forest. In fact it is the only tree representative of the forest which displays this ability to any degree.

Five stations were selected which represented gradations in habitat; Station A. was located in a forested dune area which had become completely stabilized and contained an abundance of herbaceous undergrowth and considerable humus. Station B. was chosen at a point near the edge of the forested dune and was partly exposed to the wind. Station C. was at the very edge of the forest and was also located at the edge of a blowout where the humus had been largely removed. Station D. was on the lee side of an advancing dune where the exposure, especially to the sun, was very great, and where there was no humus. Station E. was situated at the top of a high dune which was

exposed to wind from all directions, and to the sun throughout the day. This represented the most xerophytic type of habitat available upon the dunes.

Transpiration readings were recorded by means of the cobalt chloride hygrometric paper. Correlative readings were taken of atmospheric temperature, relative humidity, direct evaporating power of the air, soil moisture, soil temperature, and wilting coefficient. These were measured that the true relation of the relative mesophytism of the stations might be better understood, and that their relation to the foliar transpiring power might be expressed.

It was found that the transpiring power at station A. was less than that of any other station, and the water loss at station E. was the greatest. Stations B, C, and D, showed an increase over A. which was directly proportional to the increase in xerophytism.

Transpiration was most rapid at the stations where the lowest average soil water and the most xerophytic leaf structures were found.

It was discovered that the amount of soil moisture had no appreciable effect upon the transpiration stream except when the wilting coefficient of the soil was approached.

Light, wind, and relative humidity were the factors which most strongly influenced the fluctuation of the current. The transpiration index was found to rise very rapidly just after dawn, and more rapidly upon the open sands than in the shaded forest.

A "saturation deficit" was developed in most instances and was much more in evidence upon the open dunes than in the forest. In fact in the forest the deficit did not appear in many of the readings, especially when the day was cloudy and the relative humidity high.

Although the saturation deficit was very strongly developed upon the open sand, there was never any visible evidence of wilting there. In the early summer the soil water content in

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*A more extended report of the work on Tilia appeared in Bot. Gaz. 68: 262-286. 1919. "Comparative Studies of the folia Transpiring Power."

the forest was much greater than that of the open dune areas, but in the fall visible wilting became evident in the former of these situations where it was found that the water had been reduced to the wilting coefficient. This was evidently due to the presence of a vegetation so abundant that its demands for water could not be met by the sand which holds a much smaller amount of available water than any other type of soil. Further evidence of this was noticed upon the open sand where there was no visible wilting at any time. Although the available water for plant growth is always low there, the dmand made upon it is of course almost negligible because of the sparcity of plant growth.

More rapid water loss upon the open sand as compared to the low rate for the forest, was quite different from the findings of previous investigations made upon desert plants by Bakke,[1] Livingston, and Shreve.[2] These investigators report a very low index for the various desert xerophytes studied. In fact the first named author has suggested as a criterion for the mesophytism of a plant its foliar index of transpiration; and in the suggested scheme the mesophyte should show the highest index and the xerophyte the lowest. Intergradations in the scale would indicate different degrees of mesophytism. Yet in the work upon *Tilia* it was found that such an application would prove misleading because the transpiration current is very much greater in the most xerophytic habitat than in the established dune forest which is certainly the most mesophytic of the five situations, and the leaf structure in the former of these habitats is undoubtedly much the more xerophytic.

It will be recognized, however, that the situation in the case of *Tilia* is different from that in the investigations of the above named authors.

They were invstigating transpiration of certain xerophytes which were growing in their normal environments. This is rather an instance of a species making a rapid correlation to a forced environment; and although the assumed xerophytism

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[1] Bakke, A. L. Studies on the Transpiring power of plants as indicated by the method of standardized hygrometric paper. Jour. Ecol. 2: 145-173. 1914.

[2] Livingston, B. E., and Shreve, Edith B. Improvements in the methods of determining the transpiring power of a plant surface of hygrometric paper. Pl. World. 19: 287-309. 1916.

of leaf structure is indicative of considerable plasticity, yet the correlation in structure has not been proportional to the variation in environment, from a normal mesophytic to an abnormal xerophytic one. In other words the response to external influence lags behind the causal factors to a considerable degree.

ARTIFICIAL KEY TO THE WEED SEEDS FOUND IN COMMERCIAL SEEDS IN ILLINOIS AND ADJOINING STATES

Richard Alonzo Gantz, Muncie, Ind.

INTRODUCTION

The purpose of this work is to aid one to determine the weed seeds and seed-like-fruits frequently found in commercial grains of Illinois and adjoining states. The term, seed, in this key, is used to mean a ripened ovule. It is not used to include fruits such as an achene and caryopsis. If the structure is a fruit, it is named as such.

Since the terms seed, fruit, schene, caryopsis, nut, nutlet, utricle, spike, spikelet and involucre are used, it is necessary to define them. A seed is a ripened ovule; *e. g.*, wild mustard. A fruit is a ripened ovary with its attachments; *e. g.*, common ragweed. An achene is a seed-like indehiscent fruit in which the seed is not firmly united with the wall of the ovary; *e. g.*, curled dock. A caryopsis is a similar one seeded indehiscent fruit in which the seed is firmly united with the wall of the ovary; *e. g.*, cheat. A nut is a dry indehiscent fruit usually one celled and one seeded, with a hard bony wall; *e. g.*, hazel-nut. A nutlet is a diminutive nut; *e. g.*, wheat thief. A utricle is a small one seeded dry fruit with a thin bladdery loose ovary wall. When ripe the wall bursts and the seed is exposed; *e. g.*, lamb's quarters. A spike is a form of inflorescence with the sessile flowers arranged on an elongated common axis; *e. g.*, wheat. A spikelet is a small or secondary spike. It may consist of a one seeded fruit, caryopsis, enclosed by coverings, which are scale-like, called lemma, palea, and outer lumes; *e. g.*, yellow fox-tail. An involucre is a cluster of small leaves or bracts just below the flower. It may be modified and enclose an achene; *e. g.*, common ragweed.

The seeds and seed-like fruits were gathered during the years of 1916 and 1917 in Champaign County, Illinois. By examining commercial seeds obtained from seed houses, by getting expressions from various seed-dealers, by consulting bulletins and other literature which list troublesome weed-seeds in grains, and by the writer's experience with weed-seeds on the farm, the thirty-one seeds and fruits, which make up the key, were selected.

The descriptions have been made with the use of a lens which magnifies about ten diameters. A simple lens known as "linen tester" gives very good results. Photographs show seeds and fruits magnified four diameters. Descriptions were made and photographs taken of the fruits after they were rubbed between thumb and forefinger. The nomenclature and order of classification are those of Gray's New Manual of Botany, seventh edition, 1908. When other names are used in common manuals they are placed in parenthesis.

Two previous weed-seed keys have been made. One by Edgar Brown and F. H. Hillman, keying the seeds of six species of Poa as found in commercial seeds. "The Seeds of the Blue Grass" Bulletin 84 of Bureau of Plant Industry, U. S. D. A. The other by E. L. Palmer in which he makes a seed key to some common weeds and plants. "A Seed Key to some Common Weeds and Plants," Iowa State Academy of Science, 1916. The work was done under the direction of Professor William Trelease of the Botany Department of the University of Illinois. The writer desires to acknowledge the many helpful suggestions received.

The Key

1. Terminal appendages present. 2.
   Terminal appendages absent. 4.
2. Appendages stiff, spiny; fruit top-shaped. Ambrosia artemisiifolia.
   Appendages scale- or bristle-like. 3.
3. Achene with 2 rows of scales at apex. Cichorium Intybus.
   Achene with a whorl of short bristles at apex. Erigeron annuus.
4. Seeds shot-like. 5.
   Seeds or schemes not shot-like. 6.
5. Seeds black, surface scarcely raticulated. Brassica arvensis.
   Seeds brownish, surface distinctly reticulated. Brassica nigra.

Row 1. Lepidium virginicum.

Row 2. Plantago Rugelii.

Row 3. Solanum carolinense.

Row 4. Setaria viridis.

Row 5. Setaria glauca.

Row 6. Polygonum pennsylvanicum.

PLATE 1.

Row 1. Polygonum Convolvulus.

Row 2. Plantago aristata.

Row 3. Plantago lanceolata.

Row 4. Rumex crispus.

Row 5. Rumex obtusifolius.

Row 6. Rumex Acetosella.

PLATE II.

6. Triangular in cross section. 7.
Not triangular in cross section. 10.
7. Achene black, granular, angles rounded. Polygonum Convolvulus.
Achene brown. 8.
8. Achene attenuate at apex. 9.
Achene not attenuate at apex, 1 to 1.5 mm. long. Rumex Acetosella.
9. Achene shiny, 1.5 to 2.5 mm. long. Rumex crispus.
Achene not shiny, 2 mm. long, acuminate. Rumex obtusifolius.
10. Canoe shaped. 11.
Not canoe shaped. 12.
11. Convex side with groove across the middle. Plantago aristata.
Convex side not grooved. Plantago lanceolata.
12. Surface sculptured. 13.
Surface not sculptured. 17.
13. Surface granular. 14.
Surface otherwise. 16.
14. Achene jet black, flattened. Polygonum pennsylvanicum.
Seeds not jet black. 15.
15. Reddish to yellow, flat, two-thirds ovate. Lepidium virginicum.
Brown to black, coarsely granular. Plantago Rugelii.
Lemon yellow, slightly double convex. Solanum carolinense.
16. Achene having vertical stripes. Cirsium lanceolatum.
Surface having vertical lines. Digitaria sanguinalis.
Achene having vertical spotted ridges. Lactuca scariola.
Achene having warty ribs, obovoid. Anthemis Cotula.
Seed coiled, conical. Salsoli Kali.
Seed with 3 to 6 curved rows of tubercles.
    Seed brownish, flattened. Stellaria media.
    Seed lead colored, .5 mm. in diameter. Silene antirrhina.
Seed wrinkled, base white-tubercled. Lithospermum arvense.

Caryopsis inclosed with scales having transverse striations.

Straw colored, striations branched. Setaria glauca.

Green, striations faint. Setaria viridis.

Seed minutely pitted, ovoid to spherical. Cuscuta arvensis.

Seed with faint radiating striations. Chenopodium album.

17. Lens shaped. 18.

Not lens shaped. 19.

18. Seeds circular, .7 to .9 mm. Amaranthus graecizans.

Seeds obovate, 1 to 1.2 mm. long. Amaranthus retroflexus.

19. Groove on one side, grain reddish brown. Bromus secalinus.

No groove on one side. 20.

20. Achene seal brown, polished, ovoid. Ambrosia artemisiifolia.

Achene tan, cup shaped at apex. Cirsium arvense.

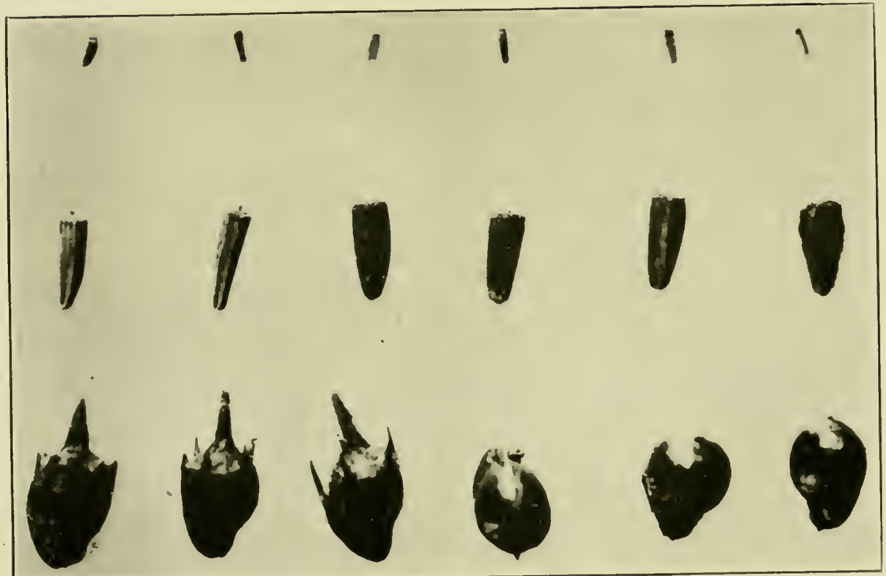
Descriptions

Gramineae. *Grass family*

Setaria glauca. *(Ixophorus glaucus.)* Yellow fox-tail. Pigeon grass. After rubbing, the spikelet consists of a grain or caryopsis and two firm coverings called respectively lemma and palea. This seed-like structure is straw colored, concave on one side and very convex on the other; prominent transverse striations mark the surface of the lemma and palea; apex slightly three toothed; 2.5 to 3 mm. long and 1.5 mm. in diameter. Common impurity in clover, millet, alfalfa and timothy. Plate I.

Setaria virdis. *(Ixophorus viridis.)* Green fox-tail. This seed-like structure, as in Setaria glauca, consists of a grain or caryopsis and two firm coverings. It is green, having the surface marked by faint transverse striations; 1.5 mm. to 2 mm. long and .8 mm. in diameter. Common in clovers, alfalfa, and millet. Plate I.

Digitaria sanguinalis. *(Syntherisma sanguinalis.)* Finger grass. Large crab grass. After severe rubbing, the spikelet consists of a grain or caryopsis and two firm coverings—lemma, which is on the convex side, and palea. It is straw col-



Row 1. Erigeron annus.

Row 2. Cichorium Inty-bus.

Row 3. Ambrosia artemisi-ifolia.

PLATE III.

ored to gray, bobbin like, surface marked by vertical lines; 2 to 2.5 mm. long. In grass, red clover and alfalfa. Plate VI.

BROMUS SECALINUS. Cheat, Chess. Grain or caryopsis, reddish brown, somewhat spindle shaped, vertical groove on one side to which is often attached a row of bristles; 6 to 7 mm. long. Impurity of wheat and red clover. Plate V.

POLYGONACEAE. *Buckwheat family.*

RUMEX CRISPUS. Curled dock. Yellow dock. Narrow-leaved dock. Achene brown, shiny, three sided, apex attenuate; 1.5 to 2 mm. long and 1.3 mm. in diameter half-way between base and apex. Common impurity in red clover, alfalfa and grass seed. Plate II.

RUMEX OBTUSIFOLIUS. Broad-leaved dock. Bitter dock. Achene dark brown, three sided, very attenuate at apex; 2 to 2.5 mm. long and 1 to 1.3 mm. in diameter half way between base and apex. In red clover and alfalfa. Plate II.

RUMEX ACETOSELLA. Field sorrel. Sheep sorrel. Redtop sorrel. Achene not easily freed from reddish brown calyx. Three sided, angles rounded, abruptly pointed at apex; 1 to 1.5 mm. long. In clover, alfalfa and grass seed. Plate II.

POLYGONUM CONVOLVULUS. Black bindweed. Wild buckwheat. Achene black, three sided, angles rounded, concave sides; 3 mm. long and 2 mm. in diameter half way between base and apex. Common in red clover, barley and oats. Plate II.

POLYGONUM PENNSYLVANICUM. Pennsylvania smart-weed, Pennsylvania persicaria. Achene jet black, lenticular, surface finely granular, short abrupt apex; 2.5 mm. short diameter and 3 mm. long diameter. Common impurity of red clover. Plate I.

CHENOPODIACEAE. *Goosefoot family*

CHENOPODIUM ALBUM. Smooth pigweed. Lamb's quarters. Pigweed. White goosefoot. The seed when deprived of its covering, which is the calyx and the wall of the utricle, appears black. If this covering is not removed, it appears gray. Somewhat lens-shaped, a groove extending nearly half way from edge to center; 1.5 to 1.8 mm. in diameter. Often in clover, alfalfa, and grass seed. Plate V.

Salsola kall *(Salsola Tragus.)* Russian thistle. Seed conical, embryo coiled, gray; 2 mm. in diameter. In clover and alfalfa. Plate IV.

Amaranthaceae. *Amaranth family*

Amaranthus graecizans. Tumbleweed. Seed shiny black. highly polished, circular with notch at one edge; .7 to .9 mm. in diameter. In red clover and grass seed. Plate V.

Amaranthus retroflezus. Rough pigweed. Redroot. Seed similar to Amaranthus graecizans in color, ovate with notch at edge; 1 to 1.2 mm. long and .8 to .9 mm. in diameter at base end. In red clover and grass seed. Plate V.

Carophyllaceae. *Pink family*

Stellaria media. *(Alsine media.)* Common chickweed. Seed brownish, three to six curved rows of tubercles, flattened; a groove extending about ⅓ distance to the center; 1 mm. in diameter. In red clover, alsik clover and alfalfa. Plate IV.

Silene antirrhina. Sleepy catchfly. Seed lead colored, four to six rows of curved tubercles on each side; .5 mm. in diameter. In grass and red clover seed. Plate IV.

Cruciferae. *Mustard family*

Brassica arvensia. Chalock. Wild mustard. Seed black, spherical with surface finely reticulated; 1.2 mm. to 1.5 mm. in diameter. Common impurity of red clover, timothy and alfalfa. Plate VI.

Brassica nigra. Black mustard. Seed brownish, globose, the surface more coarsely reticulated than the surface of Brassica arvensis; 1.3 to 1.8 mm. in diameter. In red clover and timothy seed. Plate VI.

Lepidium virginicum. Wild peppergrass. Tongue grass. Common peppergrass. Large peppergrass. Seed reddish to yellow, flat, surface granular, two-thirds ovate; 1 to 1.5 mm. in diameter. Common impurity of clover, alfalfa, and grass seed. Plate I.

Convolvulaceae. *Convolvulus family*

Cuscuta arvensis. Field dodder. Seed yellowish brown, ovoid to spherical, ridge on one side, the other rounded; surface minutely pitted; .6 to 1 mm. in diameter. Common impurity of alfalfa and red clover seed. Plate V.

Row 1. Silene antirrhina.
Row 2. Stellaria media.
Row 3. Anthemis Cotula.
Row 4. Lactuca scariiola.
Row 5. Salsoli Kali.
Row 6. Cirsium lanceolatum.

PLATE IV.

BORAGINACEAE. *Borage family*

LITHOSPERMUM ARVENSE. Wheat thief. Bastard alkanet. Corn Gromwell. Stoneseed. Redroot. Nutlet dull brown, apex pointed, base truncate having 2 white tubercles, keeled on inner side; 2.5 to 3 mm. long and 1.5 mm. wide half way between base and apex. Common impurity in wheat, rye, clover and alfalfa seed. Plate VI.

SOLANACEAE. *Nightshade family*

SOLANUM CAROLINENSE. Horse nettle. Bull nettle. Sand brier. Seed lemon yellow, slightly double convex, surface granular; 1.5 to 2 mm. in diameter. Impurity of clover and grass seed. Plate I.

PLANTAGINACEAE. *Plantain family*

PLANTGO RUGELII. Red-stem plantain. Rugel's plantain. Seeds brown to black, coarsely granular, angles acute, forms variable—oval, oblong, rhomboidal; 1 mm. in diameter at widest place and 2 to 2.5 mm. long. One of the most common weed seeds in clover, alfalfa and grass seed. Plate I.

PLANTAGO ARISTATA. Large bracted plantain. Western buckhorn. Seed brown, canoe shaped with convex side marked by a transverse groove; a white line bounding base of canoe inside, two pits appearing from concave side; 1.2 to 1.5 mm. in diameter and 2.5 to 3 mm. long. Common impurity of red clover and alsike clover. Plate II.

PLANTAGO LANCEOLATA. Buckhorn. Narrow leaved plantain. Rib grass. English plantain. Seed brown, canoe shaped with thick wall, a scar seen from middle of concave side; 1 mm. in diameter and 2mm. long. Common impurity of red clover, alfalfa, alsike clover and grass seed. Plate II.

COMPOSITAE. *Composite family*

ERIGERON ANNUM. Daisy fleshbane. Sweet scabious. White-weed. White-top. Achene brownish-white, slightly hairy with whorl of short bristles at apex; .3 mm. in diameter and 1 mm. long. Impurity of grass seed. Plate III.

AMBROSIA ARTEMISIIFOLSA. Common ragwed. Small ragweed. Hogwood. Roman wormwood. Wild tansy. Involucre grayish, top-shaped, armed with 6 to 10 short, acute spines; 3.5

to 4 mm. long. If there has been thrashing, the outer covering may have been removed, exposing the achene. It is seal brown, the surface polished, ovoid, a large tubercle at the base; 2.5 mm. long and 1.5 to 1.8 mm. in diameter. Common impurity of red clover, wheat, barley and grass seed. Plate III.

ANTHEMIS COTULA. Dog-fennel. Mayweed. Dillweed. Achene brownish, obovoid, the surface warty ribbed, a tubercle projecting from the apex; 1.3 to 1.5 mm. long. Common impurity of red clover, timothy, blue grass and alfalfa seed. Plate IV.

CIRSIUM LANCEOLATUM. *(Carduus lanceolatus.)* Common thistle. Bull thistle. Burr or spear thistle. Achene straw colored, slightly flattened, the surface marked by vertical stripes, a large tubercle in the center of a cup-like apex; 4 to 5 mm. long and 1 to 1.5 mm. in diameter. Common impurity in clover, alfalfa and grass seed. Plate IV.

CIRSIUM ARVENSE. *(Carduus arvensis.)* Canada thistle. Creeping thistle. Achene tan color, obovoid, to oblong, cup-shaped at apex with a small tubercle in the center of it; 3 to 3.5 mm. long and .7 to 1 mm. in diameter. Common impurity of clover, alfalfa and grass seed. Plate V.

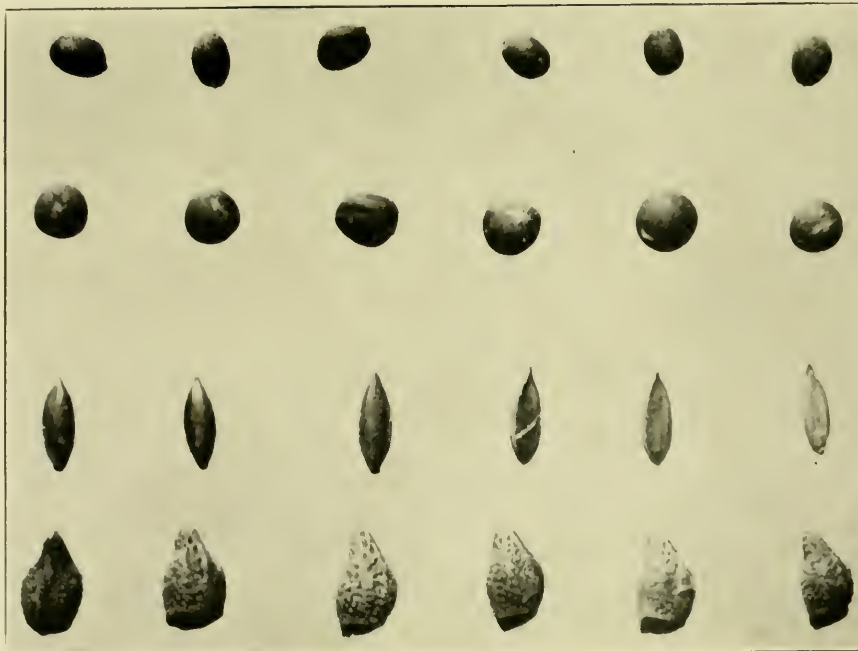
LACTUCA SCARIOLA. Prickly lettuce. Compass plant. Achene brownish, obovate with many black-spotted vertical ridges, widest towards the tapering apex; 3 to 3.5 mm. long. In grass seed. Plate IV.

CICHORIUM INTYBUS. Chicory. Blue sailors. Wild succory. Bunk. Achene light brown, often curved, the apex truncate and crowned with two rows of scales; 2.5 to 3 mm. long and .8 to 1 mm. in diameter. Common impurity of red clover and alfalfa seed. Plate III.

BIBLIOGRAPHY

Beal, W. J. The Seeds of Michigan Weeds. Bull. 260, Michigan Agricultural College Experiment Station, 1910. East Lansing, Michigan.

Blatchley, W. S. The Indiana Weed Book. Nature Publishing Company, Indianapolis, Indiana.



Row 1. Brassica nigra.

Row 2. Brassica Arvensis.

Row 3. Digitaria sanguinalis.

Row 4. Lithospermum arvense.

PLATE VI.

Britton, N. L. and Brown, A. Illustrated Flora of the Northern United States and Canada.

Brown, Edgar and Hillman, F. H. The Seeds of the Blue Grasses. Bull. 84 of Bureau of Plant Industry, U. S. D. A.

Clark, G. H. and Fletcher, Jas. Farm Weeds of Canada. Ottawa, 1906.

Cox, H. R. Controlling Canada Thistle, U. S. Dept. Agriculture, Farmers Bull. 543, 1913, Washington, D. C.

Dewey, L. H. Weeds and How to Kill Them. U. S. Dept. Agriculture, Farmers Bull. 28, 1895, Washington, D. C.

Garman, E. On Adulterant and Weed Seeds in Kentucky Samples of Blue Grass and Alfalfa. Bull. 124, Kentucky Agricultural Experiment Station, 1906. Lexington, Ky.

Garman, H. and Didlake, M. L. The Imperfections of Seeds under the Kentucky Pure Seed Laws. Bull. 127, Kentucky Agricultural Experiment Station, 1906. Lexington, Ky.

Georgia, Ada E. A Manual of Weeds. The Macmillan Company, New York.

Robinson, B. L. and Fernald, M. L. Gray's New Manual of Botany. Seventh Edition.

Hitchcock, A. S. A Text Book of Grasses.

Hillman, F. H. Testing Farm Seeds in the Home and in the Rural Schools. U. S. Dept. of Agriculture, Farmers Bull. 428, 1911, Washington, D. C.

Hillman, F. H. The Adulteration of Forage Plant Seed. U. S. Dept. of Agriculture, Farmers Bull. 382, 1909. Washington, D. C.

Moorhouse, L. A. and Burleson, W. L. Alfalfa Seed in Oklahoma, Bull. 83, Oklahoma Agricultural Experiment Station, 1909, Stillwater, Oklahoma.

Oakley, R. A. and Westover, H. L. Purity of Alfalfa Seed. U. S. Dept. of Agriculture. Farmers Bull. 757, 1916. Washington, D. C.

Oswald, W. L. Minnesota Weeds. Bull. 129, Agricultural Experiment Station, 1913. St. Paul, Minn.

Pammel, L. H. and King, Charlotte M. Iowa Seed Analysis. Bull. 146, Agricultural Experiment Station, 1913. Ames, Iowa.

Pammel, L. H. and King, Charlotte M. The Vitality, Adulteration and Impurities of Clover, Alfalfa and Timothy Seed for Sale in Iowa. Bull. 88, Agricultural Experiment Station, 1906. Ames, Iowa.

Pammel, L. H. The Weed Flora of Iowa. Bull. 4, Geological Survey, 1905. Des Moines, Iowa.

Palmer, E. L. A Seed Key to some Common Seeds and Plants. Proceedings of the Iowa Academy of Science, 1916.

Pipal, F. J. Red Sorrel and Its Control. Bull. 1917, Indiana Agricultural Experiment Station, 1916, Lafayette, Ind.

Stewart, F. C. The Impurities of Clover Seed. Bull. 21. Agricultural Experiment Station, 1911. Ames, Iowa.

Westgate, J. M. and Hillman, F. H. Cleaning Red Clover Seed. U. S. Dept. of Agriculture, Bull. 455, 1911. Washington, D. C.

Papers on Zoology

GEOGRAPHICAL VARIATION OF NOTEMIGONUS CRYSOLEUCAS—AN AMERICAN MINNOW

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The golden shiner is one of the most distinctive and best known of all the American minnows. It is usually abundant in sluggish streams and weedy ponds from New Brunswick, Ontario and North Dakota southward to Florida and Texas. Under favorable conditions it reaches a length of about one foot, and a weight of about a pound and a half, but in small ponds it is more or less dwarfed, breeding at the age of one or two years. Thus in the San Diego River of California, which is reduced during the dry season to a chain of small disconnected pools, the golden shiner, although it has become abundant since its introduction, is so greatly dwarfed that the largest adults I was able to obtain are scarcely more than three inches long to the base of the caudal fin. Most of these fishes in the San Diego River become mature at the end of their first year, and do not acquire, or acquire only in part, the peculiarly deep body which is characteristic of the adult as usually found in its native waters[1]. I have also examined mature dwarfed examples from Texas, Iowa and Ohio, but these specimens, although small, have usually acquired the deep form of the larger adults. This dwarfing is one instance of the great adaptability of the golden shiner.

Excluding a doubtful form, *Notemigonus crysoleucas* is the only species in its genus. It has been recognized,[2] however that the species is divisible into two intergrading subspecies: *crysoleucas* proper, from the greater part of the wide range of the species, and *boscii*, from the South Atlantic States and Florida. The variations and inter-relationships of these two subspecies, in the different parts of their range, form the main theme of the present paper.

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[1]In discussing *Semotilus bullaris*, Dr. Kendall has recently stated (Bull. Bur. Fish., 35, 1918, p. 511): "Small adult fish resemble young of the larger fish, being silvery and having a dark stripe along the side". Similar neotenic relations, as is well known, prevail in the Salmonidae.

[2]First by Jordan and Meek (Proc. U. S. Nat. Mus., 8, 1885, p. 15).

According to current descriptions, *boscii* differs from *crysoleucas* in the larger scales; in the brighter colors of the breeding male, ad in the greater length of the anal fin. The variation to which these characters are subject has been studied in some detail.

1. *The Size of the Scales*

In 56 counts of the number of transverse rows of scales in specimens of *boscii* from Florida and South Carolina, an extreme variation of from 42 to 53 rows was found, the mode of variation being about 46 rows. In 127 counts of the transverse scale rows of specimens from the given range of *crysoleucas* proper, the mode of variation is at 47 rows instead of 46; the extremes of variation (from 42 to 53 rows) as determined for *boscii,* were found to hold also as the usual extremes for typical *crysoleucas,* although two specimens showed a higher number (in one case 55, in the other 57, on one side only). These figures indicate that there is no wide geographical variation in the size of the scales of *Notemigonus crysoleucas.*

In both *crysolucas* and *boscii* the lateral line is frequently variously incomplete.

2. *The Colors of the Breeding Male*

In the southeastern form, *boscii,* the males in the spring are described as assuming bright colors, caused chiefly by the development of red color on the lower fins. In typical *crysoleucas,* however, the lower fins are usually marked with orange in the breeding fishes (of both sexes), and these fins are occasionally red.[3] o data is available on the intergradation of the two forms in respect to coloration.

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[3]Dr. Tar'eton Bean (Bull. Am. Mus. Nat. Hist., 9, 1897, p. 344) described as a race of *crysoleucas*, a fish from Central Park, New York City, characterized by the "permanent vermilion color" of the lower fins. Hk apparently was dealing however with examples of an introduced European species, *Scardineus erythrophthalmus.*

3. *The Number of Rays in the Anal Fin*

The longer anal fin of *boscii,* containing more rays than that of *crysoleucas* proper, is the most important of the characters which distinguish the two forms. Within the species, including the two subspecies, the variation in the number of branched rays in the anal fin is from 8 to 17, more than one hundred per cent. A variation of five rays, which is unusually wide when the number is so low, occurs normally in a single lot from a single locality. Thus, in a series from Saginaw Bay, Michigan, the rays vary from 8 to 12; from Dewey Lake, Michigan, 10 to 14; from the Huron River basin, Michigan; from Pikeville, Indiana, 9 to 13; from Lake Monroe, Florida, 13 to 17.

The most intersting aspect of this variation in the number of branched rays of the anal fin is not its wide extent, but rather the geographical distribution of its variants. This is indicated in the two following tables.

Tables showing the geographical variation in the number of branched rays of 465 specimens of Notemigonus crysoleucas. branched rays of 487 specimens of Notemigonus crysoleucas.

Branched annal rays										Localities (states)
8	9	10	11	12	13	14	15	16	17	
1	7	42	203	119	23	2				North Dakota, Wisconsin, Michigan, Ontario, Nova Scotia, Iowa, Northern Missouri, Illinois, Indiana, Ohio.
			2	12	17	7				Texas, Louisiana, Arkansas, Oklahoma, Southern Missouri, Virginia, Maryland, Delaware, Pennsylvania.
					4	12	23	14	1	South Carolina, Georgia, Alabama, Florida.

Estimated modal numbers of branched anal rays	*Regions*
11	Red River of the North
11	North Dakota
11	Wisconsin (Lake Pepin)
11	Michigan
11	Northern Illinois
11	North central Ohio
11½	Iowa and northern Missouri
11½	About southern end of Lake Michigan
12	Indiana
12	Western Ohio
13	Southern Missouri
13	Texas
13	Arkansas
13	Maryland and Potomac River
13½	Southern Virginia
14	Alabama
14½	South Carolina
15	Florida

It thus appears that, as regards the number of anal rays, the most important distinctive feature, *crysoleucas* blends into *boscii,* the number of rays becoming gradually more numerous from the northwest to the southeast. How gradual this intergradation really is, can be emphasized by considering the conditions in Illinois and the adjacent states. In Indiana I find the number of anal rays to vary from 9 to 14, twelve occurring most frequently. In Michigan, in northern Illinois, and in the states to the west of Illinois, I find the variation to be from 8 to 13 instead of 9 to 14; the number 11, rather than 12 occurring most frequently. It seems rather surprising that the golden shiners of Indiana should present this slight racial difference when compared with others from the Illinois River basin, but the difference is in agreement with the more southern facies of the fauna just southeast of Lake Michigan. About the southern tip of Lake Michigan the modal number is between 11 and 12.

Among stream fishes, the distribution of species and variants is usually correlated, not with latitude or area, as in the case of terrestrial animals, but rather with the extent of the stream basins themselves: for the history of the streams and the history of the stream fishes are intimately connected. The case of the golden shiner forms one of the apparent exceptions to this general law, for in *Notemigonus* the distribution of the variants seems to be correlated with area and perhaps with temperature, rather than with the stream basins. A closely similar case appears to occur among the sun-fishes, and others will probably be demonstrated when our freshwater fishes are more extensively studied.

THE MOLLUSCA OF PIATT, CHAMPAIGN, AND VERMILION COUNTIES OF ILLINOIS

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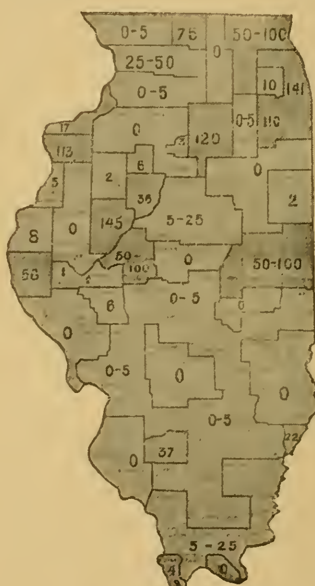
This report on the mollusks of these three counties is based upon collections and observations made from the Autumn of 1907 to the Summer of 1911, supplemented by such additional data as given in Baker (1906). The late Mr. Charles A. Hart accompanied me on a great many of these excursions and took a lively interest in the study; to him particularly I wish to show my gratitude.

I am also greatly indebted to the following gentlemen: Dr. Charles C. Adams for valuable suggestions and interest in the survey; to Dr. Frank C. Baker for accurate determinations of my material and checking on my identifications; Dr. Victor Sterki for identifications of the Sphœriidœ and Ppidœ; Dr. Bryant Walker for determination of *Paravitrea significans;* my colleagues, Drs. J. Douglas Hood, Arthur G. Vestal, Robt. D. and Hugh Glasgow, H. E. Ewing and Frank Elmer Wood, for contributions of specimens; Drs. Wm. Healey Dall and Paul Bartsch for their kindness in going over the manuscript and bringing the nomenclature to date; and finally to the pioneer ecologist, Dr. Stephen Alfred Forbes, for the use of his library and for valuable suggestions.

Baker's catalog of the mollusks of Illinois (1906) lists one species from Piatt Co., twenty-three from Champaign Co., and four from Vermilion Co. The present paper lists fifty-two, seventy-eight and sixty-seven species respectively, a total of one hundred and sixteen species. The important fact to note is that the material on which this paper is based was collected at odd times, and nearly always when engaged in entomological work. An exception to this is the Brownfield Woods (also known as the Augerville Woods) near Urbana, where a special study was made of the ecology of forest inhabiting snails for a thesis. It is clear that this paper cannot be considered as even fairly



complete, for if an intensive survey is made, the number of species will probably be over two hundred.

Primarily as a stimulus to others, in the hopes that we may know more of the ecology of our mollusk-fauna, I prepared a map of Illinois on which I summarized our knowledge of this fauna to date. In the preparation of this map I followed the data given by Baker and that in this paper. There are only five counties with more than one hundred species reported from them, and what is most regretable, there are thirty-two counties of which we have no record at all. Almost one-third of the entire State, representing some of our richest faunal regions, is still almost unknown so far as mollusks are concerned!

It is to be hoped, however, that none shall stop at mere collecting of specimens, but that notes shall be taken of the ecology of the species found,—that apparent maze of interrelations existing between individuals, species and the complex environment, which, combined, spell life and give to Nature true orientation and significance.

THE MOLLUSCA OF THE THREE COUNTIES

The following are the localities visited:

Piatt Co. (1 and 2) White Heath and Monticello; four trips to the Sangamon River and one trip to a small patch of woods near White Heath.

Champaign Co. (3) Urbana; five visits to Mr. C. A. Hart's back yard at 923 W. Green St., where several logs rested undisturbed for years. (4) Mount Hope Cemetery, south of Urbana, one trip. (5) Crystal Lake and cut-offs near Urbana, nine trips. (6) Salt Fork, Urbana, one trip to the historic "boneyard" branch, three to the main stream, and one to a sewer outlet. (7) Brownfield (Augerville) Woods, 3¼ miles Northeast of Urbana, about sixty trips. (8) the Cottonwood Woods, 4 miles Northeast of Urbana, near the Brownfield Woods, ten trips. (9) St. Joseph, Salt Fork and Spoon Creek, two trips. (10) Homer and Homer Park, one trip.

Vermilion Co. (11) Muncie, five trips to Stony Creek and to the woods bordering it, one trip to the Salt Fork. (12) Hillery, two trips to the Middle Fork and the woods bordering it, one trip to the woods north of Hillery. (13) Danville, one trip to woods northwest of town.

Peculiarities of the Fauna

The Sangamon River. It is a tributary of the Illinois River. During late Summer and Autumn it is very shallow at White Heath and Monticello. Due to the very high rises in Spring, which often overflow the river's flood-plain, great changes occur in the mollusk habitats. In addition to the changes in depth of water and current, the character of the bottom changes in many places. What was gravel one day, is sand the next, or an ox-bow forms and the channel is changed over night. *Amblema undulata, Quadrula pustulosa, Fusconaia rubiginosa, F. coccinea, Tritogonia tuberculata* and *Eurynia fasciata* were the dominant clams. The less common species were: *Lampsilis ventricosa, L. anodontoides, Strophitus edentulus, Anodonta grandis, Anodontoides ferussacianus subcylindraceus, Lasmigona costata, L. complanata, Alasmidonta calceola* and *A. marginata.*

With the exception of *Eurynia fasciata,* the dominant clams are summer breeding forms, i. e., the sex products mature from fall to Spring, and the young are discharged during the Summer months. The others are the winter breeding species, the embryos of which mature in Spring and are set free in Autumn and the following Spring. The summer breeders find plenty of water when their young are discharged, also plenty of fish to which these young glochidia may become attached. Conditions appear, therefore, more favorable to the development of this type of clam. On the other hand, the Winter breeders find the river very shallow and with fewer fish when their young are released. This hypothesis seems valid as an explanation of the abundance of certain clams at this particular place.

At Havana, Illinois, the Illinois River is very broad and deep all year round. Fish are always plentiful. Therefore both the Summer and Winter breeders are in abundance. It would appear also that as the Spring rains swell the tributaries of the Illinois River, that fish from it will swim up these tributaries to spawn and bring with them the encysted glochidia, and that these are set free in these tributaries. As the late Summer and Winter conditions of the Sangamon River are not favorable to the development of these tiny clams, only a few survive. Whether or not these explanations are true, remains to be proven by more intensive studies.

Prof. F. E. Wood (1910, p. 558) gives the following count and list of clams that he found at White Heath, all of them in one heap and empty,—the results of a muskrat raid: 41 *Amblema undulata,* 4 *Quadrula pustulosa,* 1 *Fusconaia coccinea,* 7 *Lasmigona* sp., 3 *Tritogonia tuberculata,* 7 *Eurynia fasciata,* 1 *Lampsilis ventricosa*, 3 *Lasmigona complanata* and 1 *Anodonta grandis*. Such heaps were plentiful and show only too well how severe are the inroads made by *Fiber zibethicus* in the clam world, notwithstanding the fact that his chief food is vegetable matter. The muskrat takes the clams during Autumn, Winter and early Spring, when the corn and grain fields offer him no food.

Vermilion County. The Vermilion River, with its North and Middle Forks, rises in Ford and Iroquois Counties and drains into the Wabash River. The Middle Fork at Hillery contains much drifting sand. The depth of water varies in all these branches according to the season. Too few collections were made of the Unionidae to warrant making definite conclusions, however, it is evident that in several respects the fauna of this drainage system is quite different from that of the Sangamon. *Quadrula cylindrica* and *Obovaria circulars* collected here are typical of the Wabash Drainage.

The hillsides at Hillery are very favorable for *helices; Polygyra elevata, P. albolabris* and *P. thyroides* are the most abundant. Unfortunately man with his fire, destroyed an extensive area of this splendid *Polygyra habitat;* the calcined shells are strewn all over the place. Near the stream the lowland mesophytic plant association merges into a typical hydrophytic type with *Lymnæa humilis modicella, Segmentina armigera* and *Carychium exile* as the dominant mollusks.

At Muncie is an excellent sample of dry upland association and near to it, a well-drained mesophytic association; unfortunately, the mollusk fauna was very limited in both species and individuals. This place no longer represents natural and normal habitats, being badly distorted and changed by hogs, cattle, horses and man. The stream at the Big Four R. R. crossing is very rapid, its bed being chiefly rock. On one side are high bluffs; on the other side is a broad, level flood-plain which exhibits several terraces. Numerous cut-offs occur, usually dry in Summer and Autumn. The small fauna of these is chiefly composed of *Lymnæa humilis modicella, L. caperata, Physa gyrina, Aplexa hypnorum, Planorbis trivolvis* and *Segmentina armigera. Mancassellus macrurus, Branchippus* sp., Amphipods, Odonata larvæ, and a host of aquatic and semi-aquatic insect larvæ and adults, are in abundance. It is a melting point of terrestrial and aquatic conditions, and the aquatic forms must endure much dessication when the waters dry up in late Summer. Numerous birds come here to find food.

Champaign Co. This county is at the divide between the Sangamon, Vermilion and Embarass Rivers. Champaign and Urbana are almost the highest portions of the county. The woods are nearly all cleared and pastured, and the few that remain, even if undisturbed by axe or stock, are more or less abnormal due to the inroads of great numbers of field mice and shrews during Winter when the adjoining corn fields no longer suit them. This destruction of our forests, and as a consequence the development of corn and grain fields, means the destruction of our larger land snail habitats, and it is only a question of brief time, if not actually now, when these large Polygyras will no longer be collected by the hundreds. This fact should inspire students to survey those counties of Illinois from which we have few or no records, counties which are so situated that they are still rich in natural abodes, undisturbed by man.

The Brownfield and Cottonwood Woods are located 3¼ and, 4 miles respectively, to the Northeast of Urbana. Their area is about eighty acres each. Until 1910 the only intruders in the Brownfield Woods (also called Augerville Woods), were rabbit hunters, botanists and entomologists. Since then, church picnics were held there, and more or less of a habit, fires were built and the burning embers not always extinguished, hogs and chickens entered, and trees were cut down by the neighbors. The Brownfield Woods is in the main part well drained, is composed chiefly of a mesophytic plant association, with a small sample of wet lowland type near the intermittant creek which flows thru the woods. The fauna of this creek is very poorly developed.

The mollusca of these woods are quite well developed; the following species have been collected: *Polygyra elevata, P. zaleta, P. pennsylvanica, P. thyroides, P. hirsuta, Circinaria concava, Zonitoides arboreus, Z. mimusculus, Z. nitudus,* *Vitrea indentata, V. hammonis, Paravitrea significans, Euconulus chersinus, Agriolimax campestris, Philomycus carolinensis, Pyramidula alternata, P. solitaria, P. perspectiva, Helicodiscus parallelus, Sphyradium edentulum, Succinea avara, Strobilops labyrinthica, Gastrocopta contracta, G. tappaniana, G. holzineri, Vertigo tridentata* and *Carychium exile,* a total of twenty-seven species.

The Salt Fork drainage feeds into the Vermilion. The "Boneyard" branch is its source. A few intermittant feeders are found as far north as Rantoul, near the Mackinaw region where also the Sangamon has its source. The first Unios to be found are *Carunculina parva* and *Anodontoides ferussacianus subcylindraceus,* and wherever ox-bows are formed, *Anodonta grandis* is almost certain to be found. But few Sphæriidæ were found, no doubt more exist if only a more careful search is made for them. In the ecologically annotated list of species data is given covering the habitats of the Ancylidæ, etc., found here. At Crystal Lake the littoral fauna is well developed,—mostly insect and snail, of the latter *Lymnæa humilis modicella, L. parva, Pomatiopsis lapidaria* and *Physa gyrina* being the dominant forms.

In 1910 the Salt Fork was dredged and as a result many faunal changes occurred. Numerous ox-bows were formed and at times these were literally alive with *Carunculina parva, Musculium transversum* and several species of *Sphærium,* and of course, large numbers of dragon fly larvae and nymphs. On one occasion a nymph of *Gomphus* sp. was collected with one of its legs caught between the valves of *Sphærium striatinum.* The dredged area is practically devoid of mollusks, though in time these will invade it. During the Winter, *Physa gyrina* and *Planorbis trivolvis* were frequently found crawling on the underside of ice.

At St. Joseph, prior to dredging, the stream was rather wide and had very muddy banks. *Amblema undulata* and *Carunculina glans* were the most numerous clams. The latter was only found here and particularly near the outlet of a slaughter house. *C. parva* was not found at this particular place, though elsewhere it was common. Many of the "Quadrulas" were found with their shells deformed by the hoofs of cattle.

ECOLOGICALLY ANNOTATED LIST OF SPECIES
CLASS PELECYPODA

Order Prionodesmacea
Family Unionidæ

GENUS LAMPSILIS Rafinesque, 1820

Subgenus Lampsilis s. s.

1. *L. multiradiata* (Lea)—Reported by Mr. Wm. A. Marsh from the "Big Vermilion River." It prefers muddy or sandy bottoms, with only a few feet of water.

2. *L. ventricosa* (Barnes)—Found in all three counties,—at White Heath, Monticello, Salt Fork, Muncie and Hillery. It is a very variable species in color, rays, degree of corpulency and thickness of the shell. It prefers muddy bottoms of the larger streams, and is frequently associated with *Eurynia fasciata* Raf. At Havana, Ill., on the Illinois River, it is a very common clam.

GENUS EURYNI Rafinesque, 1820

3. *E. anodontoides* (Lea)—Found only at Monticello, Piatt Co. It is a member of the deeper water fauna, either muddy or sandy bottoms, where it can burrow; often among rocks near shores. In the Winter it burrows into the mud. At Havana, Ill., it is one of the most abundant clams.

4. *E. ellipsiformis* (Conrad)—Reported by Mr. W. W. Calkins from the "Vermilion River." Its habitat is about the same as that of *L. multiradiata*.

5. *E. lienosa* (Conrad)—Reported by Mr. Wm. A. Marsh from the "Little Vermilion River."

6. *E. ligamentina* (Lamarck)—Found only once, at Muncie, Vermilion Co., on a muddy bottom.

7. *E. fasciata* (Rafinesque)—Found in all three counties,—White Heath, Monticello, St. Joseph, Muncie and Hillery. Very plentiful. It prefers the larger streams and thrives on any kind of a bottom. Those on sandy bottoms are thicker-shelled. The St. Joseph specimens are quite thin.

8. *E. subrostrata* (Say)—Abundant at St. Joseph, Champaign Co., in quiet, muddy water. Dr. Charles C. Adams also found it very plentiful in a small pond, partly dried up, at White Heath, Piatt Co.

GENUS CARUNCULINA Simpson (in Baker), 1898

9. *C. glans* (Lea)—Found only at St. Joseph, Champaign Co., about the outlet to a slaughter house. *C. parva* also occurs in this stream but not at this particular place.

10. *C. parva* (Barnes)—St. Joseph and Crystal Lake, Champaign Co.; Hillery, Vermilion Co. The female shells are greatly inflated. The species prefers a muddy bottom, burying itself to a depth of several inches; slow streams, and nearly always near their sources, are preferred. Quite abundant.

GENUS OBOVARIA Rafinesque, 1819

(Subgenus Obovaria s. s.)

11. *O. circulus* (Lea)—Hillery, Vermilion Co. It is a typical member of the Wabash River Drainage System, and is quite abundant. It prefers the deeper waters.

GENUS TRITOGONIA Agassiz, 1852

12. *T. tuberculata* (Barnes)—Sangamon River, at White Heath and Monticello; very abundant and of large size. It lives in water of all depths, preferring a sandy bottom. Musk rats do not eat this species frequently because the valves fit tightly, and because at the least signs of any intrusion, *tuberculata* closes its valves tightly and keeps them closed for a long period. Musk rats prefer other clams, such as are easier to open.

GENUS STROPHITUS Rafinesque, 1820

13. *S. edentulus* (Say)—White Heath and Monticello, Piatt Co., St. Joseph, Champaign Co. In the larger streams and bayous, on muddy bottoms, usually associated with *Anodonta grandis.*

GENUS ANODONTA Lamarck, 1799

14. *A. grandis* (Say)—At all stations in the three counties, —in lakes, bayous, and streams, preferring waters devoid of current. Muddy bottoms are preferred. Very often the entire

outside of the shell is found to be covered with the bryozoon *Plumatella polymorpha*. A hydrachnid mite, *Diplodontus* sp. frequently infests the mantal cavity. Dead valves are very often found with *Ancylus* attached to them.

15. *A. grandis* Say var. *gigantea* Lea—Mr. Wm. A. Marsh reports it from the "Big Vermilion River." No specimens were collected which could be referred to this or any of the other varieties.

16. *A. implicata* (Say)—Only at St. Joseph, Champaign Co. The only other Illinois record is that of Mr. Marsh from Lake Co. The very great variation within the species of *Anodonta,* even among individuals of the same species, makes it very difficult to make accurate determination from shell characters alone. Slight differences in the habitat (from muddy to gravelly or sandy situations) often produce marked varietal differences. The St. Joseph specimens were all dead, and the identification was made by Dr. Frank C. Baker.

GENUS ANODONTOIDES Simpson (in Baker), 1898

17. *A. ferussacianus* (Lea) var. *subcylindraceus* (Lea)—Found in all three counties (Monticello, St. Joseph, Crystal Lake and Muncie), in small streams or near the sources of the larger ones; the habitat is much the same as that of *Carunculina parva* with which species it is usually associated. Fairly abundant.

GENUS ARCIDENS Simpson, 1900

18. *A. confragosus* (Say)—Found only at Monticello and White Heath. It is a typical Illinois River species, abundant at Havana. Like *Eurynia anodontoides* and a few others, it appears to slowly ascend the Sangamon River, but the shallow water inhibits its establishment in large numbers.

GENUS LASMIGONA Rafinesque, 1831

Subgenus Platynaias Walker, 1917

19. *L. compressa* Lea—Hillery, Vermilion Co. Usually buried several inches in mud in streams that are neither deep nor rapid. It is fairly common.

Subgenus Lasmigona s. s.

20. *L. costata* (Rafinesque)—White Heath and Monticello only. This also is a deep river species which ascends in small numbers such tributaries as the Sangamon. It prefers muddy bottoms, but at one station it was the only form among the rocks. Muskrats prefer this species to other clams. This may account for the non-abundance of *costata* in shallow waters.

Subgenus Pterosygna Rafinesque, 1831

21. *L. complanata* (Barnes)—White Heath and Monticello, Piatt Co., St. Joseph, Champaign Co. Its habitat is much the same as that of *L. costata* and the two are usually found together. *Amblema undulata* is also usually associated with them. A specimen of *complanata* was found which measured ten inches across. Young shells are plentiful, and in many instances are distorted by cow hoofs.

GENUS ALASMIDONTA Say, 1818

Subgenus Pressodonta Simpson, 1900

22. *A. calceola* (Lea)—White Heath and Monticello. Associated with *A. marginata,* on muddy bottoms in water only a few feet deep.

Subgenus Rugifera Simpson, 1900

23. *A. marginata* (Say)—White Heath, Monticello and Hillery. With the preceding species; not very abundant.

GENUS ELLIPTIO Rafinesque, 1819

Subgenus Elliptio s. s.

24. *E. gibbosus* (Barnes)—White Heath, Piatt Co., collected by Dr. Charles C. Adams; also at Hillery, Vermilion Co. It prefers flowing waters of a few feet in depth only, with muddy bottoms in which these clams usually remain buried.

GENUS UNIOMERUS Conrad, 1853

25. *U. tetralasmus* (Say)—Crystal Lake, Champaign Co. Found always buried deeply in mud of quiet waters.

GENUS PLEUROBEMA (Rafinesque, 1820) Agassiz

26. *P. clava* (Lamarck)—Hillery, Vermilion Co., Dr. J. D. Hood, collector. This is another of the typical members of the Wabash River drainage. It prefers deeper waters, usually muddy bottoms.

27. *P. coccinea* (Conrad)—Monticello, Piatt Co., and Hillery, Vermilion Co. Fairly abundant at Monticello, in soft mud and usually seeking the deeper waters.

GENUS FUSCONAIA Simpson, 1900

28. *F. rubiginosa* (Lea)—White Heath, Monticello, St. Joseph, Homer Park, Muncie and Hillery. Very abundant; prefers the deeper waters, any kind of bottom.

GENUS QUADRULA (Rafinesque, 1820) Agassiz

Section Quadrula s. s.

29. *Q. cylindrica* (Say)—Hillery, Vermilion Co., Dr. J. D. Hood, collector. Rare at this place; typical of Wabash River drainage.

Section Theliderma (Swainson, 1840) Simpson

30. *Q. metanevra* (Rafinesque)—Deep waters of the Middle Fork at Hillery, Vermilion Co. Rare.

31. *Q. pustulosa* (Lea)—White Heath and Monticello, Piatt Co. This is another of the abundant and typical species of the Illinois River at Havana; it prefers muddy bottoms, but is often found among rock and sand.

GENUS AMBLEMA Rafinesque, 1819

32. *A. undulata* (Barnes)—In all three counties; very abundant. In streams and rivers of all depths, usually with muddy bottoms. Young shells are often deformed by cow hoofs. None of the closely related species, *A. plicata* and *Megalonaias heros* were found, although at Havana, Illinois, they are quite abundant.

GENUS ROTUNDARIA (Rafinesque, 1820) Simpson

33. *R. granifera* (Lea)—Only one dead valve was found at Hillery, Vermilion Co. It is very typical. The species probably inhabits the deeper waters.

Order Teleodesmacea

Superfamily Cyrenacea

Family Sphæriidæ

GENUS SPHÆRIUM Scopoli, 1777

34. *S. occidentale* (Prime)—Muncie, Vermilion Co., in soft mud of ponds and bayous, or cut-offs; abundant wherever the

current is sluggish or wanting. Usually associated with *Musculium transversum.* This Sphærium was often found in places completely dried up in the Summer.

35. *S. sulcatum* (Lamarck)—In soft mud at Crystal Lake, near Urbana. Not abundant.

36. *S. solidulum* Prime—A form very close to this species, and probably referable to it, was collected in mud at Crystal Lake, near Urbana; rare.

37. *S. stamineum* Conrad—Monticello, Piatt Co., St. Joseph and Homer Park, Champaign Co. In small creeks, rivers and ponds, buried in mud or among the roofs of aquatic plants.

38. *S. striatinum* Lamarck—Very abundant at Crystal Lake, St. Joseph, and the Salt Fork, Champaign Co., and at Hillery, Vermilion Co. It lives in soft mud, or at times sandy situations, buried often to a depth of eight inches. Among roots of water plants, associated with *Musculium transversum* and *M. partumeium.*

GENUS MUSCULIUM Link, 1807

39. *M. partumeium* Say—Crystal Lake, Salt Fork and Urbana, Champaign Co. Not very abundant, associated with *transversum* in soft, muddy bottoms.

40. *M. transversum* Say—Very abundant in all three counties, perhaps the most abundant of all the Sphæriidæ. Gregarious, usually associated with *M. partumeium, S. striatinum, S. occidentale* and some species of *Pisidia.* It lives in soft mud in ponds and slowly moving streams, under and among stones, among roots of aquatic plants and similar situations. Individuals were found with from 20 to 30 young within the mantle cavity.

41. *M. truncatum* Linsley—Reported from Urbana by Dr. Frank C. Baker, the specimens being in the collections of the Ill. State Lab. Nat. Hist.

GENUS PISIDIUM Pfeiffer, 1821

42. *P. compressum* Prime—Crystal Lake and Salt Fork, Champaign Co., buried in soft mud or among the roots of aquatic plants. It was very abundant in small streams and lakes.

43. *P. noveboracense* Prime—Salt Fork and in a stream of the Embarras River drainage, Northwest of Champaign, Champaign Co., in waters of moderate current, buried in soft mud or sand.

44. *P. walkeri* Sterki—Salt Fork, Champaign Co., associated with *P. compressum*, among roots of plants.

CLASS GASTROPODA

SUBCLASS Anisopleura

Order Prosobranchiata

Superfamily Taenioglossa

Family Viviparidæ

GENUS CAMPELOMA Rafinesque

45. *C. rufum Haldeman*—Monticello, Piatt Co. Also reported by Mr. Wm. A. Marsh from the Vermilion River. It prefers muddy shores of streams usually not very rapid; burrows in the mud.

Family Valvatidæ

GENUS VALVATA Muller, 1774

46. *V. bicarinata normalis* Walker—St. Joseph, Champaign Co., on water lilies and on the bottom of slowly moving streams or ponded waters, often burrowing itself into the mud or vegetable debris. It withstands much dessication.

Family Amnicolidæ

Subfamily Amnicolinæ

GENUS AMNICOLA Gould and Haldeman, 1840

Subgenus Amnicola s. s.

47. *A. limosa* Say var. *parva* Lea—Crystal Lake, Urbana, and Champaign Co. at St. Joseph, in mud and among roots of water plants, usually in shallow water where there is but little current.

Subgenus Cincinnatia Pilsbry, 1891

48. *A. cincinnatiensis* Lea—Monticello, Piatt Co., Crystal Lake and Urbana, Champaign Co., Muncie, Vermilion Co. On the surface of muddy bottoms or buried in same; also on aquatic plants and about roots; usually near shore.

Subfamily Pomatiopsinæ

GENUS POMATIOPSIS Tryon, 1862

49. *P. lapidaria* Say—Crystal Lake, Champaign Co. Amphibious; among vegetation and debris at margins of ponds. It withstands much dessication and is very often to be found in temporary waters.

Family Pueuroceridæ

GENUS PLEUROCERA Rafinesque, 1818

50. *P. elevatum* Say var. *Lewisii* Lea—White Heath and Monticello, Piatt Co. It prefers sandy bottoms of large streams, or among rocks. At Havana, Illinois, this is a very common species. The Piatt Co. specimens are very typical, and the species is fairly abundant, associated with *Goniobasis livescens.*

GENUS GONIOBASIS Lea, 1862

51. *G. livescens* Menke—Monticello, Piatt Co., and Hillery, Vermilion Co., among water weeds, on muddy or sandy bottoms; common.

52. *G. pulchella* Anthony—"Big Vermilion River" according to Mr. W. W. Calkins. Mr. E. C. Faust in the Journal of Parasitology (Vol. iv, No. 3) gives as the host of *Cercaria aurita* Faust, *G. pulchella,* but he does not state who determined his material. He gives as his locality "Salt Fork of Sangamon River, Homer," which locality is somewhat dubius,—geographically speaking.

53. *G. semicarinata* Say—"Big Vermilion River" according to Mr. Wm. A. Marsh. This may prove to be a mistake for *G. costifera* Haldeman, which species it resembles considerably.

Subclass Euthyneura

Order Pulmonata

Suborder Basommatophora

Superfamily Limnophila

Family Physidæ

GENUS PHYSA Draparnaud, 1801

54. *P. ancillaria Say* var. *warreniana* Lea—Crystal Lake, Champaign Co., *after* the Salt Fork was dredged. Not common. It resembles *P. sayii* but is only one-half its size. The specimens are mature.

55. *P. gyrina* Say—In all ponds and streams visited, in all three counties,—a most prolific and active species, probably the commonest of all gastropods. It is found on stones, twigs, aquatic plants, in slow running water, stagnant pools, ponds, rapid streams, temporary pools, at times in damp places far from bodies of water. It endures dessication. In January, 1909, I found it crawling on the under side of ice at Crystal Lake.

56. *P. sayii* Tappan—Urbana, Champaign Co., Dr. Frank C. Baker det. The specimens are in the collections of the Ill. State Lab. Nat. Hist. Excepting for *warreniana,* I found no *Physa* which approached *sayii.*

GENUS APLEXA "Fleming" Sowerby, 1822

57. *A. hypnorum* Linnæus—Muncie, Vermilion Co., in slowly moving or pounded waters, usually on plants or debris, under leaves, or on the muddy bottoms. It endures much dessication.

Family Ancylidæ

Subfamily Ferrissiinæ Walker, 1917

GENUS FERRISSIA Walker, 1903

Subgenus Lævapex Walker, 1903

58. *F. kirklandi* Walker—Salt Fork, Crystal Lake, and Urbana, Champaign Co. Found in great abundance on stems and the under sides of leaves of water lilies. The water of the lake was ponded since the dredging of the Salt Fork; this limpet was not found prior to the ponding of the waters of this lake. *F. tardus* was the only form found prior to this, but after the dredging of the Salt Fork, *tardus* disappeared completely and was replaced by *kirklandi. Gundlachia meekiana,* present in the lake before its waters became ponded, also disappeared.

(Subgenus Ferrissia Walker, 1903)

59. *F. rivularis* Say—White Heath, Piatt Co., Salt Fork, Urbana, Champaign Co., on sticks and plants. At White Heath, Piatt Co., Salt Fork, Urbana, Champaign Co., on sticks and plants. At White Heath it was found in a small stream near the Sangamon River, attached to rocks where the current was the strongest. In the Salt Fork also, it sought places of swift current.

60. *F. shicki* Pilsbry—Salt Fork, Urbana, Champaign Co. In the collections of the Ill. State Lab. Nat. Hist. Special attention was paid to the Ancylidæ to rediscover *shimeki,* but none were located.

61. *F. tardus* Say—Sangamon River at White Heath, Piatt Co., on stones and empty *Anodonta* valves, usually among rich algal growth, preferring quiet, shallow water. It was found at Urbana, Crystal Lake, and in the Salt Fork. See remarks under *kirklandi.* Mr. Charles A. Hart collected it at Muncie, on rocks in Stony Creek.

GENUS GUNDLACHIA Pfeiffer, 1850

Subgenus Kincaidella Hannibal, 1912

62. *G. meekiana* Stimpson—Crystal Lake, Urbana, abundant on floating sticks; April. After the Salt Fork was dredged and the waters of Crystal Lake became ponded, this interesting limpet disappeared.

Family Lymnæidæ

Subfamily Lymnæinæ

GENUS LYMNÆA Lamarck, 1799

Subgenus Pseudogalba Baker, 1913

63. *L. humilis* Say var. *modicella* (Say)—White Heath, Piatt Co., Crystal Lake, Champaign Co., Muncie, Vermilion Co. Very abundant, on sticks and woods, on muddy bottoms, etc., stones, of slow moving streams or ponds. It prefers the marginal zone, often entirely out of the water on damp, or moist mud banks; sometimes quite distant from water. At the Brownfield Woods it was present in the intermittant stream, a stream which was usually dry. This Lymnaea endure much dessication. It is associated mostly with *L. parva* and *Physa gyrina.*

64. *L. obrussa* (Say)—Urbana, Salt Fork, Crystal Lake, Champaign Co. In ponded waters, among leaves; also in small streams with sluggish current, upon sticks, leaves, stones, etc. It also can endure considerable dessication.

65. *L. parva* (Lea)—Salt Fork, Crystal Lake, Champaign Co., associated with *L. humilis modicella* and of more or less the same general habits. Not very common.

(Subgenus Galba Shranck, 1803)

66. *L. caperata* (Say)—Urbana and Cottonwood Woods, Champaign Co., Muncie, Vermilion Co. Usually in temporary bodies of water, ponds, bayous and slowly moving streams, preferring the outer zone where it lies among the vegetation and debris associated with *Aplexa hypnorum, Physa gyrina* and *Sphaerium occidentale*. Endures much dessication.

67. *L. palustris* (Muller)—Urbana, Champaign Co., collections of the Ill. State Lab. Nat. Hist. Young specimens were collected by me in 1910 in a creek feeding into the Salt Fork near a slaughter house at St. Joseph. The surfaces of these were much malleated.

Subfamily Planorbinæ

GENUS PLANORBIS Muller, 1774

Subgenus Hipeutis Agassiz in Charpentier, 1837

68. *P. exacuous* Say—Crystal Lake, Urbana, Champaign Co. Similar in habits and habitat as *P. parvus,* associated with it. Sometimes it is found on lily pads.

(Subgenus Gyraulus Agassiz [in Charpentier,] 1837)

69. *P. deflectus* Say—Crystal Lake, Urbana, Champaign Co. On sticks, stones, and plants in quiet waters, usually in deeper water than that preferred by *parvus.*

70. *P. parvus* (Say)—Monticello, Piatt Co., Crystal Lake, Urbana, and Salt Fork, Champaign Co. On stems of submerged plants and on objects in the water. Often in tangled masses of *Spirogyra* and other algae. Very abundant, often associated with *P. exacuous.*

(Subgenus Helisoma Swainson, 1840)

(Section Pierosoma Dall, 1905)

71. *P. trivolvis* (Say)—White Heath and Monticello, Crystal Lake, Urbana, Salt Fork, St. Joseph, and Homer Park, Muncie, Hillery and Danville. Very abundant, crawling along muddy bottoms of streams, ponds, etc., on sticks, stones, aquatic plants, etc. Gregarious. Associated usually with *Physa* and *Lymnaea.*

GENUS SEGMENTINA Fleming, 1817

72. *S. armigera* Say—Monticello, Piatt Co., Cottonwood Woods, Crystal Lake and Urbana, Champaign Co., Muncie,

Vermilion Co. In small streams and ponded waters, in hoof prints of cattle, marshy areas, etc., on aquatic vegetation, debris of all sorts, crawling on muddy bottoms, etc. Endures much dessication. Associated usually with other Planorbinæ.

Superfamily Akteophila

Family Auriculidæ

GENUS CARYCHIUM Muller, 1774

73. *C. exile* H. C. Lea—White Heath, Piatt Co., Brownfield Woods, Champaign Co., Hillery, Vermilion Co. Almost amphibious; very abundant in wet places under logs and pieces of wood, in wet moss, and quite often in standing water under logs. At Hillery it is the dominant mollusk of the swampy lowlands. Gregarious; on one occasion over a hundred specimens were taken from a log two feet long and about a foot in diameter. Its movements are slow and erratic, the long shell seemingly too heavy for the animal; it is carried at an angle of about 55°. This species usually occurs alone, but at times the following snails are its companions: *Gastrocopta contracta* and *tappaniana, Agriolomax campestris, Vitrea hammonis* and *indentata,* and *Zonitoides arboreus.* Of these, the most common companion is *G. Contracta.* In very wet places it is associated with the smaller species of *Lymnaea.* No specimens of *C. exiguum* were found, although Baker ('02, p. 256) states the two species are almost always found together. Almost a thousand specimen of *Carychium* were examined.

Suborder Stylommatophora

Monotremata

Vasopulmonata

Orthurethra

Family Valloniidæ

GENUS VALLONIA Risso, 1826

74. *V. pulchella* Muller Monticello, Piatt Co., Urbana, Champaign Co., Danville, Vermilion Co. This is a species of the open prairie, and is plentiful under logs in open lots. I have never found it in the deep woods. No other species of *Vallonia* was found although a very careful search was made.

Family Pupidae

GENUS STROBILOPS Pilsbry, 1892

75. *S. affinis* Pilsbry—In back yard of Mr. C. A. Hart's home at 923 W. Green St., Urbana. Under logs that laid there undisturbed for many years. Not abundant with *Gastrocopta contracta.*

76. *S. labyrinthica* (Say)—Brownfield Woods only. Not common. It was found near the outer border of the woodland, in open spots as a rule. Under loose bark of logs, in half decayed wood, under logs, among dead leaves and in the sod at base of trees; usually associated with *Gastrocopta contracta, Zonitoides arboreus, Vitrea indentata* and *Euconulus chersinus.* Its movements are slow and deliberate. The shell is carried flat, occasionally wabbling from side to side.

GENUS PUPOIDES Pfeiffer, 1854

77. *P. marginatus* (Say)—Near the Cottonwood Woods, Champaign Co., and at Oakwood, Vermilion Co. This is a species of the open prairie, occurring under logs and railroad ties. It is seldom found in woods.

GENUS GASTROCOPTA Wollaston, 1878

78. *G. armifera* (Say)—Urbana and Mount Hope Cemetery, Champaign Co., Muncie, Vermilion Co. This species prefers the dry upland and open associations, living as a rule under logs, stones and other objects. Not found as yet in the deep forest.

79. *G. armifera* Say var. *affinis* Sterki—Monticello, Piatt Co., under a log in a wet lowland association. This subspecies appears to be adapted to more hygrophytic habitats than is *armifera* s. s.

80. *G. contracta* (Say)—At all localities in the three counties. This is the commonest member of the *Pupidae,* and next to *Zonitoides arboreus,* perhaps the commonest snail. It prefers the mesophytic forest, living there under a great variety of situations, and from this optimum, it runs into both upland and lowland types, being able to withstand more the hydrophytic than the mesophytic extremes. It commonly lives under bark and in the interstices of bark, under logs, etc. On one occasion fifteen specimens were collected from a square meter

of clear forest floor. It also lives in crumbly soil. It is associated with a host of other snails, particularly the following: *Helicodiscus parallelus, Zonitoides arboreus, Gastrocopta tappaniana, G. holzineri, Strobilops labyrinthica, Pyramidula perspectiva* and *alternata, Zonitoides nitidus, Z. minusculus, Vitrea indentata* and *hammonis, Paravitrea significans, Euconulus chersinus* and *Sphyradium edentulum.* All, or most of these, are species that inhabit the moist areas under logs, or under bark. In Mr. Hart's back yard, *contracta* was associated with *G. armifera, Vallonia pulchella, Euconulus trochiformis* and *Strobilops affinis.* The movements of *contracta* are slow and precise, the shell being carried erect, though appearing cumbersome for the animal.

81. *G. holzigeri* (Sterki)—Brownfield Woods, Champaign Co. Found only on one occasion, under a log, associated with *G. contracta and Helicodiscus parallelus.* It prefers exposed hillsides.

82. *G. pentodon* (Say)—Brownfield Woods, Champaign Co., Muncie, Vermilion Co., very rare.

83. *G. tappaniana* (C. B. Adams)—Monticello, Piatt Co., Brownfield Woods, and University Forest, Champaign Co., Hillery, Vermilion Co. This species is rare in the Brownfield Woods,occurring only in moist places, such as under logs, pieces of bark and dead leaves, stones, and rubbish of all sorts, or on twigs or at base of trees. At Hillery I found it under pieces of bark in the river bottoms, associated with *contracta* and *Carychium exile.* The shell is carried almost flat. The animal moves about very sluggishly.

GENUS VERITGO Muller, 1774

Subgenus Vertigo s. s.

84. *V. ovata* Say—Monticello, Piatt Co., low moist places, under leaves, stones, sticks, etc.

85. *V. tridentata* Wolf—Brownfield and Cottonwood Woods, rare. Under loose bark of fallen trees, associated with *Gastrocopta contracta* and *Sphyradium edentulum.* According to Binney, this is one of the more aquatic species. Shimek records it on rather exposed, rocky, moss-covered banks.

Subgenus Angustula Sterki

86. *V. milium* (Gould)—Monticello, Piatt Co. Under a log in a wet lowland association, with *Gastrocopta armifera* var. *affinis*. Rare.

Heterurethra

Superfamily Elasmognatha

Family Succineidæ

GENUS SUCCINEA Draparnaud, 1801

87. *S. avara* Say—Monticello, Piatt Co., Brownfield and Cottonwood Woods, Champaign Co. Not common. Usually found in a wet lowland association, attached to stones, leaves, stems and trunks of trees.

Sigmurethra

Superfamily Holopoda

Family Helicidae

GENUS POLYGYRA (Say, 1818) Pilsbry

Subgenus Triodopsis Rafinesque, 1819

88. *P. albolabris* (Say)—Hillery, Vermilion Co. It occurs plentifully among the leaves and under logs in the ravines of the moist woods. Usually associated with *fraudulenta, elevata* and *zaleta*. Forest fires almost wiped out this species and others of the genus from this area.

89. *P. clausa* (Say)—Danville, Vermilion Co., in moist woods, under a log; not common.

90. *P. elevata* (Say)—Brownfield Woods, Champaign Co., Muncie and Hillery, Vermilion Co. At Hillery, this species is very common on the wooded clay hillsides, and among the accumulations of leaves and debris in the ravines. Associated with *albolabris, thyroides, fraudulenta* and *zaleta*.

91. *P. fraudulenta* Pilsbry—Hillery, Vermilion Co., not very common. In the ravines, also in an outcrop of loess. Prefers a moist situation under fallen leaves or bark of logs. Usually associated with other of the larger gelices.

92. *P. mitchelliana* (Lea)—Hillery, Vermilion Co., among leaves on moist ground in the ravines. Rare.

93. *P. pennsylvanica* Green—White Heath, Piatt Co., Brownfield Woods, Champaign Co., Muncie and Hillery, Ver-

milion Co. The White Heath specimens are very dark, almost brick red in color. This species is usually found at the base of tree trunks and about logs, and among fallen leaves. A few times, in November, I noticed them in small cavities in the surface of the soil. It is usually associated with *Zonitoides arboreus, Pyramidula alternata* and *Polygyra thyroides*. *Circinaria concava* is often present as an intruder, as is evident from the number of empty shells of this *Polygyra*.

This *Polygyra* is very shy in nature, its movements slow, and as a rule very careful. The shell is carried back of the center of the animal and lies almost flat. The least disturbance causes the animal to retreat into its shell. Upon coming out again, it apparently uses much caution. Shrews eat this *Polygyra* quite often. In the burrow of one shrew, under a log, 93 empty shells of *pennsylvanica* were found. Of these, 42 (or 48%) had the spires broken by the shrew. It would appear that due to the extreme shyness of this snail, the shrew is obliged to break the shells in order to get at the animal. In this same place were 154 empty shells of *P. thyroides* of which only 23 or 16% had the spires broken. The habits of *thyroides* will be discussed in their proper place, suffice it to say here that this snail is bolder, and hence the shrew gets its choice meal with a minimum expenditure of effort.

94. *P. thyroides* (Say)—White Heath, Piatt Co., Brownfield and Cottonwood Woods, Champaign Co., Muncie and Hillery, Vermilion Co. About half of the specimens found were dentate. This species is our commonest of the larger helices, and is typical of the mesophytic woods. It endures conditions entering into the xerophytic and hydrophytic associations, but is able to get along much better in the wet than in the dry. Dryness causes it to aestivate. In the Cottonwood Woods it was very abundant. This woods is damper than the Brownfield. I found that in woods that were dry, though not exactly xerophytic, that there was a tendency among the *thyroides* to approach the subspecies *bucculenta*. While typically a ground species, *thyroides* has been found to ascend tress, having been found as much as ten feet from the ground. In this respect it resembles *Pyramidula alternata*.

In habits this species is very bold, and even when handled quite roughly, it does not withdraw into its shell. A small percentage, however, seem to be more cautious. This snail is a voracious feeder; its excrement is dark in color, often olive green, its form long and slender, spirally coiled. During Spring i. e., as they emerge from hibernation, the "basking" habit is well marked. The common short-tailed shrew, *Blarina brevicauda* Say, preys largely upon this snail. During Winter the shrews leave the barren corn fields and burrow into the woods. Here their burrows open under logs; the Polygras hibernate under logs, often in burrows of shrews. In fact it would appear as if *Blarina* prepares a suitable retreat for these snails in order that later, when snow covers the ground, its feast may be a certainty. In the notes under *pennsylvanica* reference was made to 154 empty shells of *thyroides* in a shrew's nest, and that of these, only 23 had the spires broken. The reason for this is that this snail is not timid and hence the shrew does not have to break the shell to get at the animal. The few broken shells probably indicate individuals that were somewhat cautious, or, due to considerable handling by the shrew, some of these snails retreated into their shells.

Shull ('07, P. 495) has shown that shrews move the snails near the ground surface as the temperature falls, and move them further into the burrows when the temperature rises. Dead shells were never transported. The basis for distinguishing between live and dead snails must be odor. Another serious enemy of *thyroides* is *Circinaria concava*.

95. *P. zaleta* (Binney)—Brownfield Woods, Champaign Co. (one young shell), Hillery, Vermilion Co. At the last place this species has its optimum habitat requirements, living in the damp, wooded ravine slopes, among dead leaves, twigs, debris, and in the loose crumbly earth and humus. It wants shade. Its companions are usually *albolabris elevata*, and *fraudulenta*. It is not a timid species.

(Subgenus Stenotrema Rafinesque, 1819)

96. *P. fraterna* (Say)—Hillery, Vermilion Co., in shaded, moist situations, under bark, leaves and logs. Usually with *thyroides*.

97. *P. hirsuta* (Say)—White Heath, Piatt Co., Brownfield and Cottonwood Woods, Urbana, Champaign Co., Muncie and Hillery, Vermilion Co. A rather common species, living in damp situations, such as under debris or bark of fallen logs, or under loose bark of standing dead trees. Adults from the Brownfield Woods vary greatly in size. The following snails are associated with it: *Gastrocopta contracta, Zonitoides arboreus, Vitrea indentata, V. hammonis, Polygyra thyroides, Pyramidula alternata* and *P. perspectiva.* The animal is very active. The young are more gregarious than the adults. I found this snail frequently among the gills of fleshy fungi, and among mycelium.

98. *P. monodon* (Rackett)—Muncie and Hillery, Vermilion Co. Its habitat is similar to that of *hirsuta,* excepting that it prefers drier situations. Usually it is found under stones. In one instance I found it in the open prairie, under a boulder. It associated with *Vitrea hammonis, Zonitoides arboreus* and *Pyramidula perspectiva.* The open prairie form is smaller than those from damp ravines.

Superfamily Agnathomorpha

Family Circinariidæ

GENUS CIRCINARIA (Beck, 1837) Pilsbry

99. *C. concava* (Say)—White Heath, Monticello, Brownfield Woods, Cottonwood Woods, St. Joseph, Homer Park, Muncie, Hillery and Danville. A fairly common species, found in almost all kinds of situations. At times it was found under four to eight inches of soil. It probably is also subterranean in habits. I have found it at night crawling boldly over logs in search of prey. It seems to prefer cool, damp woods, and at Hillery was rather abundant under debris on the banks of the Middle Fork of the Vermilion River. The species is more or less solitary in habits, though at times two and three may be found together; usually one or two of these disappear mysteriously. Ordinarilly *concava* is timid, but when in quest of food it knows neither fear nor delay, and its appetite is always voracious. The lair of *Circinaria* is decorated with the empty shells of its victims, in the main part species among which it had associated. These usually are our several species of *Polygyra, Vitrea ndentata, i Paravitrea significans, vonitoides*

arboreus and *Philimycus carolinensis.* It seems to have respect for the slimy mucus of *Philomycus,* but the stiff hairs on the shell of *Polygyra hirsuta* do not seem to worry it. It is nocturnal in habits.

Superfamily Aulacopoda

Family Zonitidæ

Subfamily Zonitidæ

GENUS VITREA Fitzinger, 1853

100. *V. hammonis* Strom—Monticello and White Heath, Piatt Co., Brownfield and Cottonwood Woods, Urbana, St. Joseph, Champaign Co., Muncie and Hillery, Vermilion Co. This species prefers a moist situation. It is gregarious, occurring in great numbers in crevices of the bark of decaying trees, logs and in debris. It is usually associated with *Euconulus trochiformis, Gastrocopta contracta, Zonitoides nitidus* and *Carychium exile.*

101. *V. indentata* (Say)—Monticello and White Heath, Piatt Co., Brownfield and Cottonwood, Urbana, St. Joseph and Homer, Champaign Co., Muncie and Hillery, Vermilion Co. Very abundant, gregarious, almost as abundant as *Z. arboreus,* occurring in almost as many diverse habitats. It was collected in the interior of very soft and wet logs, in small cavities in the pileus of a fleshy fungus *(Russula emetica* Fr.*)* in the interstices of bark, under logs, in crumbly soil under logs, in leaf mould, under loose bark of standing dead trees, in moss, under fallen twigs, under stones, in both high and low places, at times in situations that were quite dry. It was found almost always with *Z. arboreus* and *nitidus,* but frequently with the following species also: *Polygyra hirsuta, thyroides, monodon, fraterna,* and *fraudulenta, Helicodiscus parallelus, Pyramidula alternata, P. perspectiva, Vitrea hammonis, Paravitrea significans, Euconulus chersinus, Philomycus carolinensis, Strobilops labyrinthica, Gastrocopta contracta* and *Agriolimax campestris.*

In bringing to the laboratory Pupidæ, Zonitidæ and other of the smaller snails, it was quite an easy matter to separate *indentata.* All that was necessary was to slightly moisten the entire mass and then just pick up the snails that were crawling away. These were *indentata,*—it is not a shy species, in fact is perhaps our boldest and most active one. It carries its shell at an angle of 45° but the rapid movements of the animal in crawling causes the shell to wabble from side to side. It is a voracious feeder. The eggs are tiny, 1.2 mm. by 0.99 mm. They are laid during April, and the young hatch in 21 days.

GENUS PARAVITREA Pilsbry, 1898

102. *P. significans* (Bland)—Brownfield and Cottonwood Woods, Champaign Co. Not common. This is the first record of this species in Illinois, and its range is thus extended about three hundred miles northward. Dr. Bryant Walker made the identification. Fourteen specimens were collected in three years, of these nine came from the Brownfield Woods. It occurs under logs, large limbs, etc., usually in the crumbly soil. In fact nearly all my material came from such soil. Moist, cool situations are preferred, and in the Brownfield Woods it was found only in the deepest ravines, and on the north slopes of these. In the Cottonwood Woods it was taken in the lowest portions, where the moisture was greatest. It appears to be subterranean in habits. It was collected with *V. indentata, Z. arboreus, Circinaria concava* (which feeds on it) and *Pyramidula alternata*. It is a very shy species. Its movements are slow and careful. The shell is carried at an angle of about 30° from the horizontal.

GENUS EUCONULUS Kobelt

103. *E. chersinus* (Say)—Brownfield Woods, Champaign Co. Not common. Under damp logs, in the interstices of bark, on fallen leaves, twigs, etc., and once under stones. It does not seem to prefer the very moist situations, and is usually associated with *Gastrocopta contracta, Paravitrea significans, Strobilops labyrinthica, Vitrea indentata, Zonitoides arboreus, Pyramidula alternata, Helicodiscus parallelus* and *Sphyradium edentulum*. The animal is very shy.

104. *E. trochiformis* (Montfort)—In Mr. Hart's back yard, Urbana, under a log; not very common.

Subfamily Ariophantinae

GENUS ZONITOIDES Lehman, 1862

105. *Z. arboreus* (Say)—White Heath, Monticello, Brownfield and Cottonwood Woods, Urbana, St. Joseph, Homer, Homer Park, Muncie, Oakwood, Hillery and Danville; almost

everywhere and in all sorts of situations; perhaps the commonest snail. It prefers damp places, especially under boards, logs, interstices of bark, fallen twigs, under stones, in leaf mould, and in crumbly soil. In Winter individuals are found all huddled together in deep crevices and in the burrows of insects. This species is associated with nearly all the mollusks found in the Augerville Woods, including those of the hygrophytic plant association.

Gregarious, very active, very voracious. The shell is carried at an angle of 45°, the head and neck stretched out far. The eye peduncles are always thrust out nervously, as if in search of danger. It is relatively easy to separate *arboreus* from *nitidus* and *hammonis* by the manner in which the shell is carried. In addition to this, the animal of *nitidus* is decidedly blacker. In *hammonis* the last whorl is much wider than in the other species.

106. *Z. minusculus* (Binney)—Monticello, Piatt Co., Brownfield and Cottonwood Woods, Urbana, Champaign Co., Muncie, Vermilion Co. Not common. Found in the woods among decayed logs, in humus and old leaves, under bark, etc. It prefers damp and cool habitats, but at times is to be found in moist prairie situations, under boulders. This species is probably subterranean in habits.

107. *Z. nitidus* (Muller)—Monticello, Piatt Co., Brownfield and Cottonwood Woods, Urbana, Champaign Co., Muncie and Hillery, Vermilion Co. This species is commonly gregarious under logs and loose bark. It prefers damp situations and so far has been found in this region only along the shaded ravines. It often congregates in the interstices of the bark. Associated with *arboreus, indentata, hammonis, Agriolimax campestris* and *Gastrocopta contracta.*

GENUS GASTRODONTA Albers, 1850

108. *G. intertexta* (Binney)—Reported by Mr. Wm. A. Marsh from Vermilion Co.

109. *G. ligera* (Say)—Reported by Mr. Wm. A. Marsh from Vermilion Co.

Family Limacidæ

GENUS AGRIOLIMAX Morch, 1868

110. *A. campestris* (Binney)—White Heath, Monticello, Brownfield and Cottonwood Woods, Urbana, St. Joseph, Homer, Homer Park, Muncie, Oakwood, Hillery and Danville. Another of our very abundant mollusks. It is found everywhere, in forest and open, on streets and walks, under debris of all kinds, under logs, bark, stones, leaves, etc., preferring cool, moist habitats as a rule, and associating with nearly all the terrestrial molluks, in particular with the Zonitidæ. In hydrophytic associations it is found with Lymnæidæ and Physidæ, sometimes in places that are extremely wet.

The average duration of the egg stage, as determined in the laboratory, was 13 days 7 hours. The eggs are spherical, 1.5 mm. to 2-5 mm. in diameter. Sometimes unusually large and elliptical eggs occur among them. The young slugs measure 3 mm. upon hatching.

Family Philomycidæ

GENUS PHILOMYCUS (Rafinesque, 1820) Ferussac

111. *P. carolinensis* (Bosc)—White Heath, Piatt Co., Brownfield Woods, Cottonwood Woods, Urbana, St. Joseph, Homer, Homer Park, Champaign Co., Muncie, Oakwood, Hillery and Danville, Vermilion Co. This is the commonest slug occurring under bark. It frequents "starting" bark of fallen or standing dead trees, sometimes in the interior of decayed trunks. With *Pyramidula alternata* it is the first invader under bark, thus favoring rapid disintegration of the wood. This slug is more or less solitary, but under the bark of a large log as many as a dozen specimens will be found scattered about.

The eggs resemble drops of whitish gelantine with their centers much whiter. They measure 4 mm. by 3.2 mm. When deposited they are practically spherical, but within a few hours they change to elliptical. The egg stage is approximately seventeen days.

This slug has frequently been found completely covered with the excrement of the larvæ of *Scolecocampa liburna,* a lepidopter that riddles dead, soft wood. In such cases the bark still covers the log, although it is completely loosened. This slug lives among certain ants *(Camponotus heruculaneus* L.*),* among salamanders *(Plethodon erythronotus)*, coleopterous larvæ (especially of *Pyrochoa flabellata*), diplopods, chilopods, etc. The ease and thoroughness with which this slug covers itself with thick mucus is, no doubt, a very successful protection against being devoured by other animals. Even *Circinaria* respects this slime.

Family Endodontidæ
Subfamily Endodontinæ

GENUS PYRAMIDULA Fitzinger, 1833
Subgenus Patula Held, 1837

112. *P. alternata* Say—At all localities in all three counties. Gregarious; fairly abundant. It seeks moist habitats, usually under starting bark, where, with the preceding species, it is the first invader. Under stones, leaves, debris, in humus, etc. It associates usually with Zonitidæ and Pupidæ. Considerable variation in the height of the spire was noted.

Specimens collected in very humid regions died if placed in cages that were not kept moist, but specimens collected in dry habitats, did well in the laboratory. If the cages were kept moist, these individuals also did well. This species is inclined to be quite bold, but when it must retreat into the coils of its shell, it secretes an abundance of red, frothy mucus which completely fills the aperture. This has saved many an individual from the carnivorous snail, but the short-tailed shrew, *Blarina brevicauda,* simply breaks the top of the spire and thus reaches its victim. On rainy days *P. alternata* climbs to a height of ten feet or more. Its eggs are white, opaque, agglutinated and almost spherical. They measure on the average 2.25 mm. in diameter, and the entire egg stage lasts about thirty days.

113. *P. solitaria* Say—Brownfield Woods, Champaign Co., and Muncie, Hillery, Vermilion Co. Only one specimen was found in the Brownfield Woods; it was juvenile, and was found buried in six inches of soil. At Muncie, six specimens were found in four inches of soil, under a log. Dead individuals were quite plentiful at Hillery. This species associates, as a rule, with *alternata*.

Subgenus Gonyodiscus Fitzinger, 1833

114. *P. perspectiva* Say—Brownfield and Cottonwood Wood, Champaign Co., Hillery and Oakwood, Vermilion Co. In the

Brownfield and Cottonwood Woods the species was abundant, usually two individuals found together. This is probably the northernmost range of this species; it is very abundant in Tennessee and Alabama. It seems to prefer a much drier habitat than the other Pyramidulas. It was also found under bark of standing trees. On one occasion it was collected under a boulder in the glacial drift near Hillery. At this same town, a dozen specimens were found under the bark of a single log. It associates with other Pyramidulas, and with the Polygyrinæ and Zonitidæ.

GENUS HELICODISCUS Morse, 1864

115. *H. parallelus* Say—At all localities in the three counties. It is plentiful in places, usually found in the crevices of the bark, under logs, in loose, crumbly soil, etc., preferring cool situations either moist or wet. It is very rare in the dry, open areas. It associates with the majority of the smaller forms. It appears to be subterranean in habits. The animal is very shy, its movements very slow. The shell is carried almost flat. In eating it nibbles at the surface of leaves, resembling in this respect the work of certain leaf skeletonizers of the insect realm.

Subfamily Punctinæ

GENUS SPHYRADIUM Charpentier

116. *S. edentulum* Draparnaud—Brownfield Woods, rare; only three specimens were found in three and one-half years. These were under logs of moderate size, and in the interstices of bark, associated with *Gastrocopta contracta*.

LITERATURE CITED

Baker, Dr. Frank C. The Mollusca of the Chicago Area, Pt..

1898 1, Pelecypoda. Bulletin III, Nat. Hist. Surv., The Chicago Academy of Sciences.

1902 The Mollusca of the Chicago Area, Pt. 2, Gastropoda. Bulletin III, Nat. Hist. Surv., The Chicago Acad. Sci.

1906 A Catalog of the Mollusca of Illinois. Bulletin III, State Lab. Nat. Hist., vol. VII, Art. VI.

1911 A Monograph of the Lymnæidæ. Special Bulletin, The Chicago Academy of Sciences.

1912 Recent Additions to the Catalog of Illinois Mollusks. Trans. Ill. Acad. Sci., vol. V, p. 143.

SHULL, DR. A. H. Habits of the Short-tailed Shrew, *Blarina*
1907 *brevicauda*. The American Naturalist, vol. XLI, pp. 495-522.

WOOD, PROF. FRANK E. A Study of Mammals of Champaign
1910 Co., Illinois. Bulletin Ill. State Lab. Nat. Hist. vol. VIII, pp. 501-613.

SOME BIRD CHARACTERISTICS

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THE SHRIKE

This bird is variously known as the Butcher Bird, English Jay, Mouse Hawk, Winter Butcher and Summer Butcher.

It is one of the strangest of all our birds. Naturalists were long undecided where to place it, whether as an accipitrine or a Pica. That is, was he a hawk or a crow? He had the characteristics of both and lacked some of the essential features of both. For instance, he had all the courage, the fierceness and boldness of the hawks, but he had the feet of the magpie and the jay.

The upper mandible was notched and hooked like the hawks, but he had no grasping talons. He was a blood-thirsty killer like the hawks, but like the crows, jays and magpies, who secrete their food, he impales his prey on a thorn, barbed-wire fence, or hangs it by the head in a crotch or fork of a tree.

Then again he looks much like the southern mockingbird, builds a nest like one and in the same localities. Also he is an imitator; uses the notes of other birds as the mockingbird does, but does this to lure birds to his vicinity, that he may catch and kill them. So where did he belong?

Some ornithologists of the old world still insists that as he is a bird of prey, he should be classed with the raptores or hawks and owls. Then there was another trouble, he also looked much like the kingbirds and other flycatchers and like the king-bird he would fight bravely and put to flight the biggest eagle, hawk or crow that came within his territory or menaced his baby birds that he was conducting about the fences and hedges, and so the merry war went on.

Finally it was decided that he did not properly belong any of these families and it was decided to give him a place to himself, the Larridae and a cousinship to the Vireos and Waxwings and there he will stay.

There are seven species of this bird in North America, over 100 in the world, two only to be found in Illinois and central states; these are the Winter or Northern Shrike and the Summer or Migrant Shrike.

These two species look very much alike except that the winter one is a little larger and with less black on back and wings. They are about as large as the Robin Redbreast. They are never very numerous, but in a winter drive of eight or ten miles, I often see one perched on a telephone wire facing the north and apparently oblivious of the coldest weather.

They sometimes come into the towns in pursuit of the House-sparrow, which, when they capture, they scalp, tear the skull open, feed on the brains and then hang the body up on a thorn or by the head in the forks of a limb.

If their killing propensities were confined to this sparrow alone, we might wish their shadows would never grow less. It has been thought the impaling process of birds, mice, grasshoppers, etc., is done for the purpose of afterwards coming back for another feast, but repeated observations have never shown them doing this. It is a cruel, strange trait that is inexplainable.

The shrike is an early nester, often in early March. The winter variety leaves early for the far north, and its place is taken by the summer species which nests with us. No attempt is made for concealment. A lone osage, orange or crab-apple tree by the side of the road where every passerby can see it, is a favorite location.

The nest on the outside is a rough looking affair, composed of many sticks and thorns, but lined with fine grasses and the softiest downiest feathers that can be found. Eggs almost invariably six, grayish white and spotted with various shades of brown.

Later in the season, when the young have left the nest, it is a most interesting sight to see the parent birds with the six little chuckle-headed young ones lined up on a barbed-wire fence teaching them to catch grasshoppers. They are quite fearless when nesting, and I have had my hand severly pinched by the mother bird for daring to put it in her nest.

One winter time while driving along the road over in the Spoon-river country, a young farmer who was getting out his shock corn, called to me to "come over and see this mouse-hawk catch mice." I needed no second invitation, and going over watched the proceedings. The farmer would tear down a shock and a mouse would scamper from it across the snow to take refuge in another shock. The shrike that was perched in the top of a small tree, a full hundred yards away, would come as straight as a bullet, catch the mouse, beat it on the hard snow, toss it up in the air, catch it in a new place and hammer it some more, and then fly away with it across the river which was near by.

In a few minutes it would be back again, ready to repeat the performance. After seeing it kill two or three mice, I determined to take a hand, and when the next mouse raced across the snow, I gave chase to it, but the shrike was right on hand and not to be daunted by my presence. It was nip and tuck between the two of us, which would get the mouse but tuck won, flying right between my feet, catching up the rodent and after the pounding process, flew with it across the river where it had carried the others.

I now resolved as the stream was well frozen over, to cross and see what was being done with all these mice. A little way back from the bank, in the thick woods, I found a honey-locust tree with more than a dozen mice impaled on its sharp thorns. All seemed to be intact and the thorn in nearly all seemed to be through the throat.

It will sometimes make a dash at a caged bird hung in a window and lose its life.

A bold, fearless, cruel, rapacious bird, but on account of the great number of mice, grasshoppers, beetles, etc., which it destroys, believed to do much more good than harm and should not be wantonly destroyed.

THE PROTHONOTARY WARBLER.

This beautiful little bird is often called the Golden Swamp Warbler. Its mission seems to be to add a bit of cheer and color to the dark swamps and desolate places of the rivers and lakes. It is a deep orange-yellow except the wings and tail, which are a slaty blue. The female is not so intensely colored. The notes are a clear ringing tweet, weet, weet, out of all proportion to the size of the bird.

They will not be found in the parks or towns or wooded hills. They frequent no localities except rivers and lakes and swamps of willows and buttonwoods and borders of pools, only rarely do they nest over the water of a running stream. They associate with the tree swallows, grackles and red-wing blackbirds nesting in the same localities. Sometimes a grackle or a Jennie Wren will be found in the same tree, the Grackles occupying an open cavity higher up, while the warbler will choose one down nearer the water.

The male is extremely jealous of intrusion by others of his own tribe, upon his immediate premises he will scrap valorously if one of them comes near his chosen domicile, though he does not seem to object to the presence of other birds.

The Thompson Lake country on the Illinois river is headquarters for these strange warblers, strange because they stand almost alone in their habit of nesting in the holes of old stumps, snags and dead trees, almost always just a few feet above the water which sometimes rises and destroys their nests. They are queer too, because of the material used in constructing their nests, which, when it can be obtained is made almost exclusively from green moss that grows around the base of willow trees standing in the water or mud. If a high stage of water covers up this material, they will use instead, fine blades of grasses. However when the moss can be found, nothing else is used.

The cavity selected is most times one made by the downy woodpecker or chickadee, but sometimes cavities in live trees are used, mortices and knot holes in bridge piling and railroad trestles are used. The highest nest I have ever observed in many years observation, was one about twelve feet up in a little pecan tree, but rarely are they over six feet above water. The hole selected in the tree is packed full of the moss to within five or six inches of the opening, and then a cup-like depression is hollowed out to hold the eggs. The usual set of eggs is six, though sometimes only five. In my time I have seen three nests containing seven eggs.

The eggs are the most beautiful of all the bird families, almost round, smooth and glassy, creamy white, thickly spotted all over with reddish brown spots. They are hardly colony nesters as are the red-winged blackbirds and some others, but are restricted in their habitat and around Thompson, Mud-Grass, and the other lakes of this region, a pair will be found nesting every hundred yards or so if suitable conditions can be found.

On account of their frequenting old willows, dead snags, thunder-brush, etc., they are peculiarly the prey of the bird loving snakes, such as the Bull, King, Black Racer and Ring snakes, all of whom love a dinner of bird eggs or young birds.

The writer has often while pushing his boat around under the low growing willows and old snags and rapping on their hollow trunks had these reptiles come rushing out of a hole, fall into the boat and go scampering over feet and legs into the water. An investigation would usually result in finding a Prothonotaries nest with contents destroyed except sometimes a lone egg or young bird. Occasionally they do not vacate so readily, especially the bull snake, who will hang stubbornly to his possession and fight to the last, or till the stub is torn to pieces when he will reluctantly take to the water.

North of the latitude of Chicago these beautiful warblers become scarce, though to the south they breed sparingly clear to the gulf and winter in Central America.

Their food habits are entirely insectivious and worm eating, and doing no harm but much good.

CONSTITUTION AND BY-LAWS

Illinois 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 *Active Members, Non-resident Members, and Life Members.*

Active Members shall be persons who are interested in scientific work and are residents of the State of Illinois. Each active member shall pay an initiation fee of one dollar and an annual assessment of one dollar.
Non-resident Members shall be persons who have been members of the Academy but have removed from the State. Their duties and privilges shall be the same as those of active members except that they may not hold office.

Life Members shall be active or non-resident members who have paid fees to the amount of twenty dollars. They shall be free from further annual dues.

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.

All workers in science present at the organization meeting who sign the constitution, upon payment of their initiation fee and their annual dues for 1908, become charter members.

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.

The Board of State Museum Advisers, created under the provisions of the Civil Administraive Code of Illinois shall be consulted by the officers of the Academy in all matters which concern the general policy of the Academy in its relations to the Division of State Museum.

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 Librarian, 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. Publication

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 be ordered by a three-fourths vote of the members present at any regular meeting.

Article X. Amendments

This constitution may be amended by a three-fourths vote of the membership present at an annual meeting, provided that notice of the desired change has been sent by the Secretary to all members at least twenty days before such meeting.

BY-LAWS

I. The following shall be the regular order of business:

1. Call to order.
2. Reports of officers.
3. Reports of standing committees.
4. Election of members.
5. Reports of special committees.
6. Appointment of special committees.
7. Unfinished business.
8. New business.
9. Election of officers.
10. Program.

Adjournment.

II. No meeting of the Academy shall be held without thirty days' previous notice 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. Papers presented *in absentia*, shall be read by title only, unless the Academy votes to hear them.

IX. The Secretary and Treasurer shall have their expenss paid from the Treasury of the Academy while attending council meetings and annual meetings. Other members of th 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

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(Revised December, 1919)

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