PROCEEDINGS

OF THE

Iowa Academy of Science

FOR 1908

VOLUME XV

EDITED BY THE SECRETARY

PUBLISHED BY THE STATE

DES MOINES:
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LETTER OF TRANSMITTAL.

DES MOINES, IOWA, July 20, 1908.

To His Excellency, Albert B. Cummins, Governor of Iowa:

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

Respectfully submitted,

L. S. ROSS,

Secretary Iowa Academy of Science.

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1908.

President—Samuel Calvin.
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Ex-officio—Samuel Calvin, F. F. Almy, S. W. Beyer, L. S. Ross, H. E. Summers.
Elective—R. B. Wylie, L. Begeman, D. W. Morehouse.

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Todd, J. E. 1888-89
Witter, F. M. 1889-90
Nutting, C. C. 1890-92
Pammel, L. H. 1893
Andrews, L. W. 1894
Norris, H. W. 1895
Hall, T. P. 1896
Frankin, W. S. 1897
Macbride, T. H. 1897-98
Hendrixson, W. S. 1899
Norton, W. H. 1900
Veblen, A. A. 1901
Summers, H. E. 1902
Fink, Bruce 1903
Shimek, B. 1904
Arey, M. F. 1905
Bates, C. O. 1906
Tilton, John L. 1907

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YOUTZ, L. A. . . . . New York City, N. Y.

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PROCEEDINGS OF THE

Twenty-Second Annual Session of the Iowa Academy of Science

The meetings of the twenty-second annual session of the Iowa Academy of Science were held in the Chemical Lecture room at the Iowa State Normal School, Cedar Rapids, on May 1 and 2, 1908.

In the business meetings the following matters of general interest were presented:

REPORT OF THE SECRETARY.

To the Members of the Iowa Academy of Science.

The twenty-first annual meeting of the Academy was held at Drake University, Des Moines, on Friday and Saturday, April 26 and 27, 1907. The meeting was well attended. When called to order on Friday afternoon nineteen members were present. The papers presented at the meeting were interesting and valuable. The Academy was fortunate in being able to hear two excellent public lectures by Professors H. L. Russell and W. W. Campbell at the evening meeting.

The membership list is undergoing a revision that the committee is attempting to make thorough. Quite a number of names appear in the list in the Proceedings that will be stricken out in accordance with the requirements of the by-laws. At the last meeting four new names were proposed for fellows, two were transferred to the corresponding members list, and fourteen names were proposed as associate members. These names were all acted upon favorably by the council. By some error, the addresses of most of those proposed as members did not reach the secretary and correspondence with the fellows of the Academy failed to obtain the desired information with reference to eight of the number. A repetition of such an error is not probable.

The publication of the Proceedings has been delayed even more than it was last year. The meeting of the Academy was held in April; the last paper for publication was not received by the secretary until in August, although the endeavor was made to collect them early after the meeting. The Executive Council of the State is very careful concerning the ordering of State printing. A delay was caused by the Council awaiting a decision of the Attorney-General with reference to its powers in relation to the publication. Another delay was due to the fact that when the manuscript of the Proceedings was ready for publication the State Printer was at work on the Code. The result was that nothing could be done on the Proceedings until January, 1908, and then the work was slow because of other State work in press. An attempt has been made in the notices of the meeting of 1908 to impress upon the members of the Academy the necessity of compliance with the regulations requiring copies of papers presented to be left with the secretary at the time of the meeting and in typewritten form. If the manuscript can be given to the printer early after the meeting then no great delay is probable as there is little State work in the office during the summer.

The value of the work of the Academy should increase from year to year. It is very true that the great majority of the members do not have much time available for scientific investigation. Routine class work or professional duty requires most of the time and energy; but if the members will decide very early in the year to make reports upon some certain lines of study it is probable that sufficient time for more good work may be found.

Respectfully submitted,

L. S. ROSS, Secretary.

REPORT OF THE COMMITTEE ON THE METRIC SYSTEM.

1. When the Congressional Committee on Coinage, Weights and Measures decided not to report the Littauer bill back to the House of Representatives, another chapter in the fight for the introduction of the metric system in this country was closed. A large number of the manufacturers and some engineers are still strongly opposed to the passage of such a bill, even if it provides, as in this case, for the use of the metric system only by the various departments of our national government.

But it can hardly be claimed, even by the most sanguine supporters of the present confusion of weights and measures, that the metric movement has been definitely disposed of. A careful study of the voluminous report of the congressional committee shows this clearly.

The assertion is often made that the supporters of the bill were merely professors and theorists without knowledge of practical affairs and that a discussion of the merits of the system is purely of academic interest. It is true that the theorists stand together on this question, but it is also true that there is by no means perfect harmony on the other side. Many large manufacturing concerns have come over to us and a great number of engineers are strongly in favor of the introduction of the metric system.

To give an example: The standardization committee of the American Institute of Electrical Engineers submitted in April, 1906, the following resolution to be voted upon by the members of this large and influential society: "That the committee unanimously recommends the introduction of the metric system into general use in the United States at as early a date as possible without undue hardship to the industrial interests involved." Out of 1,747 votes, received a month later, 1,569 favored the resolution.

2. Strongly convinced of the final victory of our case, your committee presents herewith a short review of the substantial progress made by the metric system during the past few years in all civilized countries.

To begin with an apparent defeat, namely the rejection of a bill providing for the obligatory use of the metric system in Great Britain, this bill was passed by the House of Lords, but defeated March 22, 1907, in the lower house by the small majority of 150 to 118. Such a close vote would have been impossible only a few years ago and shows clearly the decided change which has taken place in the attitude of the British public. Over 50 Chambers of Commerce, sixty teachers' associations, inspectors of weights and measures in 80 districts, thirty retail trades associations and numerous chambers of agriculture and farmers associations endorsed the bill, and the congress of trades unions representing some five million workmen passed unanimously a resolution in favor of it. There exists in England a strong society, the Decimal Association, with 1,500 members, drawn from all classes of the population—members of parliament, scientists, manufacturers, etc.—all working for metric reform. Has not the time arrived for all of us who are interested in this important question to band together and take a more active part in this great educational movement?

That the majority of the British colonies have strongly declared in favor of the introduction of the metric system is well known. Mauritius and the Seychelles are already metric countries, while New Zealand passed a bill in 1905 authorizing the establishment of the system by the government.

And now let us turn to other than English-speaking countries. A decree of Sept. 25, 1905, made the system obligatory in all Portugese colonies; in Denmark a law was passed May 5, 1907, requiring the use of the metric system for all public acts except in the land survey, the date for its enforcement to be fixed by the king, but not later than 1910.

China is seriously considering the adoption of a uniform system of weights and measures and its ambassadors to the various civilized countries are making a thorough investigation of the various systems in use. Let us hope that this means another country added to the already large number of countries where the metric system is used exclusively.

3. Legislative action is doubtless necessary to secure for a country a uniform and efficient system of weights and measures; but everyone recognizes that the mere passage of a law is not sufficient to make the metric system a success. It must work out its own destiny; if the people have not been sufficiently educated to appreciate its advantages and are not in sympathy with such a legislative measure, its enforcement is made very difficult, as for example in Turkey, Greece and Portugal. The metric system must in fact first conquer a country unaided by laws and statutes, while these must finally be passed to restrain those who do not want to learn, from doing mischief.

The metric system shows its greatest advance during the past few years outside of legislative domain. In Japan, for example, it is taught now in schools and is used almost exclusively in geodetic work, meteorology, medicine, pharmacy and in the army; in Egypt, though most of the officials are Englishmen, it is used in the public works department, the customs, postoffice and railways.

Still more important seem the steps taken by large international associations representing important industries. The international screw system is being introduced rapidly in large continental factories and especially for screws of smaller size it is used by the great majority of watchmakers all over the world.

The international association of silk manufacturers has accepted the metric system so that Mr. Roy in a report to a congress held in 1905 in Manchester could say that it is used now everywhere in the silk trade.

In the manufacture of lenses and optical instruments it has replaced the old system, it is being introduced for the measurement of bullets, and was accepted as the sole standard by the international aeronautic association.

The carat, a unit of mass used for jewels and precious stones, has 22 different values ranging all the way from 188.5 mg. to 254.6 mg. In April, 1905, the international commission of weights and measures proposed to have the carat represented by a mass of 200 mg. Assurance that this proposition will be accepted has been given by the association of jewelers in Paris (1905), Germany, Antwerp (1906), Prague, Melbourne and Great Britain (1907).

4. Finally let us return to our own country and look at one of the victories won. This case seems of great importance since it flatly contradicts many claims by the opponents of the metric system. Let me quote from the American Bulletin of Commerce and Trade, Sept. 15, 1907: "About the first of the present year the Baldwin locomotive works secured an order for 20 locomotives from the Chemin de Fer d'Orleans with the understanding that the work was to be completed in six months. The work was completed on schedule time and the locomotives were shipped during the past month. * * * The railroad company supplied the mechanical drawings and these, of course, had all measurements indicated according to the metric system. There were 500 sheets of drawings with an almost countless number of measurements indicated. * * * Metric standards were purchased, metric gauges and templets were prepared and every workman who was to touch the job was given a jointed meter rule graduated to millimeters. It is an interesting fact * * * that not the least difficulty was experienced with the use of the new measure from the start and that during the entire work there was not an error made which was traceable to the change in systems."

The superintendent of the works makes the following interesting remarks on his experience: "It was a matter of short time delivery. The locomotives had to be done. We found that the men took to the metric system without any trouble at all. With them to use it once was to understand it. We found that the liability to make mistakes was less and that the decimal arrangement of the measures greatly facilitated the work." He also states that there would be no great loss to the manufacturers due to the change of the master dies, templets and the like and that to use again his own words, "if the metric system were suddenly adopted, say next week, it would not disturb manufacturers to any appreciable extent. * * * Arguments which are advanced by those who oppose the system do not take into account shop practice."

A practical demonstration as this is indeed of much more value than all assertions of a hypothetical nature on either side. Let us hope that our manufacturers will have soon many more such lessons.

5. In conclusion your committee submits to you the following resolution with the request that if it is passed copies of the same be forwarded to the members of Congress from the State of Iowa, the Secretary of State, the Secretary of Commerce and Labor and to the members of the House Committee on Coinage, Weights and Measures:

RESOLUTION.

Whereas, The metric system possesses great advantages over the system now in common use and is being adopted more and more throughout the world, and is used without difficulty, with facility and satisfaction in American shops upon foreign work,

Be it Resolved, That the Iowa Academy of Science again expresses its conviction that the exclusive use of this system for all public transactions is highly desirable, and

Be it Resolved, That Congress be urged to pass legislation looking towards the introduction of the metric system for general use in the United States at as early a date as possible.

Respectfully submitted,

K. E. GUTHE,
F. F. ALMY,
Committee.

REPORT OF COMMITTEE ON DEATH OF LORD KELVIN.

Lord Kelvin died Tuesday, December 17, 1907, at 83 years of age. At the time of his birth his father, James Thomson, was a farmer in the north of Ireland. After educating himself the father became a teacher of mathematics in the University of Glasgow, where William did his undergraduate work. At St. Peter's College, Cambridge, he graduated as Second Wrangler, thence to France, the Mecca of all mathematicians, where he worked with the famous Regnault.

At the age of 22 he was called to his native Glasgow to occupy the chair of Natural Philosophy, where he remained until 1890. In 1894 he became Chancellor. "The celebrations in '96 when he had spent 50 years in his professorship were perhaps the most memorable tributes ever paid to the scientific achievements of any one man and also the most singular testimony of the cohesion of men of science all over the world."

In Lord Kelvin there was the ideal three-fold process at work, brilliant theory, application of theory, and useful inventions. Helmholtz said he had "the gift of translating real fact into mathematical equations and vice versa," a much greater feat than the mere solution of set problems. He broke down the old dividing wall between mathematical and experimental physics thus making theory and practice an organic unit which is at once the glory and power of our basic science.

The speculative side of his nature found early expression in the controversy, then raging between science and religion over the age of the solar system. His views on the constitution of matter, that famous old theory which supposes matter to be composed of indivisible vortex-rings, the parent of our modern electron theory, the nature of the ether and his theory of light, have been of most pregnant consequence to modern scientific thought.

On the practical side science is indebted to him for many useful discoveries and inventions. Those in connection with the Atlantic cable, for which he was knighted in 1866, being the most conspicuous. The mirror galvanometer, the siphon recorder, the quadrant electrometer, and the current balance are among the most important instruments in electrical measurement.

He was the proprietor of over fifty patents covering the familiar screw-down water tap, the mariner's compass, and the apparatus for recording and predicting tides.

As a teacher it is said that he often overestimated his audience. No one was more convinced than he that science is comprehensible measurable law for as he said, "if you can measure that of which you are speaking and express it by a number, you know something of your subject, but if you cannot measure it by a number your knowledge is of a sorry kind and hardly satisfactory." He had little concern for merely literary conventions as many of his readers can testify. He was fearless and mentally honest and "never sold the truth to serve the hour." His writings have found place in the greatest scientific journals of the world. The Philosophical Magazine and the Proceedings of the Royal Society received constant contributions from his pen. Among his books may be mentioned "Molecular Dynamics and Wave Theory of Light, Treatise on Natural Philosophy, and his Baltimore Papers."

Lord Kelvin was a pre-eminently great man of science who deserved and won the highest honors both English and foreign, that could be bestowed. His interment in Westminster Abbey is a fitting recognition of a most wonderful life.

Be it Therefore Resolved: That the members of the Iowa Academy of Science have noted with profound regret the death of Lord Kelvin. An ideal man of science whose life and achievements have united to give not only distinction but honor and quality to the work we love.

He died full of years but his death could at no time be less than a great loss to any nation. Respectfully submitted,

D. W. Morehouse,
Maurice Ricker,
Committee.

REPORT OF COMMITTEE ON LIFE MEMBERSHIP AND PRIZES.

Your committee to whom was referred the matter of life membership and prizes for research work beg leave to report as follows:

LIFE MEMBERSHIP.

First. That the constitution be amended as follows: Insert after "necesssary to election" in section 3, (4) Life members chosen from fellows.

Second. In section 4, after the words "his election," A person may become a life member on payment of $7.00 after his election as a fellow, the transfer to be made by the treasurer.

Third. That said life membership fees be invested and only the interest of the same be used for current expenses of the Academy.

Prizes. That we recommend the awarding of an annual prize for meritorious scientific research work done in Iowa in the following sciences: Chemistry, Physics, Astronomy, Geology, Zoology or Botany. That the matter of arranging for the annual prize be left to the executive committee, except that not more than $25.00 be appropriated for this purpose.

(Signed) L. H. Pammel,
M. F. Arey,
C. O. Bates.

REPORT OF COMMITTEE ON MEMBERSHIP.

NAMES PROPOSED FOR FELLOWS.

Guy West Wilson, Fayette; George F. Kay, Iowa City; A. G. Smith, Iowa City; transfer from member to fellow, C. E. Bartholomew, Ames.

NAMES PROPOSED FOR MEMBERS.

Henry McSweeney, Newgate; C. H. Anthony, Cedar Falls; C. A. Scott, Ames; C. L. Robinson, Norwalk; Mrs. A. D. Feuling, Ames; C. D. Learn, Clermont; R. E. Conklin, Des Moines; S. W. Hockett, Waterloo; L. D. Curtis, Alta; A. J. Wheat, Emmetsburg; G. G. Wheat, Emmetsburg; Miss Allison E. Aitchison, Cedar Falls.

DROPPED FROM THE LIST OF CORRESPONDING MEMBERS.

J. C. Brown, Gertrude Coburn, H. H. Hume, C. W. Mally, C. D. Read, W. M. Stull.

REPORT OF COMMITTEE ON RESOLUTIONS.

Resolved, That the Iowa Academy of Science expresses its approval of the policy of the Director of the Iowa State Bacteriological Laboratory in establishing branch laboratories; that we advocate the extension of this plan until all parts of the State are properly cared for, and that we consider an adequate legislative appropriation for the purpose as not only eminently proper but highly desirable.

Resolved, That the Iowa Academy of Science returns its thanks to the President and Faculty of the Iowa State Normal School for their courtesy in furnishing facilities for its meetings and in opening their homes to its members; to the local committee for well planned arrangements and to the young ladies of the department of Domestic Science for a very enjoyable demonstration of their abilities in preparing and serving a banquet.

E. W. ROCKWOOD,
H. E. SUMMERS,
E. A. JENNER,
Committee.

SPECIAL RESOLUTION.

WHEREAS, We have learned with deep regret that Mr. F. M. Witter, County Superintendent of Schools of Muscatine, Iowa, deems it necessary to withdraw from active participation in the work of the Academy; and

WHEREAS, Professor Witter, as one of the founders, as third President, as an indefatigable contributor to the Proceedings, and always as an enthusiastic member, exerted a notable influence in establishing the Academy on a firm foundation; therefore be it

Resolved, That the name of F. M. Witter be retained permanently on the roll of Fellows as long as he may continue a resident of Iowa; and be it further

Resolved, That the Secretary be instructed, in case of the removal of Mr. Witter from the State, to transfer his name to the list of Corresponding Fellows without further action by the Academy.

TREASURER'S REPORT.

RECEIPTS.

Cash on hand, April 26, 1907	$264.07	
Dues and initiation fees	116.00	
Sale of Proceedings	3.50	
Interest on deposits	15.33	$398.90

EXPENDITURES.

Programs and incidental expenses, 20th meeting	$ 4.00	
Programs and incidental expenses 21st meeting	4.00	
Expenses of lectures, 21st meeting	70.16	
Binding, reprints, mailing, Proceedings of 20th meeting	71.00	
Postage, typewriting, and incidental expenses of Secretary, 1906-07	16.82	
Postage, typewriting, and incidental expenses of Secretary, 1907-08	29.09	
Honorarium to Secretary, 1907-08	25.00	
Postage for Treasurer	4.00	
Cash on hand, April 30, 1908	174.83	$398.90

Respectfully submitted,

H. E. SUMMERS, Treasurer.

OFFICERS FOR THE YEAR 1908-09.

President	Samuel Calvin
First Vice President	F. F. Almy
Second Vice President	S. W. Beyer
Secretary	L. S. Ross
Treasurer	H. E. Summers

Executive Committee—Ex-officio: Samuel Calvin, F. F. Almy, S. W. Beyer, L. S. Ross, H. E. Summers. Elective: R. B. Wylie, L. Begeman, D. W. Morehouse.

NAMES OF MEMBERS OF THE ACADEMY COUNCIL.

M. F. Arey, T. H. McBride, L. H. Pammel, F. M. Witter, T. E. Savage, C. O. Bates, A. Marston, Maurice Ricker, H. E. Summers, N. Knight, A. A. Bennett, H. W. Norris, L. S. Ross, F. F. Almy, W. H. Norton, S. W. Beyer, B. Shimek, G. E. Finch, R. B. Wylie, S. Calvin, C. C. Nutting, E. W. Stanton, G. L. Houser, L. Begeman, W. S. Hendrixson, A. C. Page, J. L. Tilton, A. W. Martin.

NAMES OF FELLOWS AND MEMBERS PRESENT AT THE TWENTY-SECOND SESSION.

F. F. Almy, A. A. Bennett, S. F. Hersey, C. C. Nutting, A. G. Smith, Guy W. Wilson, M. F. Arey, E. J. Cable, E. A. Jenner, A. C. Page, S. W. Stookey, B. H. Baily, S. Calvin, G. F. Kay, L. H. Pammel, C.E.Bartholomew, E. K. Chapman, C. N. Kinney, E. W. Rockwood, J. L. Tilton, C. O. Bates, G. E. Crawford, D. W. Morehouse, L. S. Ross, G. W. Walters, L. Begeman. K. E. Guthe, G. W. Newton, B. Shimek, G. G. Wheat.

PROGRAM OF THE IOWA ACADEMY OF SCIENCE.

The president's address by Professor John L. Tilton and the lecture on "Old and New Theories of the Formation of the Earth," by Professor Moulton, were given at the Auditorium Friday evening. Reception to members of the Academy at the residence of President Seerley, after the lecture.

Review of Solar Observations Made at Alta, Iowa, During the Past Five Years.... ....David E. Hadden
The Vitality of Weed Seeds Under Different Conditions of Treatment and a Study of Their Dormant Periods........H. S. Fawcett
Some Seeds of the Genus Pyrus........L. H. Pammel
The Genesis of the Loess, a Problem in Plant Ecology........B. Shimek
A Hybrid Oak........B. Shimek
Notes on Peronosporales for 1907........Guy West Wilson
A Key to the Families of Ferns and Flowering Plants of Washington......T. C. Frye
The Forestry Problem of the Prairies of the Middle West........Hugh P. Baker
Notes on the Routine Diphtheria Determination in the Laboratory........L. S. Ross
Isolation of Diphtheria Bacilli from Serous Fluid of a Cadaver........L. S. Ross
The Uric Acid Ferments........E. W. Rockwood
The Determination of Ferrous Iron........Nicholas Knight
The Decomposition of Dolomite........Nicholas Knight
The Analysis of Some Iowa Waters........Nicholas Knight
The Life of Portland Cement........G. G. Wheat
The Loess of the Paha and the River-Ridge........B. Shimek
Some Peculiarities in the Elastic Properties of Certain Metals........K. E. Guthe
An Experimental Determination of the Charge of an Electron by Wilson's Method, Using Radium........L. Begeman
Nucleation According to Barus........L. Begeman
Evaporation from Water Surfaces Exposed to the Sun........A. G. Smith
The Protozoa of Fayette, Iowa........Guy West Wilson

NECROLOGY.

CHARLES ALDRICH.

The death of Charles Aldrich on March 8, 1908, closed the labors of a prominent pioneer who occupied an important place in the development of public institutions. For more than fifty years his pen was busy working up an interest in the upbuilding of museums, libraries and educational institutions, the collection of historical material and advocating the extension of scientific work in the State. His communications issued in the paper he founded in Webster City, or contributions to the Marshalltown Times-Republican, the old Iowa State Register, The Register and Leader, The Des Moines Capital, The Chicago Inter-Ocean, or Dubuque Daily Times, frequently advocated the scientific work of the State and Nation at large.

His letters written while unofficially connected with the Hayden Geological Survey and published in the Chicago Inter-Ocean under the name of David Gray on May 30, June 10, 20, July 4, September 1, 8, 14, 23, 26, 30, in 1875, gave a popular description of the geology of Southern Colorado as well as accounts of the Indians and cliff-dwellers of that region.

Mr. Aldrich was born in Ellington, N. Y., October 2, 1828. His education was received in the public schools of Jamestown, N. Y., and later in the academy of the same place.

He early began his work in a newspaper office and established the Cattaraugus Sachem. Many years later he published in the Cattaraugus Republican* some interesting reminiscences of his Indian experiences of his early life. Later he established a weekly journal at Olean, N. Y., in 1851-56. He founded the Webster City Freeman, June 29, 1857.

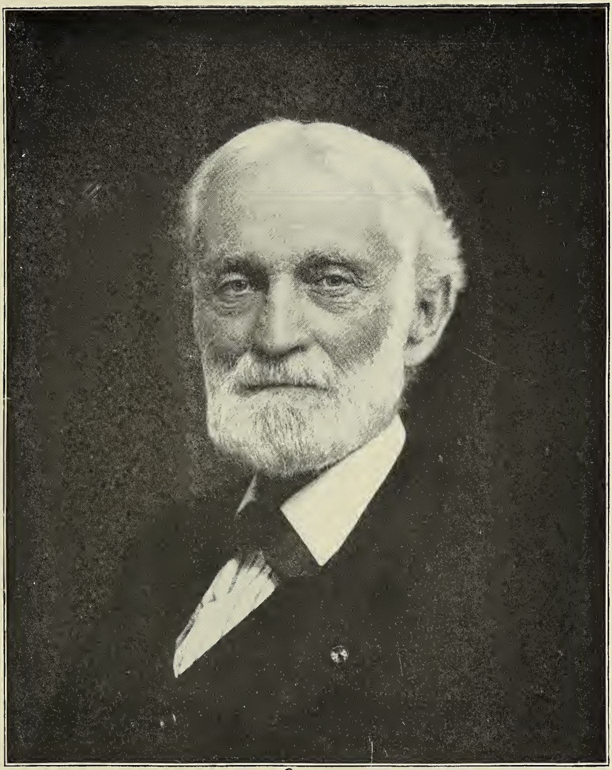
During all these years he missed no opportunity of contributing to the various newspapers of the State. Mr. Aldrich was especially interested in bird protection. Thus he introduced the first measure working toward the protection of our birds, the bill passing in 1870. His articles published on this subject were numerous.[1]

He was very much interested in domestic animals, he had pets of all kinds and notes were occasionally published on the intelligence of some of these animals, as for instance, an account of his horse Joseph, under the title of "The Death of Joseph"; also a biography and the characteristics of a cat[2] which he called "Shorty," and the biography and characteristic anecdotes of a cat describing the intelligence of this animal which he had had under observa-

* November 25, 1890.

1. Bird Protection in England, Des Moines Capital, April 4, 1899; Hawks and Owls, Boone News, Dec. 6, 1904; Stop Murdering the Birds, Boone Co. Republican, April 10, 1903; Taming of a Wild Bird, Capital, April 5, 1899; Wild Birds Know their Friends, April 24, 1897; A Word for the Sparrow, Capital, May 15, 1900; Birds out of Season; The Merciless War upon the Birds, Report Iowa State Horticulturist Society 1884; Birds in Town, Des Moines Capital, Jan. 9, 1901.

2. "Our dear old Shorty," Chicago Field, April 16, 1881.



CHARLES ALDRICH.

tion for 15 years; essentially the same facts were given in a shorter article in the American Naturalist.[3] Along a somewhat different line is the article on the "Survival of Wild Habits in Domesticated Animals,"[4] also a fascinating account of a Peagreen Rattlesnake[5] and an account of the migrations of ants.

Mr. Aldrich advocated the teaching of science in the public schools, he advocated the establishment of a geological survey and an investigation and a study of the Indian mounds in Iowa.[6] He mentioned in one of his articles in the Iowa State Register the great value to science in having museums like the Davenport Academy where pre-historic relics may be studied, and the great value to the countries of museums like that of South Kensington, the United States National Museum and of the Philadelphia Academy, and the collection of Professor Cope.

His articles on botanical subjects were not numerous. In his letters to the Inter-Ocean he mentioned some of the characteristic vegetation of Colorado[7] and in one described the variation in the growth of the Virginia Creeper. He was also a great lover of forests and the conservation of the natural resources of the country. Many times he spoke to me about the timber which is being destroyed today and the necessity of preserving our forests, and our timber for future use. "It is a shame," he said, "to cut the small poles of oak and hickory."

He paid many beautiful tributes to his scientific friends, among these he wrote biographical sketches of Dr. Chas. A. White, Dr. C. E. Bessey, Col. Geo. Waring, Professor Call of the State University, and of the service to science by such men as Prof. Herbert Osborn, Professor Riley, Joseph Leidy and Dr. Edward Cope, a tribute to the work of Gilbert White, whose place he visited in the old historical city of Winchester and in the little hamlet of Selbourne, near that place, the father of English natural history was born. The venerable yew, mentioned by him, near the church of which Gilbert White was rector, was still standing when Aldrich visited the place. He deplored the fact that so simple a slab should indicate when White was born and when he died. Aldrich says that "his best monument is his delightful book which bids fair to live for all time."

Mr. Aldrich was intimately acquainted with a great many men of public life and also a great many scientists, among them a number of the Hayden Survey, who have become famous in the study of geology of our country. Mention may be made of A. D. Wilson, Franklin Rhoda, F. W. Endlich, W. H. Holmes, G. B. Chittenden, P. S. Brandigee, Henry Gannett, W. R. Atkinson, A. C. Pealem, G. M. Bechler, W. H. Jackson, McGee, Fletcher; he was also acquainted with Lincoln, Grant, Johnson, McKinley, and many other notable public men.

It was my pleasure to have known Mr. Aldrich intimately for more than sixteen years and he has always expressed great interest in the scientific work of the Academy of Science. He desired particularly that they should occupy some room in the historical building for their meetings. He encouraged science in every possible way.

Through his efforts the State has been fortunate in securing several valuable manuscripts pertaining to natural history. He took a keen interest in the early explorations of the northwest and Coues expresses his gratitude to Mr.

3. May, 1884.
4. American Naturalist 1881—563.
5. Reptilian Studies, Chicago Inter-Ocean, July 7, 1874.
6. Des Moines Register and Leader, Oct. 6, 1904. Open Mounds in Leigh, Webster Co. Burlington Hawkeye, June 1, 1900.
7. American Naturalist, March, 1881.

Aldrich for services rendered in connection with the publication of the Coues' Lewis and Clark Expedition to the Rocky Mountains.

It was a pleasure and a delight to have known Mr. Aldrich and he has left his impress upon the educational and scientific work of the State, not so much by his contributions to science as by his keen interest in the work and getting others started.

L. H. Pammel,
H. E. Summers,
L. S. Ross,
Committee.

PRESIDENT'S ADDRESS.

SCIENCE REQUIRED FOR A GENERAL EDUCATION.

BY JOHN L. TILTON.

At first I thought that for this occasion I would prepare a paper on one of the important lines of recent scientific discussion. After the kind acceptance by Professor Chamberlin of our invitation to address us this evening I gave up all intention of preparing a paper, thinking that the address which we are about to hear would render the presentation of a related subject by me undesirable; but when I found that the omission of a paper styled the "Presidential Address" would be considered an unacceptable "innovation," I immediately decided to present briefly a pedagogical question which has been forced upon my attention again and again, and I doubt not has been the occasion of much thought on the part of every teacher present; a question that demands the thoughtful consideration of every scientist engaged in educational work. The question is this: What sciences should be required *for a general education?*

As I view the field, the time is past in which there is a failure to recognize the value of a critical examination of scientific data, a logical development of scientific theory, and a consideration of the important bearing of such data and theories upon modern life; though there may be a partial failure of such recognition on the part of some whose education is purely literary. Indeed, we rejoice to see the evidence of scientific method applied in all branches of education, notably in sociology, psychology and history; and we are glad that all lines of education can combine to establish care in gathering data, and correct method in developing thought; but amid the great numbers of authors and topics for study, and the pressure of other worthy courses for recognition, there seems to be no generally accepted conclusion as to just what sciences should be included in a course designed to give a general education. In conversation with men from various colleges it is not uncommon to find evidence of attempts even in recent years to reduce required scientific work to a minimum, regardless of the importance of the various branches both in modern life and in education; while among teachers of science there are those who favor specialization in one branch of science without a general knowledge of other sciences as a prerequisite, except so far as immediately necessary to the subject in which there is to be specialization.

There is much to be said in favor of work involving specialization and original research. That various and deep problems are involved in the full investigation of any subject seems to be overlooked by those who decry the narrowness of the specialist; and the breadth of education that has often preceded specialization is a source of surprise to the critic. It is not my purpose to discuss the need and value of specialization. That courses leading to such an end have places in modern education seems recognized by all, but, on the other hand, a peculiar condition confronts us that we should not overlook. Many high schools graduate students who have had much of language and little of science, and colleges admitting such graduates permit them to elect still more of language and a minimum of science. The problem then becomes, what sciences shall be required of those who, having learned to love other subjects, now shun science, either because they do not know what they lack, or because the small amount which they have had has given them the impression that they cannot shine in that line of work with a desired brilliancy. Indeed, dislike of science and failure at first to excel in it are often due to a complete lack of opportunity which has left the student unaware of his own ability, and developed love for other studies to the exclusion of science. This unfortunate result will be reproduced constantly in such public schools as exclude both nature and science from consideration in the grades, and, if they present them at all in the high school, present them under the guidance of teachers who have themselves likewise neglected science. Our colleges must now. and apparently for many years to come, have among their students graduates of such smaller high schools, and for such students must seek to determine the amount and character of science which should be required.

Permit me to briefly present a solution of the problem as follows: Besides the physical geography which is so commonly taught in the lowest grade of the high school, serving as a supplementary course in geography, a pre-requisite for history and parts of literature, and also serving as a science, there should, for a general education, be required somewhere in a high school or in the early part of a college course a study of the facts and the general principles of biology, physics and chemistry.

The work in biology should develop a knowledge of the life around us so often overlooked, and a knowledge of the great groups of animals and plants, as well as of the laws which biologists have worked out, and the prominent theories; in short, it should give the student a general view of this great field of science. This can be accomplished with due regard to abnormal sensibility which the teacher sometimes discovers in a pupil.

The work in physics is that work in science now most commonly well presented in a high school. It should develop a knowledge of the general facts and principles of the subject, and a knowledge of their application in our civilization.

The work in chemistry should open the eyes of the student to the action of forces all around us unrecognized by those who have neglected the subject. It should reveal to him the facts made use of in our great industries, and present the theories concerning the constitution of matter and the laws of chemical change.

It does not seem desirable to present here a discussion of the importance of a knowledge of these three great fundamental lines of study, nor to discuss the necessity of laboratory methods, as well as of recitations and of illustrated lectures. With a knowledge of these three subjects properly developed the student is ready to grasp the meaning of processes which he sees in the industrial world, and of literature which involves these sciences. Because of study of these three fundamental subjects he is the better enabled to study our civilization in a comprehensive manner and to fill the place of a useful and well-informed citizen.

With all the important bearings of these subjects they are divergent in their relations. Omitting astronomy, which is generally included with mathematics rather than with science, there remains one other requirement which should follow these courses in biology, physics and chemistry. That requirement is geology, the keystone in the scientific part of a general education, resting upon the facts of physics, chemistry an biology, binding them all together, and completing a solid, well-grounded arch, above which may be reared philosophy concerning the past, present and future. Without the use of the facts, principles and logical deductions of geology, there can be no proper, well-grounded conception of what the earth has been and now is; no proper conception of the working of Deity in the universe; no proper conception of what life has been, and no proper view of the relationships of present life; thus no adequate comprehension of that great branch of modern reasoning expressed in that far-reaching, commonly misunderstood word, evolution. Here, too, side views of physiography and meteorology, so necessary to an understanding of the sequence and effects of base leveling, rejuvenation and climatic changes of the past, as well as of the climate and topography of the present, can and must be presented for those who may have neglected courses in those subjects.

Thus geology, the final scientific subject required for a general education, is so broad in its scope, so deep in its subject-matter, and so high in its relation to other studies, that, when thus presented, it should be left till the latter part of the college course.

In the various colleges here represented the details of the courses of necessity differ. The plans for each student who wishes to specialize in science are well and carefully laid; but can we not, for the sake of a well rounded education, see that those who do not wish to specialize in science and while seeking what they imagine to be a general education, neglect science, shall be required to study these fundamental facts, principles and theories so necessary to a good general education?

THE SOLAR SURFACE DURING THE PAST FIVE YEARS—A REVIEW OF SUN-SPOT OBSERVATIONS MADE AT ALTA, IOWA, FROM 1903 TO 1907.

BY DAVID E. HADDEN.

The present paper is a continuation of a series of sun-spot observations contributed to the Iowa Academy of Sciences at the annual session in December, 1902.*

For the purpose of representing graphically the resulting curve of the sun-spot cycle which now embraces two maxima and one minimum the numerical summaries of the seventeen year's observations have been plotted. The instruments used were a 4-inch refractor until August, 1907, and after that time a 5½-inch refractor, an 8-inch reflector was also employed and a polarizing eye-piece magnifying about 80 was principally used.

The means of obtaining the heliographic positions of the spots and faculae and the hours of observations were the same as given in my former paper. The detailed daily account of the observations have been sent regularly as heretofore to the Solar Section of the British Astronomical Association and the yearly results published in *Popular Astronomy.*

During the period now under review 810 groups were observed on the sun's disk on 1007 days of observation, distributed as follows:

Years	Groups	Observations
1903	93	230
1904	155	172
1905	192	202
1906	189	198
1907	181	205

Reviewing the sun-spot cycle of the past 17 years the minimum of 1889.6 was followed by a maximum about 1893.7, an interval of 4.1 years, the next minimum occurred in 1901.5, or 7.8 years later and the apex of the last maximum was probably passed in 1905.9, a difference of 4.4 years.

*Proc. Ia. Academy Science, Vol. X.

The following tables exhibit the numerical results of the observations from 1891 to 1907, inclusive:

Years	No. of days observations	Average groups	Annual spots	Number of faculæ	Total No. of spotless days
1891	257	2.9	14.9	3.6	24
1892	205	5.6	34.0	4.1	0
1893	177	6.6	36.6	4.1	0
1894	139	5.6	30.0	3.4	0
1895	149	5.2	30.5	3.5	0
1896	197	3.2	17.8	2.9	5
1897	198	2.2	11.0	2.3	29
1898	234	2.1	11.0	2.4	30
1899	259	1.1	4.8	1.5	108
1900	255	0.7	3.4	1.0	134
1901	269	0.25	0.9	0.3	212
1902	230	0.37	2.0	0.5	163
1903	230	1.65	7.8	1.9	32
1904	172	3.10	13.25	3.14	0
1905	202	4.00	18.18	3.9	2
1906	198	3.8	15.0	3.3	8
1907	205	3.8	15.8	3.4	0

The maximum and minimum daily number of sun-spot groups are given in the table below:

MAXIMUM DAILY NUMBER OF SUN-SPOT GROUPS

Months	1903	1904	1905	1906	1907
January	1	4	6	7	7
February	3	3	8	4	9
March	3	5	6	7	7
April	5	4	5	9	6
May	4	6	6	6	4
June	3	5	6	10	3
July	4	5	6	10	5
August	3	5	7	6	6
September	2	3	6	7	8
October	3	5	7	3	7
November	4	6	8	6	5
December	6	9	5	6	4

MINIMUM DAILY NUMBER OF SUN-SPOT GROUPS

Months	1903	1904	1905	1906	1907
January	0	1	1	1	4
February	0	1	2	2	5
March	0	2	2	1	2
April	0	1	1	1	1
May	0	2	0	2	1
June	0	2	2	1	1
July	0	1	1	4	1
August	1	2	3	1	2
September	0	1	1	1	3
October	1	2	2	0	2
November	1	1	2	1	1
December	0	2	2	4	1

1903.

The principal characteristics of the record for this year are:

1. The decided increase in the number of groups, spots and faculae.
2. The marked decrease in the total number of spotless days.
3. The frequency of spots in the southern hemisphere, and,
4. The remarkable outburst of a spot group of the first magnitude in October, which was followed by greater solar activity until the close of the year.

The year 1903 marked a distinct revival of solar activity, during the first three months the sun-spots were few and rather short lived, but in April fairly large disturbances were noted and evidences of the beginning of the cycle of greater activity were in progress, but as is frequently the case when great disturbances break out suddenly a period of quiescence supervenes, and with the exception of July the spots were principally small and transitory and in September reached a minimum, when eleven spotless days were noted.

In October solar observers were greeted with some outbursts of gigantic proportions, a superb sun-spot measuring over 135,000 miles long by 39,000 miles wide and embracing an area of over 5,000,000,000 square miles made the transit of the visible disk from the 4th to the 17th, this spot received much attention by the press and public and the coincident terrestrial electrical and magnetic effects were marked and widespread—bright auroras and remarkable electromagnetic earth currents occurred throughout the earth's northern hemisphere. A detailed illustrated account of the author's observations of this sun-spot was published in *Popular Astronomy* for December, 1903. The spots completed several rotations of the sun and the year closed with decreasing activity.

1904.

The present year was noted for:

1. The continued steady increase in the number of groups, spots and faculae.
2. The entire absence of days without spots.
3. The greater frequency of spots in the northern hemisphere, and,
4. The absence of any groups of the first magnitude.

While the numerical results of the year were nearly doubled over the preceding year, indicating the steady approach of the maximum period, the increasing activity was not marked by any giant spots or even spots large enough to be rated as of the first magnitude.

Some large and interesting spots were noted in April, May, July, August, October and December, the year closing with the disk well covered with numerous spots.

1905.

The principal features of the record for 1905 are:

1. The maintained steady increase in number and size of groups, spots and faculae.
2. The greater frequency of spots in the northern hemisphere, which was more marked in the latter half of the year, and,
3. The appearance of many large spots during the year, one of which during its transit from January 28th to February 10th, was of giant magnitude.

The year opened with much solar activity, which culminated in the greatest solar spot of the present cycle and probably the largest single sun-spot of the last thirty years, visible in the closing days of January and the first decade of

February. Its length exceeded 100,000 miles and width 60,000 miles. It consisted of a great compact mass of penumbra with large central umbra and numerous nuclei, changing more or less from day to day and spectroscopically very active, brilliant reversals and diagonal distortions of the hydrogen lines were frequent. This disturbance reappeared in the latter part of February and March, but gradually subsided. Other groups of spots only slightly inferior were present in March and July. In the latter month another giant spot appeared which during its transit was subjected to many changes in which hydrogen played a prominent part with the formation of fissures and bridges.

August witnessed the return of these disturbances. Another splendid group of vast dimensions appeared early in October, not as compact as previous ones, but its separate portions embraced a region of 135,000 miles by 100,000 miles. A second one nearly as large and somewhat scorpion-shaped followed it about a week later and during the last week a third stupendous spot with large elongated umbra indicated something of the gigantic but mysterious forces which are at work at the climax of a sun-spot maximum period. The balance of the year witnessed streams of smaller spots across the spot zones.

1906.

The principal characteristics of the 1906 record are:

1. A slight decrease in the mean daily number of groups, spots and faculae.

2. Marked fluctuations of activity, followed by periods of distinct decline, spots of the first magnitude being present in January, March, July, August and December, with minima in February, September and October.

3. The increase in number of spotless days; at least eight days in October were free from spots.

Reviewing the record for the present solar cycle so far, the observations this year appear to point to the maximum as having been passed during the latter months of the year 1905 and the more gradual and steady decline towards the minimum has now set in.

The principal disturbances of the year were observed in July, when the spot zones were studded with both large and small spots, some with "bridged" umbrae and curious whorls of penumbra studded with circling nuclei.

1907.

The numerical results of this year were almost precisely the same as the preceding year. The year was remarkable for the number of large spots which were visible, every month witnessing one or more "greater" sun-spots, the groups of February and June were of giant size and nearlv equalled those of the previous year.

In October four large groups were visible and one increased to a train of very large spots of tremendous extent, which made a second transit only slightly reduced in size in November. The year closed with decreasing activity.

In the subjoined tables are given the monthly summaries of the daily observations taken from January, 1903, to December, 1907. The columns are self-explanatory.

The results as thus tabulated are indicated graphically in Plate I, which exhibits the monthly fluctuations during the period under review and also the preceding twelve year's record:

Months	Number of observing days	Groups	Average number of spots	Faculæ	Average north latitude	Number groups south latitude	Number spotless days
1903.							
January	12	0.60	3.60	0.60	0.25	0.33	5
February	16	1.30	3.50	1.30	0.50	0.80	1
March	15	1.47	7.01	1.30	1.20	0.27	5
April	18	2.06	7.40	1.90	1.10	0.96	2
May	18	1.50	5.80	2.00	0.67	0.62	4
June	23	1.48	7.30	2.00	0.56	0.87	2
July	26	2.15	12.60	2.15	0.85	1.30	1
August	21	1.48	8.10	2.40	0.43	1.04	0
September	21	0.67	2.43	1.90	0.43	0.24	11
October	26	1.96	10.54	1.65	0.96	1.00	0
November	19	2.47	15.00	2.16	0.63	1.84	0
December	15	2.93	11.07	3.20	1.20	1.73	1
1904.							
January	10	2.70	13.75	3.14	1.50	1.20	0
February	15	1.73	7.71	2.43	1.10	0.60	0
March	14	3.50	11.21	2.21	2.10	1.20	0
April	11	2.82	9.45	2.70	2.20	0.60	0
May	9	3.78	14.10	3.90	2.00	1.80	0
June	12	3.17	16.75	3.10	1.60	1.40	0
July	21	3.14	17.62	3.20	1.80	1.30	0
August	20	3.85	17.20	3.75	1.80	2.00	0
September	15	1.67	6.73	2.70	0.70	1.00	0
October	13	3.54	16.31	3.54	1.90	1.60	0
November	20	3.30	11.70	3.50	1.40	1.80	0
December	12	4.25	16.50	3.50	2.90	1.30	0
1905.							
January	11	4.10	15.45	3.60	1.70	2.30	0
February	17	4.77	18.80	4.40	2.40	2.40	0
March	12	3.60	18.30	4.30	2.00	1.60	0
April	12	2.90	11.50	3.70	1.40	1.40	0
May	17	3.20	14.51	4.30	2.10	1.10	2
June	16	3.50	13.88	4.20	1.60	1.80	0
July	24	4.30	21.79	3.80	1.70	2.60	0
August	23	5.00	16.00	4.30	3.50	1.50	0
September	17	3.40	14.00	2.80	2.00	1.20	0
October	20	3.90	24.30	4.00	3.00	0.85	0
November	17	5.80	34.00	3.90	3.80	2.00	0
December	16	3.60	15.60	4.00	1.90	1.80	0
1906.							
January	11	4.10	15.00	4.00	2.50	1.60	0
February	10	2.80	7.10	3.50	2.20	0.60	0
March	7	4.70	16.60	4.00	2.60	2.10	0
April	15	4.00	16.30	3.90	3.00	1.00	0
May	22	3.50	15.80	3.00	3.00	0.50	0
June	23	4.20	17.00	3.30	3.40	0.80	0
July	25	7.10	25.10	3.50	5.50	1.60	0
August	23	3.30	10.90	3.10	1.70	1.60	0
September	21	3.70	14.00	2.90	1.90	1.80	0
October	20	1.00	4.60	3.00	0.30	0.70	8
November	10	3.10	13.20	2.40	1.70	1.40	0
December	11	4.30	23.80	3.10	3.00	1.30	0
1907.							
January	8	5.2	22.2	4.0	3.7	1.5	0
February	12	6.5	29.0	3.7	3.5	3.0	0
March	16	4.0	13.4	3.6	2.0	2.0	0
April	13	3.3	13.5	2.8	2.1	1.2	0
May	15	2.5	8.0	2.9	1.1	1.3	0
June	22	2.0	10.2	3.0	0.9	1.1	0
July	26	3.2	13.4	2.9	1.2	2.0	0
August	23	4.0	13.5	3.0	1.3	2.7	0
September	13	4.8	21.7	3.8	3.1	1.7	0
October	22	3.7	17.6	3.6	1.5	2.2	0
November	20	3.2	16.3	3.8	1.5	1.7	0
December	15	2.9	10.9	3.2	0.7	2.2	0

Plate 2 represents graphically the yearly curve of the seventeen year's observations, both of the mean number of groups and average number of spots in the groups, the former being indicated by the lower smooth line and the latter by the upper dotted one.

Bibliography of author's published sun-spot observations since 1902:

The Recent Large Sunspots. Popular Astronomy, Vol. XI, December, 1903.
Review of Solar Observations, 1902. Ibid. Vol. XI, November, 1903.
Review of Solar Observations, 1903. Ibid. Vol. XIII, April, 1905.
Review of Solar Observations, 1904 and 1905. Ibid. Vol. XIV, December, 1906.
Review of Solar Observations, 1906. Ibid. Vol. XV, December, 1907.

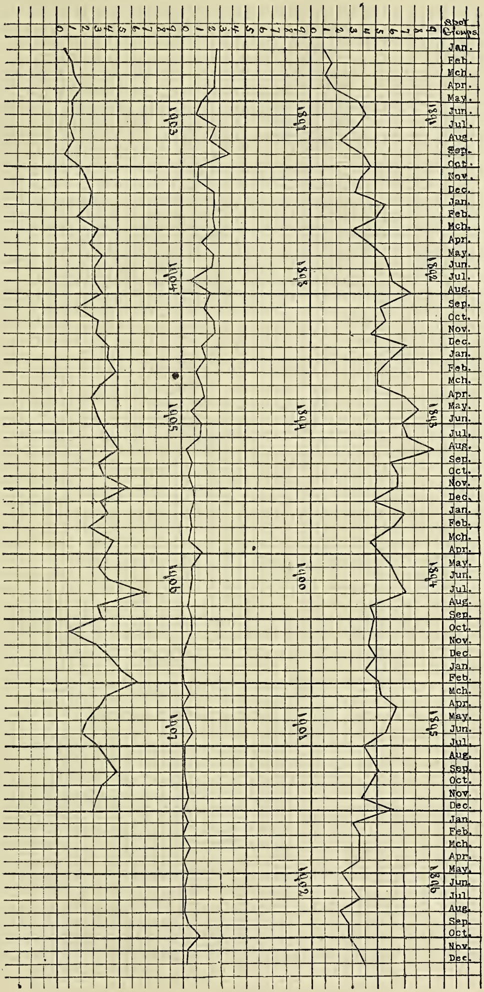


PLATE I.

Review of Solar Observations—David E. Hadden.

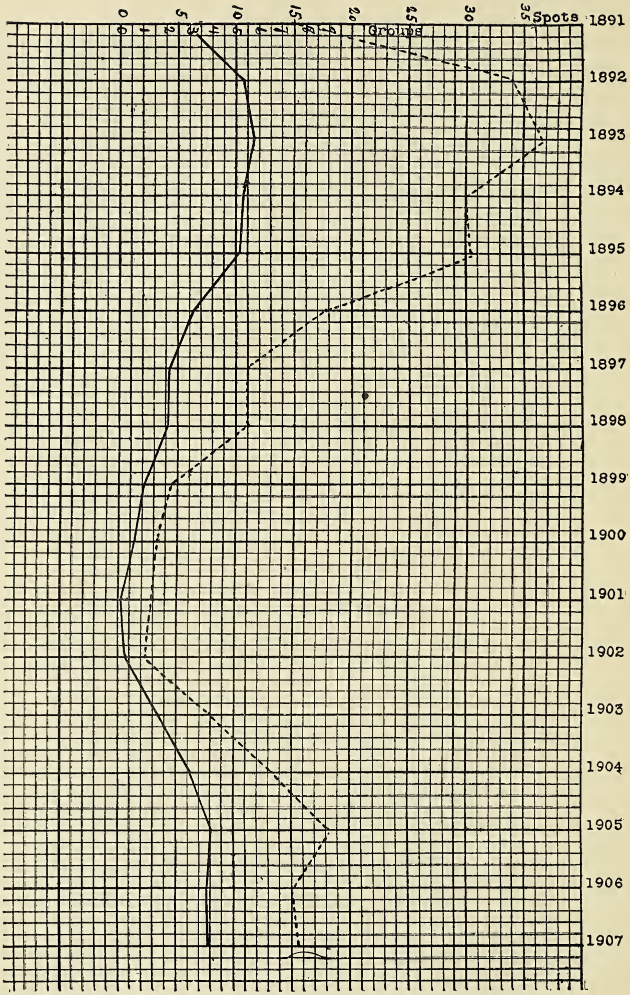


PLATE II.

Review of Solar Observations—David E. Hadden.

THE VIABILITY OF WEED SEEDS UNDER DIFFERENT CONDITIONS OF TREATMENT, AND A STUDY OF THEIR DORMANT PERIODS.

BY H. S. FAWCETT.

The viability of a seed is its capacity to live after maturity, and its dormant period is the time required for the seed to germinate after being planted.

A great deal of investigation has been carried on for many years past to determine the viability of seeds; more especially of cultivated seeds of the farm and garden, but not so much attention has been given to weed seeds. In 1897 Mr. C. R. Ball of this college published an article on "Seed Testing; Its Importance, History and Some Results, With a Partial Bibliography." This article contains a long and valuable bibliography referring to all the most important literature before 1897.

Some of the recent articles on the subject are: Bull. 38 of the Nevada Station, on "Nevada and Other Weed Seeds," with figures of weed seeds by F. H. Hillman; "The Germination of Weed Seeds," by L. H. Pammel and G. M. Lummis, 1902; Bull. 58 of the Bureau of Plant Industry, on "The Vitality and Germination of Seeds," by J. W. T. Duvel, and "Rules and Apparatus for Seed Testing," in Circular 34 of the Office of Experiment Stations, 1904.

The object of the present investigation was to make a comparative study of the viability of different species of weed seeds, especially those found in cultivated fields and pastures, and to study their dormant periods in order to determine if possible any means of destroying these seeds. A test was also made of the effect of freezing and thawing on the vitality and the length of the dormant period for each species.

Ninety-two samples of weed seeds, representing fifty-two different species, were used. These samples were collected in September, October and November of 1904. Care was taken to collect, whenever possible, thoroughly mature seeds. The seeds were nearly all collected before they dropped to the ground and when dry they were threshed out and placed in paper envelopes.

For the germination tests fifty seeds of each sample were placed in sand, in boxes, under benches in the greenhouse, and kept as near as possible under uniform conditions. These tests were repeated each month from November until May, all the boxes of all previous months being left. All the boxes were kept moist and a daily record was kept of the number of seeds germinating. In addition to these tests seeds from a large number of these samples were placed out of doors in order to expose them to the effects of freezing and thawing. The seeds were placed in sacks inside a thin wooden box and a thin layer of sand placed around them. The box was then sunk into the ground so that the top part was just exposed. These seeds were taken out in April and planted side by side with seeds from the same sample that had been in doors all winter.

The results of these investigations are shown in the accompanying tables. The general effect of exposing the seeds to thawing and freezing was both to increase the percentage of germination and to shorten the dormant period. This was especially true of seeds with hard seed coats. Where the seed possessed thin and delicate seed coats the effect in a few cases was to lessen or destroy the vitality of the seeds.

Three samples of the common pigweed (*Amarantus retroflexus*) showed an average dormant period of nine and one-third days for those kept indoors and only six and one-third days for those exposed, an increase of about 50 per cent. For Wild Rye (*Elymus canadensis*) the dormant period was lessened from nine to five days and the percentage increased from 22 to 48 on account of exposure. In four samples of Foxtail (*Setaria glauca*) the average dormant period was lessened from eleven and one-quarter to seven days and the percentage of germination increased from 34.5 to 38 per cent because of exposure.

It is to be seen from an examination of the tables of November and December that as a rule the highest dormant periods are found in those seeds that have the hardest and thickest seed coats. For these two months, Rag Weed *(Ambrosia trifida)* and Barn Yard Grass *(Panicum crus-galli)* have the longest dormant periods, that for the Rag Weed being one hundred and fifty-two days and that for Barn Yard Grass one hundred and seventy-eight days. It was late in the spring before either would germinate. It is seen also from the tables that for some of the hard seeded species the dormant period decreases in each succeeding month not quite in proportion to the time between the successive plantings. This shows that these species refuse to germinate even under the most favorable conditions until they have had a period of rest. The tables also show a general falling off of the percentage of germination for those seeds planted in January and February, as compared with the two months preceding and the two months following. This indicates that there are two natural periods for the best seed germination, the fall and the spring.

The entire test experiment shows a very low average per cent of germination, although care was taken to collect seeds from healthy, mature plants. This suggests one of two things, either that the average per cent of fertile weed seeds is low or that many seeds quickly lose their vitality if they are not allowed to come in contact with moist soil.

The highest average percentage of germination, as well as the shortest dormant periods, is shown by the common mustard (*Brassica sinapistrum*). The percentage of germination for November and December was 100 per cent and for the six months 90.3 per cent. Both Mustard and Yarrow showed a gradual decrease in vitality from month to month, while the dandelion showed a gradual increase.

The general conclusion to be drawn from these experiments is that most weed seeds with thick seed coats require a more or less extended period of rest after maturity, that the seed of the Mustard and Pepper Grass require little time for rest, that the vitality of nearly all weed seeds is weakened by drying out and that the power of germination is increased by exposure to the natural periods for the best seed germination, the fall and the spring.

VIABILITY OF WEED SEEDS.

APRIL Name of Plant	Kept Indoors During Winter: No. of seeds	Date of planting	Days dormant	No. of Days Required for Germination	No. of seeds germinating	Per cent of germination	Exposed to Freezing and Thawing: No. of seeds	Days dormant	No. of Days Required for Germination	No. of seeds germinated	Per cent of germination
Rumex crispus—											
Curled Dock	50	4-14	9	On 10th day, 2; 18th, 1	3	6	----	----		----	----
Curled Dock	50	4-14	----		----	----	----	----		----	----
Chenopodium album—											
Pigweed album	50	4-14	----		----	----	50	----		----	----
Pigweed album	50	4-14	11	On 11th day, 3	3	6	50	9	On 10th day, 5	5	10
Pigweed album	50	4-14	7	On 18th day, 3; 10th, 1	4	8	50	7	On 8th day, 18; 9th, 2; 11th, 1; 20th, 2	23	46
Pigweed album	50	4-14	----		----	----	50	5	On 6th day, 9; 9th, 2	11	22
Amarantus retroflexus—											
Tumbleweed	50	4-14	----		----	----	50	----		----	----
Tumbleweed	50	4-14	7	On 8th day, 4; 14th, 2	6	12	----	----		----	----
Tumbleweed	50	4-14	7	On 8th day, 1; 10th, 4; 11th, 2	7	14	50	7	On 8th day, 2; 10th, 6; 11th, 3	11	22
Tumbleweed	50	4-14	9	On 10th day, 1	1	2	50	9	On 10th day, 2; 11th, 2	4	8
Tumbleweed	50	4-14	5	On 6th day, 4; 9th, 4	8	16	50	5	On 6th day, 4; 9th, 9	13	26
Amarantus blitoides	50	4-14	11	On 12th day, 6; 13th, 6; 24th, 1	13	26	50	11	On 12th day, 5; 13th, 6; 22nd, 3	14	28
Ambrosia artemisiaefolia—											
Ragweed	50	4-14	----		----	----	----	----		----	----
Ragweed	50	----	----		----	----	----	----		----	----
Setaria glauca—											
Yellow Foxtail	50	----	9	On 10th day, 4; 11th, 5; 12th, 4; 18th, 3	14	28	50	6	On 7th day, 5; 9th, 8; 10th, 2; 11th, 1	16	32
Yellow Foxtail	----	----	11	On 12th day, 2; 13th, 8; 25th, 1	11	22	50	9	On 9th day, 13; 12th, 5; 20th, 1	19	38
Setaria viridis—											
Green Foxtail	50	----	6	On 7th day, 2; 10th, 36; 12th, 2; 25th, 1	41	82	50	6	On 7th day, 1; 10th, 19; 14th, 5; 16th, 3 19th, 1	29	58
Green Foxtail	50	----	7	On 8th day, 13; 14th, 2; 15th, 1	16	32	50	----		----	----
Green Foxtail	50	----	19	On 20th day, 1	1	2	50	7	On 8th day, 3; 10th, 2; 11th, 4; 12th, 3	12	24
Green Foxtail	50	----	6	On 7th day, 8; 10th, 12; 14th, 1; 26th, 1	22	44	50	----		----	----
Panicum capillare—											
Old Witch Grass	50	----	13	On 14th day, 1	1	2	50	11	On 12th day, 1	1	2
Old Witch Grass	50	----	----		----	----	50	33	On 34th day, 1	1	2
Panicum crus galli—											
Barnyard Grass	50	----	13	On 14th day, 1	1	2	50	----		----	----
Elymus canadensis—											
Wild Rye	50	----	9	On 9th day, 1	1	2	50	5	On 6th day, 9; 8th, 2; 10th, 10; 12th, 2; 15th, 1	24	48
Asclepias cornuti—											
Milkweed	50	----	----		----	----	----	13	On 14th day, 4	4	8

VIABILITY OF WEED SEEDS—CONTINUED.

APRIL—Cont'd Name of Plant	Kept Indoors During Winter: No. of seeds	Date of planting	Days dormant	No. of Days Required for Germination	No. of seeds germinating	Per cent of germination	Exposed to Freezing and Thawing: No. of seeds	Days dormant	No. of Days Required for Germination	No. of seeds germinated	Per cent of germination
Polygonum pennsylvanicum—											
Smartweed	50										
Smartweed	50										
Smartweed	50						50	9	On 10th day, 25; 11th, 3; 12th, 5; 15th, 3	36	72
Smartweed	50						50	7	On 8th day, 2	2	4
Lepidium apetalum—											
Pepper-grass	50	4-14	7	On 8th day, 20; 12th, 8; 14th, 1	29	54	50				
Pepper-grass	50		0								
Lepidium virginicum—	50		0				50	17	On 18th day, 1	1	2
Capsella bursa-pastoris—											
Shepherd's Purse	50		11	On 12th day, 1	1	2	50				
Sisymbrium officinale—											
Hedge Mustard	50		7	On 8th day, 7; 12th, 5; 25th, 1	13	26					
Brassica sinapistrum—											
Mustard	50		3	On 4th day, 32; 8th, 6; 12th, 4; 34th, 1	43	86	50	11	On 12th day, 1	1	2
Brassica nigra—											
Mustard	50		7	On 8th day, 7; 12th, 1	8	9	50				
Mustard	50										
Achillea millefolium—											
Yarrow	50										
Taraxacum officinale—											
Dandelion	50		7	On 8th day, 5; 10th, 16; 12th, 2; 18th, 3	26	52					
Sonchus oleraceus	50		7	On 8th day, 13; 10th, 2; 12th, 2	17	34					
Lactuca ludoviciana—											
Wild Lettuce	50		9	On 10th day, 1; 12th, 1; 20th, 1; 22nd, 1	4	8					
Eupatorium purpureum—											
Joe Pye Weed	50						50	9	On 10th day, 3; 11th, 8; 12th, 1; 18th, 2; 20th, 1	15	30
Bidens frondosa—											
Stick-tight	50										
Stick-tight	50						50	6	On 7th day, 1	1	2
Verbascum thopsus—											
Mullein	50	4-18					50	7	On 8th day, 1; 10th, 1; 12th, 1	3	6
Cassia chamaecrista	50						50	7	On 8th day, 1; 16th, 1; 20th, 1	3	6

Portulaca oleracea—											
Purslane	50	----	6	On 7th day, 3	3	6	----	----	----	----	----
Purslane	50	----	----	----	----	----	----	----	----	----	----
Purslane	50	----	13	On 14th day, 14	14	28	50	13	On 14th day, 6	6	12
Oenothera biennis—											
Evening Primrose	50	----	13	On 14th day, 2; 16th, 1	3	6	50	13	On 14th day, 2	2	4
Evening Primrose	50	----	7	On 8th day, 1	1	2	50	11	On 12th day, 1	1	2
Verbena urticifolia—											
Wild Verbena	50	----	13	On 14th day, 1; 16th, 1	2	4	50	6	On 7th day, 6; 10th, 5; 12th, 4; 18th, 1	16	32
Verbena stricta—											
Blue Vervain	50	----	----	----	----	----	----	----	----	----	----
Teucrium canadense	50	----	19	On 20th day, 1; 23rd, 2	3	6	50	19	On 20th day, 4; 22nd, 2	6	12
Nepeta glechoma—											
Ground Ivy	50	----	----	----	----	----	----	----	----	----	----
Plantago major—	50	----	17	On 18th day, 2	2	4	50	5	On 6th day, 30; 8th, 6; 13th, 2	38	76
Plantain	50	----	9	On 10th day, 2; 22nd, 1; 25th, 1	4	8	50	9	On 10th day, 2	2	4
Datura stramonium—											
Jimson Weed	50	----	----	----	----	----	50	----	----	----	----
Polanisia trachysperma—											
Polanisia	50	----	11	On 12th day, 2; 13th, 1	3	6	50	---	----	----	----

VIABILITY OF WEED SEEDS—CONTINUED.

Sample No.	NOVEMBER Name of Plant	No. of seeds	Date of collection	Date of planting	Days dormant	No. of Days Required for Germination	No. seeds germinating	Per cent of germination
	Rumex crispus—							
1	Curled Dock	50	10-7	10-14	------	None germinated	---	---
18	Curled Dock	50	9-7	9-24	128	On 129th day, 1; 140th, 1	2	4
	Chenopodium album—							
2	Pigweed	50	10-7	10-14	------	None germinated	---	---
20	Pigweed	50	9-7	9-24	29	On 30th day, 1	1	2
32	Pigweed	50	10-7	10-22	130	On 131st day, 1	1	2
43	Pigweed	50	10-7	10-28	------	None germinated	---	---
73	Pigweed	50	11-7	11-14	65	On 66th day, 5; 71st, 1; 75th, 1; 121st, 1	8	16
	Amarantus retroflexus—							
35	Green Pigweed	50	10-7	10-22	69	On 70th day, 4	4	8
3	Green Pigweed	50	10-7	10-14	29	On 30th day, 8; 45th, 7; 65th, 1	16	32
42	Green Pigweed	50	10-22	10-28	63	On 64th day, 1; 70th, 5	6	12
53	Green Pigweed	50	10-24	10-28	74	On 75th day, 1	1	2
69	Green Pigweed	50	10-24	11-4	45	On 46th day, 2	2	4
80	Green Pigweed	50	10-22	11-4	72	On 73rd day, 1	1	2
	Amerantus blitoides—							
6	Amaranth	50	10-7	10-14	83	On 84th day, 2	2	4
	Ambrosia artemisiaefolia—							
9	Ragweed	50	10-7	10-14	147	On 148th day, 1; 150th, 1	2	4
34	Ragweed	50	10-7	10-22	102	On 103rd day, 1; 130th, 2; 140th, 4; 150th, 1; 160th, 1	9	18
71	Ragweed	50	10-22	11-4	124	On 125th day, 3	3	6
	Ambrosia trifida—							
11	Great Ragweed	50	10-7	10-14	144	On 145th day, 1; 150th, 1; 180th, 1	3	6
46	Great Ragweed	25	10-17	10-28	129	On 130th day, 2; 140th, 1; 150th, 1	4	16
87	Great Ragweed	50	11-5	11-11	------	None germinated	---	---
	Setaria glauca—							
4	Foxtail, Pigeon grass	50	10-7	10-14	18	On 19th day, 1; 150th, 7; 160th, 2	10	20
25	Foxtail, Pigeon grass	50	9-9	9-24	9	On 10th day, 1; 95th, 1	2	4
56	Foxtail, Pigeon grass	50	10-17	10-28	28	On 29th day, 1; 150th, 1	2	4
	Setaria viridis—							
5	Green Foxtail	50	10-7	10-24	8	On 9th day, 20; 160th, 1	21	42
33	Green Foxtail	50	10-7	10-22	12	On 13th day, 19; 20th, 5; 51st, 3; 140th, 1	28	56
55	Green Foxtail	50	10-17	10-28	63	On 64th day, 1; 140th, 2; 160th, 1; 170th, 1	5	10
	Panicum capillare—							
48	Old Witch-grass	50	10-17	10-28	------	None germinated	---	---
7	Old Witch-grass	50	10-7	10-14	------	None germinated	---	---
57	Old Witch-grass	50	10-22	11-4	35	On 36th day, 1; 51st, 2	3	6
76	Old Witch-grass	50	10-22	11-4	------	None germinated	---	---
10	*Panicum crus galli*—							
	Barnyard Grass	50	10-7	10-14	176	On 177th day, 1	1	2

	Hordeum jubatum—							
26	Squirrel-tail Grass	50	9-7	9-24	13	On 14th day, 12; 21st, 10; 41st, 1	23	46
	Agropyrum tenerum—							
78	Couch-grass	50	10-22	11-4	11	On 12th day, 3; 29th, 1; 140th, 5; 160th, 2	11	22
	Elymus canadensis—							
81	Wild Rye	50	11-5	11-11	----	No seeds germinated	----	----
	Asclepias Cornuti—							
12	Milkweed	50	10-7	10-14	----	No seeds germinated	----	----
49	Milkweed	25	10-22	10-28	137	On 138th day, 2; 150th, 1	3	6
	Polygonum pennsylvanicum							
22	Smartweed	50	10-7	10-24	----	No seeds germinated	----	----
15	Smartweed	50	10-7	10-24	----	No seeds germinated	----	----
36	Smartweed	50	10-7	10-22	----	No seeds germinated	----	----
79	Smartweed	50	10-7	11-11	----	No seeds germinated	----	----
	Lepidium apetalum—							
16	Peppergrass	50	9-7	9-24	19	On 20th day, 1	1	2
5.75	Peppergrass	50	10-22	11-4	13	On 14th day, 4; 17th, 3; 19th, 2; 21st, 4; 28th, 2; 34th, 1	16	32
84	*Lepidium virginicum*—							
	Peppergrass	50	11-5	11-11	14	On 15th day, 1; 23rd, 7; 24th, 2; 46th, 5; 70th, 1	16	32
19	*Capsella bursa-pastoris*—							
	Shepherd's Purse	50	9-7	10-24	5	On 6th day, 3; 11th, 1; 19th, 2; 36th, 3	9	18
	Brassica sinapistrum—							
17	Mustard Charlock	50	9-7	9-25	5	On 6th day, 50	50	100
	Brassica nigra—							
54	Black Mustard	50	10-28	10-28	19	On 20th day, 1; 40th, 1	2	4
86	Black Mustard	50	11-5	11-11	----	No seeds germinated	----	----
	Bidens frondasa—							
8	Bur-Marigold	50	10-7	10-14	----	No seeds germinated	----	----
37	Bur-Marigold	50	10-22	10-22	----	No seeds germinated	----	----
31	Bur-Marigold	50	10-22	10-22	139	On 140th day, 2; 150th, 2	4	8
	Erigeron canadensis—							
13	Horse-weed	50	10-7	10-14	8	On 9th day, 27; 28th, 1	28	56
66	Horse-weed	50	10-22	11-4	----	No seeds germinated	----	----
70	Horse-weed	50	10-22	11-4	9	On 10th day, 1	1	2
	Solidago rigida—							
52	Rigid Goldenrod	50	10-17	10-28	----	No seeds germinated	----	----
	Achillea millefolium—							
58	Yarrow	50	10-24	11-4	9	On 10th day, 4; 11th, 3; 34th, 7; 36th, 5; 66th, 4	23	46
	Arctium lappa—							
50	Burdock	50	10-24	10-28	9	On 10th day, 2; 42nd, 1; 80th, 1	4	8
	Sonchus oleraceus—							
23	Sow Thistle	50	10-22	10-24	5	On 6th day, 6; 9th, 6; 40th, 9; 75th, 3; 78th, 1; 160th, 1	26	52
	Lactuca ludoviciana—							
24	Wild Lettuce	50	10-22	10-24	5	On 6th day, 1; 8th, 2; 20th, 1; 24th, 1	5	10
	Taraxacum officinale—							
89	Dandelion	50	11-5	11-11	27	On 28th day, 2; 31st, 1; 32nd, 1; 33rd, 1; 46th, 1; 86th, 1	7	14
	Eupatorium purpureum—							
92	Joe Pye Weed	50	10-22	11-11	49	On 50th day, 1	1	2
	Lophanthus scrophulariaefolius—							
93	Giant Hyssop	50	10-22	11-11	----	None germinated	----	----

VIABILITY OF WEED SEEDS—Continued.

Sample No.	NOVEMBER—Continued Name of Plant	No. of seeds	Date of collection	Date of planting	Days dormant	No. of Days Required for Germination	No. seeds germinating	Per cent of germination
	Convolvulus sepium—							
14	Bindweed	50	10-7	10-14	8	On 9th day, 1; 121st, 1	2	4
41	Bindweed	25	10-17	10-22	72	On 73rd day, 1	1	4
	Verbascum thapsus—							
30	Mullein	50	10-7	10-22	26	On 27th day, 2	2	4
67	Mullein	50	10-24	11-4	----	No seeds germinated	----	----
	Melilotus alba—							
49	Sweet Clover	50	10-17	10-22	----	No seeds germinated	----	----
	Cassia chamaecrista—							
44	Partridge Pea	50	10-22	10-28	46	On 47th day, 1; 64th, 1; 67th, 1; 82nd, 1; 84th, 1; 95th, 1; 100th, 1	7	14
	Acalypha virginica—							
39	3-seeded Mercury	50	10-17	10-22	139	On 140th day, 4	4	8
	3-seeded Mercury	50	10-24	11-4	130	On 131st day, 2	2	4
	Portulaca oleracea—							
40	Purslane	50	10-17	10-22	----	No seeds germinated	----	----
77	Purslane	50	10-24	11-4	----	No seeds germinated	----	----
	Mimulus ringens—							
51	*Mimulus ringens*—	50	10-17	10-28	----	No seeds germinated	----	----
62	*Mimulus ringens*—	50	10-15	11-4	----	No seeds germinated	----	----
	Oenothera biennis—							
68	Primrose	50	10-17	10-28	----	No seeds germinated	----	----
	Primrose	50	11-17	11-26	----	No seeds germinated	----	----
	Verbena urticifolia—							
59	Wild Verbena	50	10-15	11-26	----	No seeds germinated	----	----
	Verbena stricta—							
63	Blue Vervain	50	10-15	11-4	----	No seeds germinated	----	----
72	Blue Vervain	50	10-15	11-4	----	No seeds germinated	----	----
	Cynoglossum virginicum—							
63	Hound's Tongue	50	10-15	11-6	----	No seeds germinated	----	----
	Scrophularia nodosa—							
61	Simpson Honey Plant	50	10-15	11-4	----	No seeds germinated	----	----
68	Simpson Honey Plant	50	10-24	11-4	----	No seeds germinated	----	----
	Lobelia syphilitica—							
64	Great Blue Lobelia	50	10-15	11-4	----	No seeds germinated	----	----
90	Great Blue Lobelia	50	11-5	11-11	9	On 10th day, 1; 79th, 1	2	4
	Teucrium canadense—							
65	Germander	50	10-24	11-4	9	On 10th day, 1	1	2
	Abutilon avicennae—							
74	Velvet Leaf	50	10-22	11-4	----	No seeds germinated	----	----

83	*Nepeta glechoma*— Ground Ivy	50	10-22	11-4	9	On 10th day, 1; 45th, 1; 49th, 5; 50th, 1; 51st, 2; 79th, 1	11	22
82	*Monarda fistulosa*— Horse-mint	50	10-22	11-11	------	No seeds germinated	----	----
85	*Plantago major*— Plantain	50	10-22	11-11	------	No seeds germinated	----	----
88	*Datura stramonium*— Jamestown (Jimson) Weed	50	11-5	11-11	------	No seeds germinated	----	----
91	*Polanisia trachysperma*	50	10-22	11-11	------	No seeds germinated	----	----
94	*Veronica virginica*— Culver's Root	50	9-14	11-11	------	No seeds germinated	----	----

VIABILITY OF WEED SEEDS—Continued

Sample No.	DECEMBER Name of Plant	No. of seeds	Date of collection	Date of planting	Days dormant	No. of Days Required for Germination	No. of seeds germinating	Per cent of germination
	Rumex crispus—							
1	Curled Dock	50		11-11				
18	Curled Dock	50		12-2	157	On 158th day, 5	5	10
	Chenopodium album—							
2	Lamb's Quarter	50		11-11				
20	Lamb's Quarter	50		12-2	7	On 8th day, 1; 9th, 1; 11th, 3; 12th, 2; 25th, 6; 29th, 2; 30th, 1	16	32
32	Lamb's Quarter	50		11-18				
43	Lamb's Quarter	50		11-26				
73	Lamb's Quarter	50		12-2				
	Amarantus retroflexus—							
35	Green Pigweed	50		11-18	44	On 45th day, 1; 47th, 3	4	8
21	Green Pigweed	50		12-2	7	On 8th day, 3; 10th, 3; 11th, 3; 13th, 1; 16th, 2; 30th, 6; 32nd, 1	19	38
42	Green Pigweed	50		11-26	12	On 13th day, 2; 18th, 6; 32nd, 1; 61st, 15	24	48
53	Green Pigweed	50		11-26	30	On 31st day, 1; 33rd, 4; 62nd, 7	12	24
69	Green Pigweed	50		12-5	15	On 16th day, 2; 27th, 1; 35th, 3	6	12
80	Green Pigweed	50		12-2	24	On 25th day, 5; 32nd, 3; 34th, 1	9	18
	Amarantus blitoides—							
6	Amaranth	50		11-11	26	On 27th day, 5; 28th, 6; 29th, 1; 37th, 1	13	26
	Ambrosia artemisiaefolia—							
9	Ragweed	25		11-11	157	On 158th day, 1	1	4
	Ragweed	50		11-11	102	On 103rd day, 1	1	2
	Ambrosia trifida—							
	Great Ragweed	50		11-11	140	On 141st day, 1	1	2
	Setaria glauca (Foxtail)	50		11-11	45	On 46th day, 1; 145th, 1; 174th, 2	4	8
	Setaria glauca (Foxtail)	50		12-2	12	On 13th day, 2; 14th, 2; 16th, 2; 35th, 2	8	16
	Setaria glauca (Foxtail)	50		11-26				
	Setaria viridis (Foxtail)	50		11-11	12	On 13th day, 23; 16th, 5; 30th, 2; 41st, 1; 61st, 2	33	66
	Setaria viridis (Foxtail)	50		11-26	7	On 8th day, 25; 10th, 6; 13th, 3; 17th, 1; 48th, 1	36	72
	Setaria viridis (Foxtail)	50		11-18				
	Panicum capillare—							
	Old Witch Grass	50		11-26				
	Old Witch Grass	50		11-11	26	On 27th day, 6; 28th, 3; 37th, 4	13	26
	Old Witch Grass	50		12-2	30	On 31st day, 1; 32nd, 2	3	6
	Panicum crus-galli—							
	Barnyard Grass	50		11-11	27	On 28th day, 1	1	2
	Agropyrum tenerum	25						
	Couch Grass			12-2	9	On 10th day, 7; 11th, 5; 14th, 2; 16th, 3	17	34
	Elymus canadensis	50						
	Wild Rye			12-2	13	On 14th day, 1; 22nd, 1; 133rd, 1	3	6

	Asclepias cornuti—							
12	Milkweed	25	------	11-11	------	No seeds germinated	----	----
49	Milkweed	25	------	11-26	16	On 17th day, 1; 35th, 1; 37th, 1; 38th, 2; 40th, 1; 62nd, 2	8	16
	Polygonum pennsylvanicum—							
22	Smartweed	50	------	12-2	------	No seeds germinated	----	----
15	Smartweed	50	------	12-2	------	No seeds germinated	----	----
36	Smartweed	50	------	12-2	------	No seeds germinated	----	----
79	Smartweed	50	------	12-2	------	No seeds germinated	----	----
16	*Lepidium apetalum*—							
	Pepper-grass	50	------	12-2	5	On 6th day, 15; 7th, 7; 10th, 1; 25th, 1; 67th, 1	25	50
57.5	Pepper-grass	50	------	12-2	6	On 7th day, 3; 10th, 2; 11th, 2; 13th, 7; 14th, 2	16	32
84	*Lepidium virginicum*—							
	Pepper-grass	50	------	12-2	9	On 10th day, 2; 11th, 3; 13th, 2; 16th, 2; 25th, 8; 31st, 2; 35th, 2; 45th, 1; 56th, 1; 82nd, 1	26	52
19	*Capsella bursa-pastoris*	50	------	------	------		----	----
	Shepherd's Purse	----	------	12-2	6	On 7th day, 2; 10th, 1	3	6
	Sisymbrium officinale—							
27	Hedge Mustard	50	------	12-2	4	On 5th day, 16; 6th, 15; 7th, 4; 8th, 15; 10th, 1; 11th, 2; 12th, 1	50	100
17	*Brassica sinapistrum*—	50	------	------	------		----	----
	Mustard	----	------	12-2	3	On 4th day, 22; 5th, 22; 6th, 3; 13th, 1; 14th, 2	50	100
54	*Brassica nigra*—							
86	Black Mustard	50	------	11-26	5	On 6th day, 3; 9th, 7; 11th, 2	12	24
84	Black Mustard	50	------	11-26	------	No seeds germinated	----	----
	Achillea millefolium—							
58	Yarow	50	------	12-9	6	On 7th day, 14; 11th, 7; 13th, 2; 14th, 1; 34th, 2; 43rd, 1	27	54
	Arctium lappa—							
50	Burdock	50	------	11-23	12	On 13th day, 1; 17th, 2; 18th, 6; 19th, 1; 31st, 1; 35th, 1	12	24
	Taraxacum officinale—							
89	Dandelion	50	------	11-11	5	On 6th day, 2; 7th, 5; 10th, 1; 15th, 2	10	20
29.5	Dandelion	50	------	11-11	6	On 7th day, 4; 8th, 1; 10th, 3; 11th, 8; 13th, 3; 14th, 1; 25th, 1	21	42
	Sonchus oleracea—							
23	Sow-Thistle	50	------	10-24	5	On 6th day, 1; 7th, 1; 8th, 7; 11th, 2; 12th, 1	12	24
	Lactuca ludoviciana—							
24	Lettuce	50	------	9-24	------	No seeds germinated	----	----
	Eupatorium purpureum—							
92	Joe Pye Weed	50	------	11-11	15	On 16th day, 3	3	6
	Lophanthes scrophulariaefolius—Hyssop							
93		50	------	11-11	------	No seeds germinated	----	----
	Bidens frondosa—							
8	Stick-tight	50	------	11-18	------	No seeds germinated	----	----
	Stick-tight	50	------	11-18	180	On 181st day, 1	1	2
	Verbascum thapsus—							
30	Mullein	50	------	12-2	------	No seeds germinated	----	----
67	Mullein	50	------	12-2	------	No seeds germinated	----	----
	Melilotus alba—							
45	Sweet clover	50	------	12-2	5	On 6th day, 1; 116th, 1	2	4
	Cassia chamaecrista—							
44	Partridge Pea	50	------	11-26	30	On 31st day, 1; 42nd, 1; 53rd, 1; 116th, 1	4	8
	Acalypha virginica—							
75	3-seeded Mercury	50	------	12-12	------	No seeds germinated	----	----

VIABILITY OF WEED SEEDS—Continued.

Sample No.	DECEMBER—Continued Name of Plant	No. of seeds	Date of collection	Date of planting	Days dormant	No. of Days Required for Germination	No. of seeds germinating	Per cent of germination
	Portulaca oleracea—							
40	Purslane	50		11-18		No seeds germinated		
29	Purslane	50		12-12		No seeds germinated		
77	Purslane	50		12-12		No seeds germinated		
	Oenothera biennis—							
38	Evening Primrose	50		11-18		No seeds germinated		
47	Evening Primrose	50		11-26		No seeds germinated		
59	*Verbena urticifolia*—							
63	Vervain	50		11-4		No seeds germinated		
	Verbena stricta—							
72	Blue vervain	50		12-2		No seeds germinated		
	Blue vervain	50		12-2		No seeds germinated		
65	*Teucrium canadense*—							
	Germander	50		12-2		No seeds germinated		
	Monarda fistulosa—							
82	Horsemint	50		12-2	9	On 10th day, 1; 11th, 1; 13th, 6; 14th, 3; 20th, 1; 27th, 2; 29th, 4; 32nd, 1; 57th, 2	21	42
	Nepeta glechoma—							
33	Ground Ivy	50		12-2	24	On 25th, 1; 31st, 1; 45th, 2	4	8
	Plantago major—							
85	Plantain	50		12-9		No seeds germinated		
28	Plantain	50		12-2		No seeds germinated		
88	*Datura stramonium*			12-9		No seeds germinated		
	Jimson Weed	50						
	Polanisia trachysperma—							
91	Polanisia	50		12-9	8	On 9th day, 1	1	2

VIABILITY OF WEED SEEDS—CONTINUED.

Sample No.	JANUARY Name of Plant	No. of seeds	Date of collection	Date of planting	Days dormant	No. of Days Required for Germination	No. of seeds germinating	Per cent of germination
	Rumex crispus—							
1	Curled Dock	50	------	1-5	------	No seeds germinated	----	----
18	Curled Dock	50	------	1-6	------	No seeds germinated	----	----
	Chenopodium album—							
2	Pigweed	50	------	1-5	------	No seeds germinated	----	----
20	Pigweed	50	------	1-6	9	On 10th day, 1; 13th, 2	3	6
32	Pigweed	50	------	1-5	8	On 8th day, 1	1	2
43	Pigweed	50	------	1-5	------	No seeds germinated	----	----
	Amarantus retroflexus—							
35	Green Pigweed, Tumbleweed	50	------	1-5	------	No seeds germinated	----	----
21	Green Pigweed, Tumbleweed	50	------	1-6	12	On 13th day, 1; 14th, 1	2	4
42	Green Pigweed, Tumbleweed	50	------	1-5	85	On 86th day, 1	1	2
53	Green Pigweed, Tumbleweed	50	------	1-5	7	On 8th day, 1	1	2
69	Green Pigweed, Tumbleweed	50	------	1-6	6	On 7th day, 1	1	2
80	Green Pigweed, Tumbleweed	50	------	1-6	8	On 9th day, 1; 10th, 1; 11th, 1; 14th, 3	6	12
	Amarantus blitoides—							
6	Amaranth	50	------	1-5	------	No seeds germinated	----	----
	Ambrosia artemisiaefolia—							
9	Hog-weed	50	------	1-5	42	On 43rd day, 1; 104th, 1	2	4
34	Hog-weed	50	------	1-6	------	No seeds germinated	----	----
	Ambrosia trifida—							
11	Ragweed	50	------	1-5	------	No seeds germinated	----	----
46	Ragweed	25	------	1-5	15	On 16th day, 1; 29th, 1; 83rd, 1; 86th, 1	4	16
	Setaria glauca—							
4	Yellow Foxtail	50	------	1-6	84	On 85th day, 1	1	2
25	Yellow Foxtail	50	------	1-5	11	On 12th day, 3; 27th, 1	4	8
56	Yellow Foxtail	50	------	1-5	9	On 10th day, 2; 14th, 1	3	6
	Setaria viridis—							
5	Green Foxtail	50	------	1-5	7	On 8th day, 6; 14th, 2; 24th, 1	9	18
33	Green Foxtail	50	------	1-5	5	On 6th day, 10; 9th, 11; 10th, 8; 12th, 1	30	60
55	Green Foxtail	50	------	1-5	13	On 14th day, 1	1	2
	Panicum capillare—							
48	Old Witch-Grass	50	------	1-5	------	No seeds germinated	----	----
7	Old Witch-Grass	50	------	1-5	------	No seeds germinated	----	----
57	Old Witch-Grass	50	------	1-5	13	On 14th day, 2; 23rd, 3; 24th, 1; 31st, 1; 34th, 2; 41st, 1	10	20
	Panicum crus-galli—							
10	Barnyard Grass	50	------	1-5	------	No seeds germinated	----	----
	Elymus canadensis—							
81	Wild Rye	50	------	1-6	13	On 14th day, 2; 27th, 3; 28th, 1; 29th, 2; 30th, 1	9	18

VIABILITY OF WEED SEEDS—CONTINUED.

Sample No.	JANUARY—Continued Name of Plant	No. of seeds	Date of collection	Date of planting	Days dormant	No. of Days Required for Germination	No. of seeds germinating	Per cent of germination
	Agropyrum tenerum—							
78	Couch-grass	25		1-6	5	On 6th day, 1; 7th, 8; 8th, 3; 12th, 6; 16th, 5; 46th, 1	24	96
	Asclepias cornuti—							
12	Milkweed	50		1-5				
49	Milkweed	50		1-5	11	On 12th day, 1	1	2
	Polygonum pennsylvanicum—							
22	Smartweed	50		1-6	15	On 16th day, 1	1	2
15	Smartweed	50		1-5				
36	Smartweed	50		1-5				
79	Smartweed	50		1-6				
	Lepidium apetalum—							
16	Peppergrass	50		1-6	5	On 6th day, 9; 7th, 7; 8th, 1; 9th, 1; 91st, 2	20	40
57.5	Peppergrass	50		1-6	5	On 6th day, 1; 7th, 3; 8th, 1; 10th, 3; 15th, 8	16	32
	Lepidium virginicum—							
84	Peppergrass	50		1-6				
	Capsella bursa-pastoris—							
19	Shepherd's Purse	50		1-5	4	On 5th day, 1; 118th, 1; 128th, 1	3	6
	Sisymbrium officinale—							
27	Hedge Mustard	50		1-5	4	On 5th day, 5; 6th, 2; 7th, 3; 10th, 2	12	24
	Brassica sinapistrum—							
17	Mustard	50		1-5	3	On 4th day, 41; 5th, 3; 6th, 2	46	92
	Brassica nigra—							
54	Mustard	50		1-5	8	On 4th day, 2; 6th, 2	4	8
86	Mustard	50		1-6				
	Achillea millefolium—							
58.5	Yarrow	50		1-5	5	On 6th day, 12; 7th, 2; 10th, 2; 54th, 1	17	34
	Arctium lappa—							
50	Burdock	25		1-5				
	Taraxacum officinale—							
29.5	Dandelion	50		1-5	5	On 6th day, 2; 7th, 4; 8th, 9; 9th, 7; 10th, 5; 13th, 6	33	66
	Eupatorium purpureum—							
92	Joe Pye Weed	50		1-6	9	On 10th day, 2	2	4
	Lophanthus scrophulariaefolius—Giant Hyssop							
93		50		1-6				
	Bidens frondosa—							
8	Stick-tight	50		1-5				
31	Stick-tight	50		1-5				
	Verbascum thapsus—							
30	Mullein	50		1-5				
67	Mullein	50		1-5				

	Cassia chamaecrista—							
44	Partridge Pea	25		1-5	54	On 55th day, 1; 56th, 1; 57th, 1	3	12
	Acalypha virginica—							
75	3-seeded Mercury	50		1-6				
	Portulaca oleracea—							
40	Purslane	50		1-5				
29	Purslane	50		1-5				
77	Purslane	50		1-5	12	On 13th day, 3	3	6
	Oenothera biennis—							
38	Evening Primrose	50		1-6				
47	Evening Primrose	50		1-5				
	Verbena urticifolia—							
59	Wild Verbena	50		1-5				
	Verbena stricta—							
63	Blue Vervain	50		1-6				
72		50		1-6				
	Teucrium canadense—							
65	Germander	50		1-5				
	Monarda fistulosa—							
82	Horse-mint	50		1-6	6	On 7th day, 1; 8th, 3; 9th, 2; 10th, 3	9	12
	Nepeta glechoma—							
83	Ground Ivy	50		1-6				
	Plantago major—							
85	Plantain	50		1-6				
28	Plantain	50		1-5				
	Datura stramonium—							
88	Jimson-weed	50		1-6				
	Polanisia trachysperma—							
91	Polanisia	50		1-6				
	Chenopodium album—							
2	Lamb's Quarter	50		1-5				
20	Lamb's Quarter	50		1-6				
32	Lamb's Quarter	50		1-6				
43	Lamb's Quarter	50		1-5				

VIABILITY OF WEED SEEDS—CONTINUED.

Sample No.	FEBRUARY Name of Plant	No. of seeds	Date of collection	Date of planting	Days dormant	No. of Days Required for Germination	No. of seeds germinating	Per cent of germination
	Rumex crispus—							
1	Curled Dock	50		2-9	76	On 77th day, 1		
18	Curled Dock	50		2-10	31	On 32nd day, 3; 64th, 1		
	Chenopodium album—							
2	Lamb's Quarter	50		2-9				
20	Lamb's Quarter	50		2-10	12	On 13th day, 1; 25th, 1; 62nd, 1		
32	Lamb's Quarter	50		2-9				
43	Lamb's Quarter	50		2-9				
73	Lamb's Quarter	50		2-10				
	Amarantus retroflexus—							
35	Pigweed	50		2-9				
21	Pigweed	50		2-10	38	On 39th day, 2 41st, 1		
53	Pigweed	50		2-9	25	On 98th day, 2	2	4
69	Pigweed	50		2-10		On 26th day, 2		
80	Pigweed	50		2-10				
	Amarantus blitoides—							
6	Pigweed	50		2-9				
	Ambrosia artemisiaefolia—							
9	Hogweed	50		2-9	58	On 59th day, 1		
34	Hogweed	50		2-9	25	On 26th day, 1; 41st, 1; 47th, 1; 48th, 1; 49th, 2; 59th, 1; 78th, 1		
	Ambrosia trifida—							
11	Ragweed	50		2-9				
46	Ragweed	50		2-9				
	Setaria glauca—							
4	Yellow Foxtail	50		2-9	75	On 76th day, 3; 82nd, 1; 29th, 5; 39th, 1		
25	Yellow Foxtail	50		2-10	24	On 25th day, 3; 30th, 5; 39th, 1		
56	Yellow Foxtail	50		2-9	20	On 21st day, 2; 29th, 4		
	Setaria viridis—							
5	Green Foxtail	50		2-9	11	On 12th day,		
33	Green Foxtail	50		2-9	11	On 12th day, 12; 13th, 9; 16th, 2		
55	Green Foxtail	50		2-9	81			
	Panicum capillare—							
48	Old Witch Grass	50		2-9				
7	Old Witch Grass	50		2-9	73	On 74th day, 1; 76th, 3	4	8
57	Old Witch Grass	50		2-9				
	Panicum crus-galli—							
10	Barnyard Grass	50		2-9	97	On 9th day, 2	2	4
	Elymus robustus—			2-10				
81	Wild Rye	50		2-9				

	Agropyrum tenerum—							
78	Quack Grass	50	------	2-10	18	On 19th day, 1; 21st, 4; 28th, 1; 78th, 1	7	14
	Asclepias cornuti—							
72	Milkweed	50	------	2-9	25	On 26th day, 1; 27th, 1; 29th, 1; 31st, 2	5	10
49	Milkweed			•				
	Veronica virginica—							
94	Culver's Root	50	------	2-9	25	On 26th day, 1; 40th, 1; 82nd, 1	3	6
	Abutilon avicennae—							
74	Velvet Leaf	50	------	2-10	------	------	----	----
	Polygonum pennsylvanicum—							
22	Smartweed	50	------	2-10	------	------	----	----
15	Smartweed	50	------	2-10	------	------	----	----
36	Smartweed	50	------	2-9	------	------	----	----
79	Smartweed	50	------	2-9	------	------	----	----
	Lepidium apetalum—							
16	Peppergrass	50	------	2-10	12	On 13th day, 16; 19th, 1; 42nd, 2; 44th, 4	23	46
57.5	Peppergrass	50	------	2-9	------	------	----	----
	Capsella bursa-pastoris—							
19	Shepherd's Purse	50	------	2-10	31	On 31st day, 1	1	2
	Sisymbrium officinale—							
27	Hedge Mustard	50	------	2-10	7	On 8th day, 1 13th, 3	4	8
	Brassica sinapistrum—							
17	Mustard	50	------	2-10	7	On 8th day, 36	36	72
	Brassica nigra—							
54	Mustard	50	------	2-10	------	------	----	----
	Mustard	50	------	2-10	------	------	----	----
	Achillea millefolium—							
58	Yarrow	50	------	2-9	20	On 21st day, 1; 82nd, 3	4	8
	Arctium lappa—							
50	Burdock	50	------	2-9	28	On 29th day, 1	1	2
	Taraxacum officinale—							
29.5	Dandelion	50	------	2-10	24	On 25th day, 1; 30th, 1; 32nd, 1; 39th, 2	5	10
	Eupatorium purpureum—							
92	Joe-Pye Weed	50	------	2-10	------	------	----	----
	Lopanthus scrophulariaefolia							
	Giant Hyssop	50	------	2-10	------	------	----	----
8	*Bidens frondosa*—							
	Stick-tight	50	------	2-9	97	On 98th day, 4	4	8
31	Stick-tight	50	------	2-9	------	------	----	----
	Verbascum thapsus—							
30	Mullein	50	------	2-9	------	------	----	----
	Melilotus alba—							
45	Sweet Clover	50	------	2-9	------	------	----	----
	Cassia chamaecrista—							
44	Partridge Pea	50	------	2-9	------	------	----	----
	Acalypha virginica—							
75	3-seeded Mercury	50	------	2-9	------	------	----	----
	Portulaca oleracea—							
40	Purslane	50	------	2-9	------	------	----	----
29	Purslane	50	------	2-9	------	------	----	----
77	Purslane	50	------	2-9	------	------	----	----

VIABILITY OF WEED SEEDS—CONTINUED.

Sample No.	FEBRUARY—Continued Name of Plant	No. of seeds	Date of collection	Date of planting	Days dormant	No. of Days Required for Germination	No. of seeds germinating	Per cent of germination
	Oenothera biennis—							
38	Evening Primrose	50	------	2-9	------	------	----	----
47	Evening Primrose	50	------	2-9	------	------	----	----
	Verbena urticifolia—							
59	Wild Verbena	50	------	2-9	------	------	----	----
	Verbena stricta—							
63	Vervain	50	------	2-10	------	------	----	----
72	Vervain	50	------	2-10	------	------	----	----
	Teucrium canadense—							
65	Germander	50	------	2-9	------	------	----	----
	Monarda fistulosa—							
82	Horse-mint	50	------	2-10	------	------	----	----
	Plantago major—							
28	Plantain	50	------	2-10	28	On 29th day, 1	1	2
83	*Datura stramonium*	50	------	2-10	------	------	----	----
91	*Polanisia trachysperma*—	50	------	2-10	------	------	----	----

VIABILITY OF WEED SEEDS—CONTINUED.

No	MARCH Name of Plant	No. of seeds	Date of collection	Date of planting	Days dormant	No. of Days Required for Germination	No. of seeds germinating	Per cent of germination
	Rumex crispus—							
1	Curled Dock	50	------	3-10	14	On 15th day, 2	2	4
	Curled Dock	50	------	3-11	------		----	----
	Chenopodium album—							
	Pigweed or Lamb's Quarter	50	------	3-10	10	On 11th day, 1	1	2
	Pigweed or Lamb's Quarter	50	------	3-11	9	On 10th day, 1; 13th, 1; 18th, 4	7	14
	Pigweed or Lamb's Quarter	50	------	3-10	9	On 10th day, 1	1	2
	Pigweed or Lamb's Quarter	50	------	3-10	4	On 5th day, 1; 18th, 3	4	8
	Pigweed or Lamb's Quarter	50	------	3-11	------		----	----
	Amarantus retroflexus—							
35	Green Pigweed	50	------	3-10	11	On 12th day, 1; 18th, 2	3	6
	Green Pigweed	50	------	3-11	9	On 10th day, 6; 17th, 5; 21st, 1	12	24
	Green Pigweed	50	------	3-10	11	On 12th day, 6; 21st, 3	9	18
	Green Pigweed	50	------	3-10	16	On 17th day, 2	2	4
	Green Pigweed	50	------	3-10	16	On 17th day, 1	1	2
	Green Pigweed	50	------	3-10	8	On 9th day, 1; 10th, 2; 17th, 1	4	8
	Amarantus blitoides—							
	Pigweed	50	------	3-10	37	On 38th day, 1	1	2
	Ambrosia artemisiaefolia—							
	Ragweed	50	------	3-10	23	On 24th day, 1	1	2
	Ragweed	50	------	3-10	19	On 19th day, 1	1	2
	Setaria glauca—							
	Yellow Foxtail	50	------	3-10	12	On 13th day, 1; 15th, 4; 17th, 12; 23rd, 2; 25th, 1	20	40
	Yellow Foxtail	50	------	3-10	10	On 11th day, 27; 12th, 12; 17th, 5; 21st, 1	13	26
	Yellow Foxtail	50	------	3-10	13	On 14th day, 1 17th, 2; 21st, 5; 23rd, 2	45	90
	Setaria viridis—							
	Green Foxtail	50	------	3-10	9	On 10th day, 26 12th, 6	32	64
	Green Foxtail	50	------	3-10	10	On 11th day, 1; 19th, 1; 23rd, 1	3	6
	Panicum capillare—							
	Old Witch Grass	50	------	3-10	------		----	----
	Old Witch Grass	50	------	3-10	------		----	----
	Old Witch Grass	50	------	3-10	------		----	----
	Panicum crus-galli—							
	Barnyard Grass	50	------	3-10	------		----	----
	Elymus canadensis—							
	Wild Rye	50	------	3-11	9	On 10th day, 1; 28th, 1	2	4
	Asclepias cornuti—							
	Milkweed	50	------	3-10	------		----	----
	Milkweed	50	------	3-10	------		----	----

VIABILITY OF WEED SEEDS—CONTINUED.

Sample No.	MARCH—Continued Name of Plant	No. of seeds	Date of collection	Date of planting	Days dormant	No. of Days Required for Germination	No. of seeds germinating	Per cent of germination
	Ambrosia trifida—							
71	Hogweed	20	------	3-10	51	On 52nd day, 1	1	2
46	Hogweed	25	------	3-10	10	On 11th day, 1; 15th, 2; 21st, 6; 24th, 1; 39th, 2; 58th, 1	13	26
	Veronica virginica—							
94	Culver's Root	50	------	3-11	56	On 57th day, 1	1	2
	Abutilon avicennae—							
74	Velvet Leaf	50	------	3-10	8	On 9th day, 1; 10th, 1; 28th, 1	3	6
	Polygonum pennsylvanicum—							
22	Smartweed	50	------	3-10	------	------	----	----
15	Smartweed	50	------	3-9	------	------	----	----
36	Smartweed	50	------	3-10	------	------	----	----
79	Smartweed	50	------	3-11	------	------	----	----
	Agropyrum tenerum—							
78	Quack-grass	50	------	3-11	16	On 17th day, 10; 20th, 5; 22nd, 2; 45th, 1	18	36
	Lepidium virginicum—							
84	Pepper-grass	50	------	3-11	9	On 10th day, 11; 28th, 1; 38th, 1; 48th, 1	14	28
	Lepidium apetalum—							
16	Pepper-grass	50	------	3-10	9	On 10th day, 33	33	66
57.5	Pepper-grass	50	------	3-10	1.	On 12th day, 5; 17th, 1; 22nd, 2; 27th, 3; 29th, 1; 67th, 1	13	26
	Capsella bursa-pastoris—							
19	Shepherd's Purse	50	------	3-10	9	On 10th day, 1; 21st, 1	2	4
	Sisymbrium officinale—							
27	Hedge Mustard	50	------	3-10	4	On 5th day, 1; 10th, 10	11	22
	Brassica sinapistrum—							
17	Mustard	50	------	3-10	3	On 4th day, 41; 7th, 6	47	94
	Brassica nigra—							
54	Mustard	50	------	3-10	10	On 11th day, 4	4	8
86	Mustard	50	------	3-11	8	On 9th day, 1	1	2
	Achillea millefolium—							
58	Yarrow	50	------	3-11	13	On 14th day, 1; 67th, 3	4	8
	Arctium lappa—							
50	Burdock	50	------	3-10	21	On 22nd day, 1; 24th, 1	2	4
	Taraxacum officinale—							
89	Dandelion	50	------	3-11	9	On 10th day, 8; 11th, 3	11	22
	Eupatorium purpureum—							
92	Joe Pye Weed	50	------	3-11	------	------	----	----
	Lophantus schophulariafolius							
93	Giant Hyssop	50	------	3-11	------	------	----	----
	Bidens frondosa—							
8	Stick-tight	50	------	3-11	------	------	----	----
31	Stick-tight							

	Verbascum thapsus—							
30	Mullein	50		3-10				
	Melilotus alba—							
45	Sweet Clover	50		3-10				
	Acalypha virginica—							
75	Giant Hyssop	50		3-10	11	On 12th day, 1	1	2
	Portulaca oleracea—							
40	Purslane	50		3-10				
29	Purslane	50		3-10				
77	Purslane	50		3-10				
	Oenothera biennis—							
38	Evening Primrose	50		3-10				
47	Evening Primrose	50		3-10				
	Verbena urticifolia—							
59	Wild Verbena	50		3-10	14	On 15th day, 2	2	4
	Verbena stricta—							
63	*Verbena stricta*	50		3-10				
72	*Verbena stricta*	50		3-10				
	Teucrium canadense—							
65	Germander	50		3-10				
	Monarda fistulosa—							
82	Horsemint	50		3-10	9	On 10th day, 1; 17th, 2; 19th, 1; 44th, 1; 46th, 2	7	14
	Plantago major—							
28	Plantain	50		3-10	55	On 56th day, 1	1	2
	Datura stramonium—							
88	Jimson-weed	50		3-11				
	Polanisia trachysperma—							
91	Polanisia	50		3-11				

NOTES ON THE HISTOLOGICAL STRUCTURE AND SPECIFIC GRAVITY OF THE SEEDS OF PYRUS.

BY L. H. PAMMEL AND LUELLA ROBB.

A number of investigators have made a careful study of the seeds of the common quince *(Pyrus vulgaris)*, largely because of its use in connection with medicine and the interest attached to the mucilaginous character of the epidermal cell walls of the outer seed coat[1]. Little attention, however, has been paid to the structure of the seeds of the common apple. Kratzman[2], Vinton and Moeller[3], Hill[4], and Harz[5] call attention to the structure of the testa.

The cultivated apple is a very variable species, not only with reference to the general morphology of the seeds, fruit, flower and leaves, but the microscopical structure also shows considerable variation. This is not strange if one considers what the probable origin of the apple is. The so-called *Pyrus malus* is variously considered as having been derived from a wild form which exists in Europe and eastward as indicated by Prof. Beach[6], who says: "The original home of the apple, *P. malus*, is not definitely known. After examining the evidence carefully A. DeCandolle came to the conclusion that it is most (?) indigenous to the region south of Caucasus, from the Persian province Ghilan on the Caspian to Trebizond on the Black Sea, and that from prehistoric times it has existed in Europe, both wild and cultivated, over an area extending from the Caspian Sea to the Atlantic Ocean, except in the extreme north. He cites it as being found wild in the mountains of Northwest India, but not in Japan, Mongolia or Siberia."

Focke[7] says that the apple was known in both wild and cultivated forms in very early times, having been grown by the Swiss in their Lake villages, and that numerous species now known are the results of crossing and careful selection. A primitive, shrub-like form, *P. pumila*, still grows in the Caucasian and southern Altai regions and a somewhat more tree-like form, *P. dasyphylla*, is found in the orient, the flowers of both these varieties being somewhat woolly when young. The *P. prunifolia*, a garden tree, according to some authors, is found on the Siberian-Chinese borders and has a somewhat hairy blossom, woolly pistil and long stalked fruit; this is the primitive form of the Astrachan or Russian apple. Many species of the apple come from accidental crossing, and by cultivation these forms have become permanent. The Romans recognized twenty-nine varieties of the cultivated apple, while at present we have hundreds.

See Bibliography.

2. Kratzmann: Die Lehre von Samen 41.
3. The Microscopy of Vegetable foods with special reference to diagnosis of mixtures 323.
4. Annals of Botany 20; 395.
5. Landwfrthschaftliche Samenkunde. Berlin 1885.
6. Beach, Booth and Taylor, "Apples of New York." *1.*
7. W. O. Focke in Engler and Prantl, Die naturlichen Pflanzenfamilien, Rosaceæ, III Theil. 3 Abth., 22.

According to Winton and Hanausek the testa consists of six layers which they designate as: First, the outer epidermis with outer walls, greatly thickened and a laminated structure. Second, the hypodermal structure with greatly thickened pore walls. Third, the tube cells, a layer of loose tissue of two or three layers with rather thickened walls. Fourth, cross cells like the tube cells but with transversely elongated elements. Fifth, starch cells, thin walled cells which contain minute starch grains. Sixth, the inner coat or inner epidermis, as they call it, this consists of transversely elongated cells with polygonal form and intercellular spaces absent. The coat is followed by the perisperm, endosperm, and embryo.

Harz in his study of the fruit of Poterium and Sanguisorba indicates that the testa consists of elongated cells with fine granular contents, underneath the epidermas three or four rows of compressed cells, this represents probably the perisperm or the inner testa

The endosperm consists of a single row of cells somewhat longer than broad, filled with granular material, the cells of the embryo in contact with the endosperm are isodiametric or sometimes a little longer than broad without palisade parenchyma. The palisade parenchyma occurs upon the upper face of the cotyledons or where the two cotyledons meet. The embryo contains no starch, but an abundance of fat and protein.

The seeds of Sanguisorba consist of the testa and endosperm and a probable remnant of the perisperm. The testa is thin without sclerenchyma elements, the outer rows consist of rather thin walled parenchyma cells, the two or three layers underneath are like it, but somewhat more compressed, underneath these larger elements the compressed elements which probably represent the perisperm or inner seed coat are found. The endosperm, like the preceding species. It appears from these studies of Harz that there are some radical differences between the Proterium, Sanguisorba and Pyrus. The absence of the sclerenchyma in these genera is noteworthy.

The Testa. The general characters of the seed may be gleaned from the following description from the Ben Davis apple. The testa is slightly irregular on the surface, the epidermal cells of the outer testa are thick walled and laminated. The walls swell somewhat on the addition of water.

Sclerotic parenchyma. The sclerotic layer is somewhat variable as to the number of rows of cells, the number varies from fifteen to twenty, brown in color. The cells are thick walled with pore canals, the lower portion of the sclerotic parenchyma may possibly be differentiated into a distinct layer. Winton and Hanausek indicate tube cells and cross cells. The spongy parenchyma-like lower portion of the tube cells may be differentiated in some cases, we do not, however, consider that this is essentially different from the sclerotic parenchyma. Most of the variation in varieties occurs in the epidermal and aclerotic layer, shown in sketches.

Cross Cells. The cross cells are not always evident in sections of the apple seeds, but they are evident in the Baldwin and Iowa Blush apple seeds.

Starch Cells. The starch cells consist of a single layer of colorless thin walled cells filled with minute starch grains made very evident upon application of iodine to the section. The presence of starch here is very unusual in seeds. The cells of the inner seed coat are very much compressed, polygonal in outline.

The Perisperm. The perisperm is greatly reduced and consists of several thick walled compressed elements, apparently structureless. The perisperm stains yellow with chloriodide of zinc.

The Endosperm. The endosperm is fairly well developed and is even evident with the naked eye. This consists of the aleurone cells which are colorless, thick walled, polygonal, the contents consisting of protein and fat. The lower portion of the endosperm consists of compressed elements with very small cell cavities.

The Embryo. The epidermal cells both above and below are nearly isodiametric; the cells underneath are elongated of palisade form, compactly arranged; densely filled with aleurone and fat. In some cases the palisade cells are more evident on the upper face of the cotyledon. The number of rows varies from two to three. The drawings of different varieties indicate the form. The apple forms no exception to the rule found by one of us that where the germination is epigaeous, palisade cells occur on the upper surface as in Leguminosae.*

The following table shows the difference in size of the cells of the testa and embryo:

THE EMBRYO.

	Upper Cotyledon					Lower Cotyledon				
	Cuticle	Epidermal Cells		Palisade Cells		Cuticle	Epidermal Cells		Palisade Cells	
		Wide	Long	Wide	Long		Wide	Long	Wide	Long
Jonathan	thick	22.221	27.159	19.752	49.380	thin	29.628	19.752	24.690	44.442
Baldwin	thick	17.683	19.752	29.628	46.911	thin	24.690	14.814	22.221	34.566
Wine Sap	thin	22.221	24.690	22.221	69.132	thick	22.221	17.683	17.683	22.221
Iowa Blush	thick	22.221	14.814	19.752	51.849	thin	27.159	22.221	19.752	71.601
Salome	thick	14.814	14.814	19.752	42.373	thin	12.345	22.221	14.814	56.787
Greening	thin	24.690	22.221	14.814	64.194	thick	17.683	19.752	24.690	39.504
Willow Twig	thin	24.690	29.638	24.690	34.566	thick	27.159	22.221	27.159	46.911
Seedling	thick	19.752	29.628	14.814	79.008	thin	22.221	22.221	19.752	67.063
Sweet Apple	thick	19.752	22.221	19.752	88.881	thin	22.221	14.814	24.690	71.601
Northern Spy	thick	19.752	17.683	24.690	29.628	thin	14.814	19.752	17.683	42.373

THE TESTA

	Sclerotic				Elongated			
	Epidermal Cells		Parenchyna		Parenchyna		Endosperm	
	Wide	Long			Wide	Long		
Jonathan	29.628	42.378	12.345	17.683	--------	--------	19.752	29.628
Baldwin	14.814	24.690	24.690	19.752	74.070	14.814	22.221	27.159
Wine Sap	14.814	22.221	--------	--------	--------	--------	--------	--------
Iowa Blush	27.159	34.566	34.566	27.159	59.256	17.683	19.752	39.504
Salome	14.814	29.628	14.814	17.683	74.070	7.407	17.683	19.752
Greening	24.690	29.628	14.814	22.221	49.380	7.407	17.683	19.752
Willow Twig	22.221	29.628	19.752	22.221	49.380	12.345	22.221	24.690
Seedling	19.752	29.628	17.683	19.752	67.063	7.407	17.683	24.690
Sweet Apple	24.690	27.159	19.752	22.221	34.566	4.938	22.221	39.504
Northern Spy	24.690	27.159	22.221	27.159	59.256	9.876	17.683	27.159

*L. H. Pammel. Anatomical Characters of the Seeds of Leguminosæ, chiefly Genera of Gray's Manual. Trans. Acad. Sci. St. Louis. 9:91-272. pl. 7-34.

The following table will show the difference of the diameters of the seeds in width and length in millimeters:

		Kings apple	Sweet apple	Willow-twig apple	Baldwin apple	Greening apple	Salome apple	Northern Spy apple	Iowa Blush apple	Winesap apple	Jonathon apple
1st seed,	measures mm. wide	5	5	4 7/8	4 3/4	5	6	5 3/4	6	5	5
	measures mm. long	8 1/2	7 3/4	8 1/4	10	11	11	10 1/2	10	8 3/4	8 1/2
2nd seed,	measures mm. wide	4 3/4	4 7/8	4 7/8	5 1/2	4 7/8	6	6	5 1/2	4 3/4	5
	measures mm. long	12	7	9	11	9	10 1/2	11	10	8 1/2	10
3rd seed,	measures mm. wide	4	------	------	------	------	5 7/8	6	5 1/2	4 1/4	5
	measures mm. long	11	------	------	------	------	11 1/8	8 1/2	9 7/8	8	9
4th seed,	measures mm. wide	4 3/4	------	------	------	------	------	------	------	------	------
	measures mm. long	10	------	------	------	------	------	------	------	------	------

The weight of the seeds dry are given in the following table. Gram and milligram weights were used:

	Iowa Blush	Kings	Jonathon	Baldwin	Willow Twig	Salome	Winesap	Greening	Sweet Apple	Crabapple	Northern Spy	Seedling
No. of mg. 1 seed weighs	46	35	38	49	50 1/2	55	31 1/2	30	41 1/2	34 1/2	34 1/2	33
No. of mg. 7 seeds weigh	304 1/4	211	270 3/4	270	335	346	229	239	259	221 1/2	247 1/2	247
No. of mg. 10 seeds weigh	....	....	....	....	478	....	....	....	....	....	....	....
No. of mg. 12 seeds weigh	509	421 1/2	462	467	....	605 3/4	483	418 1/2	453 3/4	....	421	434 1/2
No. of mg. 16 seeds weigh	....	535	....	954	....	....	....	....	....	....	....	....
No. of mg. 17 seeds weigh	....	....	....	....	....	....	....	641	....	....	....	....
No. of mg. 23 seeds weigh	926 3/4	....	915	....	....	....	....	....	....	....	....	....
No. of mg. 25 seeds weigh	....	....	....	....	....	1 gram 129 2/3 mg.	....	....	876	....	....	....
No. of mg. 28 seeds weigh	....	991	....	....	....	....	872 1/2	....	....	....	....	....
No. of mg. 26 seeds weigh	....	....	....	....	....	....	....	....	....	....	900	....
No. of mg. 20 seeds weigh	....	....	....	....	....	....	....	....	....	....	....	705

In recent years some interesting work has been carried on with reference to specific gravity of seeds of various kinds, especially with reference to the seeds of some of our horticultural and agricultural crops, in this connection the paper of V. A. Clark is of especial interest. Clark gives the bibliography of older papers on the subject, chiefly those written by Wollny[8], Nobbe[9], and Lyon[10] and many others.

The papers by Stewart and Pammel[11], and Pammel, Weems and Scribner[12], give the specific gravity of our American seeds.

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8. Wollny, E. Saat u. Pflege d. Landw. Kultur Pflanzen. Berlin 1885.
9. Nobbe, F. Handbuch der Samenkunde, Berlin, 1876:313-321.
10. Lyon, T. L. The adaptation and improvement of winter wheat. Nebr. Expt. Sta. Bull. 72:19.
11. Stewart and Pammel. Ia. Agri. Expt. Sta. Bull. *25*:26.
12. Pammel, Weems, Scribner. Ia. Geo. Surv. Bull. *1*:68.

Clark[13] in his paper concludes that the "Correlations between specific gravity of seed and vigor of the resulting seeding are less close than correlations between the specific gravity of the seed and its germination; nevertheless such correlations do exist, it appears, in sufficient degree to make them of value in practice."

The specific gravity of the seeds before they were stratified was determined. First the dried seeds were weighed in a balance, then a common specific gravity bottle; weighed the bottle dry, full of water, and full of water and seeds to fill; the stopper to the bottle contained an opening clear through it. This method was used after consulting Prof. L. B. Spinney of the Department of Physics, who thought this would give best results:

$$\text{Density} = \frac{\text{mass}}{\text{vol.}} = \frac{\text{grams}}{\text{c. c.}} \quad \text{Vol.} = \frac{\text{mass.}}{\text{density}} \quad \text{Wt.} = \text{weight.}$$

(1) (Wt. of bottle, seeds and H_2O to fill)—(Wt. of bottle and seeds)=Wt. of H_2O to fill.

(2) $$\frac{\text{Wt. of } H_2O \text{ contained in bottle—Wt. of } H_2O \text{ to fill after seeds are put in}}{.998 \text{ the desity of } H_2O} =$$

No. of c. c. occupied by the seeds, i. e., the vol. of the seeds.

(3) $$\text{Specific gravity} = \frac{\text{density of the substance}}{\text{density of } H_2O \text{ at same temperature.}}$$

Two specific gravity bottles were used; in the first one the wt. of bottle full of H_2O=36.2467, wt. of bottle dry=29.5802, wt. of H_2O contained=difference of 6.665 gr. The first bottle was used for Iowa Blush, King and Jonathon apples, and all the rest were used in the second bottle.

The wt. of second specific gravity bottle full of H_2O	=45.527
The wt. of second specific gravity bottle dry	=20.626
The wt. of H_2O contained	24.901

	Wt. of bottle seeds and H_2O to fill		Specific Gravity
Iowa Blush	36.24167	gr.	.935
Kings	36.2211	gr.	1.188
Jonathan	36.20676	gr.	.958
Baldwin	45.413	gr.	1.072
Willow Twig	45.556	gr.	.449
Salome	45.556	gr.	1.104
Winesap	45.500	gr.	.9031
Greening	45.505	gr.	.665
Sweep Apple	45.512	gr.	.893
Crabapple	45.501	gr.	.2488
Northern Spy	45.5625	gr.	.867
Seedling	45.614	gr.	.620

It will be noticed by the preceding table that there is a very wide range of variation in the different varieties. Using the Baldwin for example:

$$\frac{\text{(Wt. of } H_2O \text{ contained in bottle or 24.901 gr.)—(Wt. of } H_2O \text{ to after seeds are put in, or 23.833 gr.)}}{.998} = \frac{1.068}{.998} = 1.070$$

13. Clark, V. A. Seed Selection According to Specific Gravity. N. Y. Agri. Expt. Sta *23*:335.

$$\text{Sp. gr.} = \frac{\text{density of substance or } 1.070}{\text{density of } H_2O \text{ at same temp. or } .998} = 1.072 \text{ sp. gr.}$$

Clark gives the following specific gravities which have been worked out for other seeds. That we may compare them with the specific gravity of the apple seeds the following table is inserted:

	Specific Gravity
Cruciferæ	about 1.21 down
Lettuce	1.10
Solanaceæ	1.12
Onion	1.18
Carrot	1.15
Grapes	1.16
Buckwheat	1.23
Naked Leguminous seeds	1.30 to 1.36 according to variety
Wheat	1.30 to 1.36 according to variety
Rye	1.30 to 1.36 according to variety

It will be seen from the preceding table that the Kings Apple had the highest specific gravity of 1.188, followed by the Salome with 1.104, the Baldwin with 1.072, the Jonathon with .958, Iowa Blush with .935, Winesap with .9031, the Sweet Apple with .893, Northern Spy with .867, Greening with .665, Willow Twig with .449, the Wild Crabapple being the lowest with a specific gravity of .2488.

BIBLIOGRAPHY.

Clark, V. A. Seed Selection According to Specific Gravity. N. Y. Agri. Expt. Sta. 25:335-384.

Cramer: Uber das Vorkommen und die Enthstehung einger Pflanzenschleime. Pflanzenphysioligische Untersuchungen von Carl Nageli und Carl Cramer, 1855, Heft. III. Pl. 27. f. 3-5.

De Leus, A. J. Dictonaire Universel de Matiere Medicale et des Therapeutiques generales, Paris, 1830. 2:558.

Focke, W. O. in Engler and Prantl. Die naturlichen Pflanzenfamilien Rosaceæ, III Theil. 3 Abth. 22.

Fluckiger & Hanbury. Pharmacographia. A history of the Principal Drugs of Vegetable Origin Met with in Great Britain and British India. London: Macmillan & Co. 1879. 269.

Fluckiger & Tschirch. The Principles of Pharmacognosy. New York, Wm. Wood & Co. 1887. 166.

Frank. Ueber die Anatomische Bedeutung und die Entstehung der vegetabilischen Schleime. Prigsheims Jahrbucher fur wissenschftliche Botanik, 1866. 5:167. Pl. 15. f. 8, 9.

Hanusek, T. F. Die Nahrungs-und Genussmittel aus dem Pflanzenreiche, Berlin, Kassel, 1884. 5:205 of Allgemeine Waarenkunde und Rohstoffe.

Harz. Landwirthschaftliche Samenkunde. Berlin 1885.

Henkel. Handb. Pharm. et. 365.

Heraud. Nouvelle Dict. etc. 150.

Herman Hager. Botanischer Unterricht in 160 Sectioneu fur angehende Pharmaceuten und studirende Mediciner. Berlin. 1885. 450. f. 657. (3rd ed.)

Hill. Annals of Botany. 20:395.

Hofmeister, W. Ueber die zu Gallerte aufquellenden Zellen der Aussenflache von Samen und Perikarpien. Berichte der K. Sachs. Gesellsch der Wissenschaften, Sitzung Am. 20 Februar 1858:22, 30. Pl. 1. f. 3.

Karsten. Deutsch Flor. etc. 783. f. 449.

Klenke Illustrirtes Lexikon der Verfalschungen der Nahrungsmittel und Getranke, etc. Leipzig, 1879. 518. (2nd ed.)

Kratzmann. Die Lehre von Samen. 41.

Luerssen, Chr. Handbuch der Systematischen Botanik. Phanerogamen, Leipzig, H Hassel. 2:834.

Lyon. The Adaptation and Improvement of Winter Wheat. Nebr. Expt. Sta. Bull. 72:19.

Nobbe, F. Handbuch der Samenkunde. Berlin 1876.

Pammel, L. H. Anatomical Characters of the Seeds of Leguminosæ, chiefly Genera of Gray's Manual. Trans. Acad. Sci. St. Louis. 9:91-272. pl. 7-34.

Pammel, Weems and Scribner. Ia. Geo. Surv. Bull. 1:68.

Pereira: Elements of Materia Medica and Therapeutics, edited by Robert Bentley and Theophilus Redwood, London 1872. 303, 826.

Stewart and Pammel. Ia. Agri. Expt. Sta. Bull. 25:26.

Stille and Maisch: Nat. Dispensatory. 487. f. 54.

Tschirch. Angewandte Pflansenanatomic. 198. f. 196.

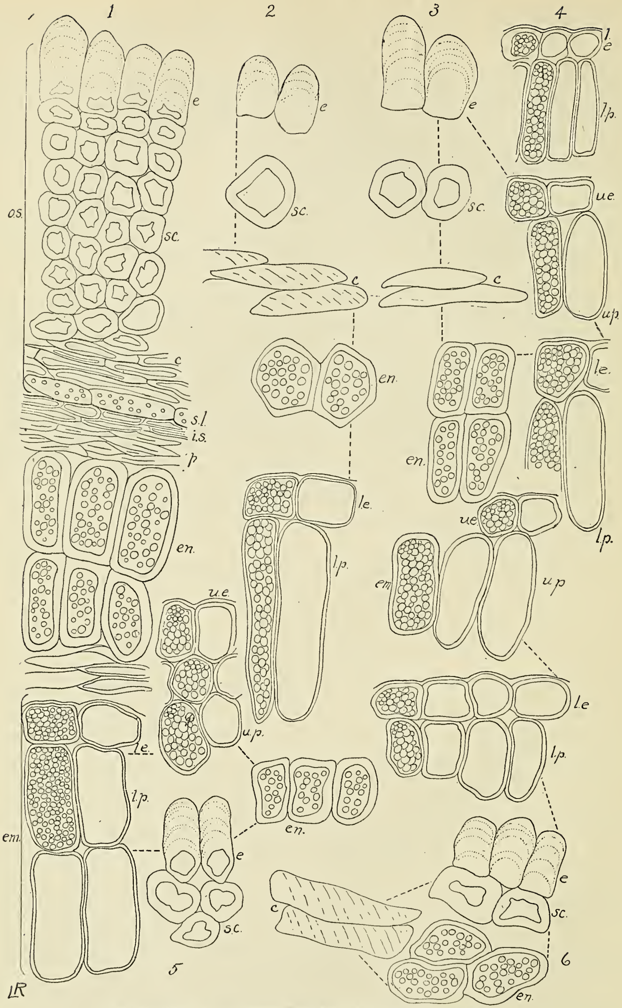
Winton and Moeller. The Microscopy of Vegetable Foods with Special Reference to Diagnosis of Mixtures. N. Y. 323.

Wollny. Saat u. Pflege d. Landw. Kultur Pflansen. Berlin 1885.

Description of Plates.

Plate 1. The histological anatomy of the seeds of the cultivated apple (*Pyrus malus*) and wild crab apple (*P. Iowensis*). Figures 1, 2, 3, 5-12, *Pyrus malus,* figure 4. *Pyrus Iowensis.* Fig. I. a complete cross section of the testa inclusive of the endosperm of Russet Apple. In the succeeding figures all letters refer to the same structure. o. s. outer seed coat. i. s. inner seed coat. p. perisperm. en. endosperm. e. laminated epidermal cells. Sc. sclerotic parenchyma. c. cross cells. s. l. single layer of starch cells. Figure 2. c. cross cells with cross striations. en. endosperm with fat and eleurone grains. l. e. epidermis of the cotyledon of upper face. l. p. palisade cells of the upper face of the cotyledon. u. e. epidermis of the lower face of the cotyledon. u. p. elongated parenchyma cells underneath. The cells of the embryo are filled with aleurone grains and fat. Fig. 1 Russet, fig. 2 Iowa Blush, fig. 3, Northern Spy, fig. 4 Crab Apple (*Pyrus Iowensis*), fig. 5 Willow Twig, fig. 6 Baldwin.

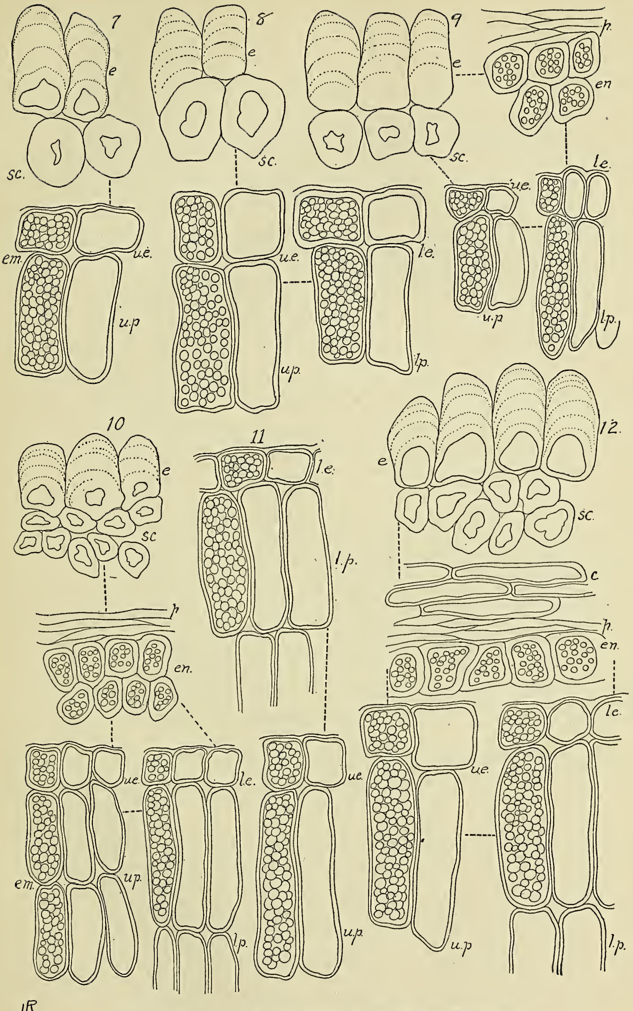
Plate 2. Fig. 7 Jonathan, fig. 8 Winesap, fig. 9 Salome, fig. 10 Greening, fig. 11 Sweet Apple, fig 12 Seedling.



SOME SEEDS, GENUS PYRUS—PLATE I—PAMMEL.

1. Russet Apple. 2. Iowa Blush. 3. Northern Spy, 4. Crab Apple.
5. Willow Twig. 6. Baldwin.

e—epidermis. *Le*—lower epidermis of cotyledon. *Sc*—Sclerotic layer. *Lp*—palisade cells, lower side cotyledon. *C*—cross cells. *Ue*—upper epidermis. *Sl*—starch layer. *Up*—pal isade cells, upper side of cotyledon. *P*—perisperm. *Ie*—inner epidermis. *En*—endosperm



SOME SEEDS, GENUS PYRUS—PLATE II—PAMMEL.

7. Jonathan. 8. Winesap. 9. Salome. 10. Greening. 11. Sweet Apple. 12. Seedling.

E—epidermis. *Le*—lower epidermis of cotyledon. *Sc*—sclerotic layer. *Lp*—palisade cells, lower side cotyledon. *C*—cross cells. *Ue*—upper epidermis. *Sl*—Starch layer. *Up*—palisade cells, upper side of cotyledon. *P*—perisperm. *Ie*—inner epidermis. *En*—endosperm.

THE GENESIS OF LOESS A PROBLEM IN PLANT ECOLOGY.

BY B. SHIMEK.

The question of the origin of the loess of the Mississippi valley has attracted the attention of the geologists of the country for two-thirds of a century. The consideration of the question has been left almost entirely to geologists, who have offered various explanations of loess-formation, all based practically on physical grounds.

The biological phases of the subject have been thus far approached almost exclusively from the faunal side.

It is the purpose of this paper to briefly set forth a preliminary statement of the relation of plants to the formation of loess, and to call attention to the fact that the investigation of the problem of the genesis of loess lies within the province of the plant ecologist, for the study of plant relations throws light on several important phases of the subject, and incidentally strengthens the aeolian hypothesis.*

That plants play an important part in modifying the materials of the surface of the earth is well known. They assist in comminuting soil and rock both mechanically and chemically; they form an anchorage for fine materials brought both by wind and water, according to location; they prevent erosion of loose soils; by their decay they cause changes in the amount and distribution of the calcium carbonate and iron constituents of the soil; and finally, they return their own substance to the soil in finely subdivided condition.**

All this results in an increase in the amount of fine materials which may be removed by wind or water, or in the building up of deposits where the vegetation is sufficient to form an anchorage for the fine materials carried by these agencies.

The study of these influences of plants, and of plant-distribution as determined by environment, throws light on the following questions related to loess-formation by aeolian agencies:

I. *Distribution of loess.*

(a). It explains the greater thickness of loess on higher grounds near larger streams, where vegetation is more abundant because of the advantages offered by both the greater elevation and the more abundant plant-covering, thus forming an anchorage for the dust carried up from the adjacent bars on which the supply of dust is renewed by each succeeding flood. That vegetation was more abundant in this territory during the deposition of loess, as now, on elevations near the large streams is shown by the greater abundance of strictly terrestrial plant-feeding mollusks in the loess now occupying these elevations, the modern

* See writer's previous suggestions in Bull. Lab. Nat. Hist., St. Univ. of Iowa, vol. V, pp. 341, 359, 360, etc.; 1904

** See writer's paper, Proc. Ia. Scad. Sci., vol. X, pp. 41-48, 1903.

terrestrial molluscan fauna being similarly developed chiefly in the grosser vegetation of such situations.

(b). It explains the difference in thickness of loess on the east and west sides of the valleys of our larger streams like the Mississippi and Missouri. The prevailing southwesterly and westerly summer winds produce xerophytic conditions with less abundant vegetation on the east side, where the dust heaps up like snow in a drift, while the west side is mostly forest-covered, and receives a thinner blanket of finer dust which settles more uniformly in the more abundant vegetation. (See Plate III, figs. 1 and 2; Plate IV, figs. 1 and 2.)

(c). It throws light on the inequality and irregularity of loess distribution, the latter being determined largely by the irregularity of plant distribution, and it suggests that the more irregular and unequal loess was deposited on drier surfaces, while those which had a dense plant-covering, forest or otherwise, received a thinner and more nearly uniform deposit.

A suggestion of the cause of local irregularities in thickness is furnished by the morainic Wisconsin-drift hills in western Lyon county, Iowa. The southwestern windward slopes and the tops are covered with a tufted scattered vegetation, while that of the leeward slopes is much denser, being partly scrub forest. The bare portions of the former lose their finer materials and coarse drift appears at the surface, while the latter retains the finer materials and thus receives additional increments, and has already formed a distinct thin loess and soil.* (See Plate V, fig. 1.) If the vegetation on the windward slopes was gradually reinforced, as during more favorable seasons, and the deposition of these finer materials continued until both slopes were covered, the deposit of loess so formed would be unequal in thickness on the opposite slopes.

(d). It explains the presence of loess in high places, and its almost general absence from the intervening lowlands, for the elevations were earliest drained, and first presented conditions suitable for dust-deposition because of their greater elevation and their early plant-covering, while the lowlands were alternately flooded and exposed.

II. *Structure and composition of loess.*

(a). The greater coarseness of loess materials on the east side of the large rivers has already been noted, together with its probable cause.

(b). The presence or absence of lime nodules and iron tubules is of no value in determining the age or identity of loess, or loess-like deposits, for they may have been formed very recently in cavities formed by or around roots, by checking or slipping, or by water. The writer has found both lime nodules and iron tubules around fresh living roots. Moreover both sometimes occur in drift.

(c). The occasional alternation of sand and loess may be explained on the basis of changes in the plant-covering of the area during the formation of the deposit.

Such alternation and interlamination of sand and loess are not uncommon, and it is a significant fact that they may be observed, so far as the writer has seen, only in the vicinity of modern or manifest old sand-dunes. Fine illustrations occur in such locations in Iowa, Nebraska, Missouri, Illinois and Indiana.

In Iowa the finest examples may be found in close proximity to the Iowan drift border.

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*See the writer's paper on "Additional Observations on Surface Deposits in Iowa," Proc. Ia. Acad. Sci., vol. IV, pp. 68-72, 1878.

Those who have studied the Iowan drift in this state agree that the ice-sheet was comparatively thin. When the ice receded upon the great plain thus bared there were projecting points and ledges of rock as well as irregular drift elevations left by the ice. These elevations formed nuclei for the collection of minute dust particles from the broad plain in the same manner in which an obstacle on the surface of the earth may form the nucleus of a sand-dune or snow-drift. Such a dune or drift will itself form an obstacle which will intercept other material brought to it by winds, and will thus assist in its own upbuilding. In the same manner, the paha and the rocky ridge formed nuclei about which gathered the dust whose accumulations form the loess caps on these elevations. The comparative thinness of the ice-sheet also resulted in the early exposure of the surfaces of these elevations while the great intermediate plains still remained ice-covered. No doubt much fine material was washed out upon the surface of the ice and this probably furnished in some places the first material which was deposited on the exposed elevations. However, by far the greater part of the loess material was evidently deposited after the ice had receded and the climate had become sufficiently moderated to permit the development of an extensive vegetation, which supported a more or less abundant molluscan fauna. The fact has repeatedly been noted that along the border of the Iowan drift and on the paha within its borders there are great accumulations of sand lying immediately beneath the loess. This sand in some places shows no lamination and was probably deposited by the Iowan ice, though it may be of Kansan origin. Very much of it, however, is distinctly laminated in a manner which suggests the structure of an ordinary sand-dune. These laminations follow the vertical contours and in some places alternate with narrow belts and bands of fossiliferous loess, the sand being entirely free from fossils in all cases mentioned. The structure of these underlying sands suggests that soon after the recession of the Iowan ice there were extensive sand-dunes formed along the borders of the Iowan drift, and that there were isolated dune areas within the Iowan border. These shifting sands were probably bare for a time and the winds easily removed the finer particles of dust in great quantities.

The successive changes were probably such as take place in recent times in any sand-dune region. At first a scant vegetation consisting, perhaps, of tufted sedges and grasses and leguminose plants, is developed. Each plant forms a nucleus about which a small amount of finer soil material is gathered. While each plant thus serves as an anchorage for fine material, there are at first comparatively broad areas of loose shifting sands between these plant-tufts. As the scant vegetation gathers the finer soil, it prepares the way for a denser vegetation, which will accumulate more fine soil to the advantage of still other plants, until the whole area is covered with a carpet of plants which will check if it does not wholly prevent wind erosion. (See Plate V, fig. 2.) In the Iowan sand-dune area the fine material thus blown out of the sands was, after the recession of the Iowan ice, carried to the above noted elevations, and there lodged. It should be born in mind that these elevations presented the first suitable surfaces for terrestrial plants, for, no doubt, for a long period the flatter areas were at least swampy, resembling probably the corresponding areas upon the Wisconsin drift plain. Other portions were, evidently, for a time shifting sands upon which vegetation gained a foothold with much greater difficulty. Upon the elevations alone was there sufficient drainage to permit the development of an early terrestrial vegetation.

During the summers many of these areas were exposed year after year by the evaporation of the waters and furnished new supplies of dust which accumulated upon the elevations in the well-developed flora which covered them. There are in some localities clear evidences of changes in surface conditions. The typical locality in the northern part of Madison township, Johnson county, will serve as an illustration. At the point in question there is a range of low hills on the south side of the Iowa river and parallel with it. These hills follow the river eastward to Curtis and thence to a point east of North Liberty. Exposures at various points indicate that the structure of this ridge is essentially that of the paha. At the intersection of this ridge and the C. R. & I. C. electric railway two cuts exhibit the structure here selected as an illustration. (See Plate VI, fig. 1.) The entire exposure in these cuts exhibits a succession of sand and loess bands following approximately the vertical surface contours. The loess bands, even where quite narrow, contain the characteristic fossil shells of terrestrial mollusks.

Upon the adjacent surfaces of the ridge there is now a forest covering and among the leaves and leaf-mould of the surface the same species of mollusks are found living.

Westward the ridges become lower and the river-valley expands into a sandy plain. During cycles of dry seasons the covering of vegetation becomes more scant and quantities of loose sand are shifted about by the winds forming small sand dunes or drifts in the fields and along the road sides and encroaching more or less upon the wooded tract. During wetter seasons the covering vegetation is more abundant and much less material is shifted about. The position and the structure of the ridge both suggest that in the past there were cycles of favorable seasons during which a dense vegetation, probably chiefly forest, was developed upon its surface and that this plant-covered area received only the finer dust blown from the adjacent surfaces. This dust formed the loess bands and entombed the mollusks living upon the surface. During dry seasons the exposed sandy areas were very much increased in extent and the sand being no longer retained by plants was carried by the winds into the forest, thus forming the sandy bands. Upon such sandy surfaces no land-snails grow today and no shells were imbedded in the sands in the past.

The structure herein discussed has been heretofore considered only in connection with the Iowan border, but may be observed in various localities remote from the Iowan border, and it is significant that in all these localities it is exhibited on ridges contiguous to manifest sand-dune areas.

For example, south of New Harmony, Indiana, along the east side of the Wabash valley there are sand ridges, evidently old dunes, which are covered with loess and exhibit essentially the same structure as that of the Iowan border as noted above. South and west of these areas there is a territory now covered with more or less shifting sand-dunes.

At Gladstone, Illinois, the bluffs near the town consist of drift, with superimposed sand which is often laminated, and this is capped with a layer of typical fossiliferous loess.* (See Plate VI, fig. 2.) Southward there extends a great sand plain which probably furnished the greater part of the loess dust. The northward continuation of the same bluffs east of New Boston shows again the same structure. There are now extensive sand-dune areas south of this point.

At St. Joseph, Mo., the same structure may be observed along the ridge north of the Francis street depot of the C., B. & Q. R. R. Opposite to this point to the south and west, there are extensive mud and sand bars, the latter during dry seasons developing to some extent a dune structure at the surface.

In the Indiana, Illinois and Missouri localities cited, this peculiar structure is shown only on the eastern side of the river.

Hooper and West Point, Neb., west of the Missouri, are located near the eastern extremity of an extensive sand dune area, a part of the famous sand-hill region of Nebraska. Exactly the same structure may be observed at both of these points and the relation of the loess to the sand is extremely suggestive of the aeolian origin of both deposits.

Sometimes the sand grades upward into loess without interlamination, and the transition may then be explained as in the following section.

(d). The gradual transition from loess to drift or sand, which may sometimes be observed, especially where loess overlies the Kansan drift or the sands of the Iowan border, is also best explained on ecological grounds, though it has usually been considered evidence that the loess and drift form a practically unbroken series, and that the loess was deposited by ice or by glacial waters.*

The fact should be emphasized that the extent of this intergradation has been greatly exaggerated. There is no general intermingling of drift and loess materials in irregular masses such as might be expected, at least locally, if water had promiscuously shifted these materials about in currents which varied in direction and force with the flood stage of the streams. On the contrary, when this transition does occur, and this is by no means the case in all places where loess and drift come in contact, it is quite consistently uniform and usually complete within a vertical distance of two to six inches. There is no interlamination of materials other than that of sand and loess already noted, no coarse materials appearing in this relation in any of the numerous sections exmined by the writer.

No cases are yet known in which drift materials appear in the loess, the one repeatedly cited in recent years by the advocates of the glacio-fluviatile hypothesis being an error in the determination of the lower member called loess. This is the supposed interloessial drift near Sioux City, Iowa, first reported by Todd and Bain** and later more fully described by the latter.*** It is a layer of boulder-bearing drift lying between what were reported to be two loesses. The writer has recently called attention† to the fact that the lower so-called loess in this and similar exposures near Sioux City is a drift clay and not loess. This drift clay is common in the Missouri river valley and in some places attains a thickness of many feet, as is shown, for example, in the great Union Pacific railway cut-off in South Omaha, Neb., where it meets the loess without the interposition of a boulder-bearing stratum.

While no interloessial drift, in the sense in which this expression was used, is known, interglacial loess-sheets are not uncommon, but they represent distinct

*For example in the following and other papers:

N. H. Winchell—6th Ann. Rep. Geol. and Nat. Hist. Sur. of Minn., pp. 87-89, 1878; Bull. Geol. Soc. of Am., vol. 14, pp. 141-2, 1903; Am. Geol., vol. XXXI, pp. 279-282, 1903.

W. J. McGee—11th An. Rep. U. S. Geol. Sur., pt. 1, 1891, pp. 442-7, etc.

J. E. Todd—Proc. Ia. Acad. Sci., vol. XIII, p. 191, 1907.

**Proc. Ia. Acad. Sci., vol. II, pp. 20-23, 1895.

***Rep. Iowa Geol. Sur., vol. VIII, pp. 283-4, 1896.

†Proc. Iowa Acad. Sci., vol. XIV, 1908.

interglacial periods, and do not connect the drift with loess. Such are the following examples which the writer has personally examined:

A post-Kansan loess between Kansan and Illinoian drifts in cut facing Hershey Ave., Muscatine, Iowa;* a similar loess between the Kansan and Iowan drifts in Jefferson twp., northwest of Iowa City;** a loess between the Kansan and Wisconsin drifts in Des Moines, Iowa;*** two loesses between the Kansan and Wisconsin drifts near Carroll, Iowa;† a loess between the Illinoian and Wisconsin drifts in the Farm creek exposure near Peoria, Ill.;‡ and other similar exposures. In all the examples mentioned the loesses are fossiliferous, and their relation to the drifts is clear.

These interglacial loesses present no evidence of close genetic relationship with the contiguous drift-sheets—on the contrary, their abundant terrestrial fossils indicate that the conditions which existed during the formation of these loesses were similar to those under which the same species exist today throughout the loess-covered area, and these species now exist abundantly on our upland surfaces in a temperate climate!

These loesses clearly represent interglacial periods of long duration, and the foregoing cases cannot be considered in connection with the occasional gradual transition from drift to loess which seldom results in the formation of a stratum more than a few inches in thickness. But even this gradual transition, which as noted may sometimes be observed, does not prove the common origin of loess and drift, for it is entirely consistent with the aeolian hypothesis and gives substantial support to it. Such gradual transition from sand or drift to finer material, such as loess, would occur on surfaces on which the covering of vegetation increased gradually, particularly where the sand-dune or drift surface was adjacent to a broader territory over whose surface the same gradual increase in vegetation had taken place. While vegetation was still practically absent, the surface materials were freely shifted about, even coarse sand being thus moved. As vegetation gradually increased the coarser material was less frequently disturbed, or when shifted became mixed with finer materials, and finally only the finest dust, now forming the loess, was transported and lodged on the more densely covered surfaces.

Where the change in vegetation was very gradual there was a corresponding change upward from coarse to fine material. Where the changes were abrupt, because of changes in drainage, etc., the lines of demarkation became sharp, and where these conditions alternated, corresponding bands of loess and sand were formed, if the surface was quite sandy.

III. *Conditions existing during deposition of loess.*

The presence of numerous fossil mollusks in the loess proves that there was an abundant vegetation on the surface at the time (or successive times) of deposition. These mollusks are herbivorous, and they are terrestrial and air-breathing, chiefly upland species, and their distribution is determined by the character of the plant covering, which serves both for shelter and food. A comparison of the distribution of modern terrestrial mollusks and the plants

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*Reported by the writer in Bull. Lab. Nat. Hist., St. Univ. of Iowa, vol. V, pp. 362-3.

**Reported by the writer, ibid., p. 366.

***Reported by McGee and Call, Am. Jour. Sci., vol. XXIV, pp. 202, et seq., 1882; and by the writer, Bull. Lab. Nat. Hist. St. Univ. of Iowa, vol. V, p. 367.

†Reported by the writer, ibid., p. 367.

‡Reported by Leverett—Monographs, U. S. Geol. Sur., vol. XXXVIII, p. 187, 1899.

among which they live, with that of the fossils in the loess, shows a striking similarity of habitats, and suggests, as the writer has repeatedly stated, that the conditions which prevailed when the loess was formed were not materially different from those now existing in the same region. The abundance of terrestrial mollusks and plants precludes the possibility of the presence of large bodies of water, or of glacial ice in a glacial climate. They render the glacio-fluviatile hypothesis wholly untenable.

IV. *Inter-loessial periods.*

In many cases where two distinct loesses are in contact, the lower is gray (post-Kansan) and contains numerous iron tubules which have been manifestly formed by roots, and these tubules often terminate abruptly in the oxidized band which so frequently separates these loesses. Less frequently they terminate similarly in the surface of contact of the loesses, the oxidized line or band being absent. (See Plate VII, fig. 1.)

This suggests that when the bluish-gray loess was at the surface it was covered with an abundant vegetation which has left evidence of its existence in these tubules. When the succeeding ice-sheet overwhelmed the territory this vegetation was destroyed, and the loess surface, just beyond the ice-border and on the elevations which had not been denuded by the thin ice-sheet, and from which the ice first disappeared, remained bare of plants for some time, and finally gradually developed a scant flora. During this partial or complete denudation the oxidization of the iron-stained surface probably took place, though it is possible that the iron was in part washed down to its present level after some of the superimposed newer loess was formed. (See Plate VII, fig. 2.)

The influence of the second ice-sheet would have been felt for some distance beyond its border, and the same sharp division of loesses would have resulted. It is probably for this reason that the sharp division of the post-Kansan and later loesses may be traced for a considerable distance beyond the borders of the later drifts, especially the Iowan.

A subsequent restoration of favorable conditions resulted in the development of another flora which built up the upper (newer) loess.

In addition to the foregoing important considerations there are other questions of interest which may be solved by due reference to the behavior of modern plants. The peculiar loose lobular structure of the upper three to five feet of much of the loess is evidently due in large part to the action of roots; the vertical cleavage of loess is probably due to the same cause; the fact that roots will decay in loess and completely disappear without leaving a trace of carbonaceous material is not without interest; this, together with the fact that exposed plant materials completely decay long before they could be covered by dust in the manner suggested by the aeolian hypothesis, accounts for the absence of plant remains in the loess; the effect which roots might have by dissolving shells of the fossil mollusks and thus making some of the loess apparently non-fossiliferous is also noteworthy; and perhaps other minor problems may be suggested.

It is also worthy of note that sometimes the study of the local flora makes it possible to determine the limits of loess and drift formations without making sections. Thus along the timbered portions of the Iowan drift border in Johnson and Iowa counties in Iowa it is possible in some cases to accurately limit the Iowan sands and the loess by the species of trees making up the forest covering, the dominant species on the sands being *Quercus velutina*, the yellow oak, and *Q. macrocarpa*, the bur oak, while on the loess of the Kansan *Q. alba*, the white oak, and *Q. rubra*, the red oak, take possession. This change is striking even in places where surface overwash, etc., have made the immediate surface deceptive.

The foregoing considerations suggest something of the importance of the study of plants in the field in connection with loess investigations and justify the title of this paper.

EXPLANATION OF PLATE III.

Fig. 1. The wooded bluffs above Florence, Neb. These rounded wooded bluffs are the prevailing type on the west side of the Missouri river. (See p. 58.)

Fig. 2. The abrupt treeless bluffs above Missouri Valley, Iowa. This represents the prevailing type on the east side of the river. (See p. 58.)

PLATE III.

FIG. 1.

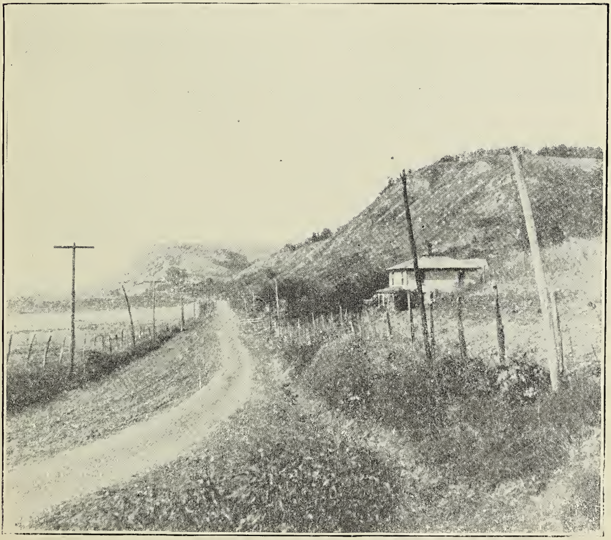

FIG. 2.

Explanation of Plate IV.

Fig. 1. A portion of the face of the loess bluffs at Council Bluffs, Iowa, showing the tufted xerophytic vegetation with large bare spaces between the plants. Dust may therefore be whipped up these abrupt slopes much as snow is driven up the face of a snow-drift. (See p. 58.)

Fig. 2. A view of the top of the high ridge above Hamburg, Iowa, looking north. The slopes to the left face the river and are treeless. The eastern sheltered side is forest-covered and less abrupt. Where the eastern slopes of these ridges are treeless the return currents of air also whip the dust toward the crest of the ridge, and make these slopes almost as abrupt as those on the west side. (See p. 58.)

PLATE IV.

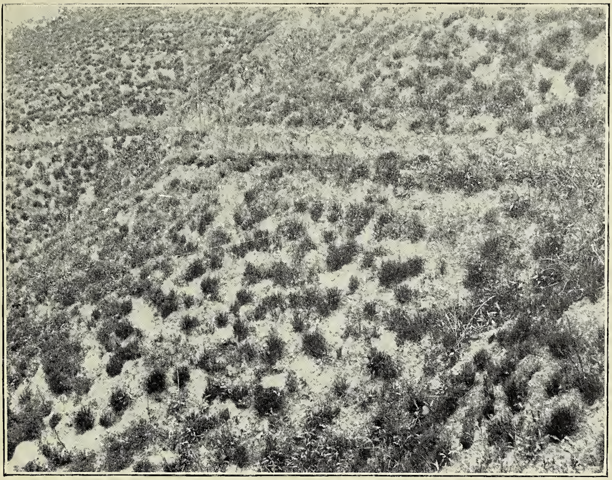

FIG. 1.

FIG. 2.

EXPLANATION OF PLATE V.

Fig. 1. The northerly slopes of a portion of the Wisconsin drift moraine in southwestern Lyon county, Iowa, showing more or less forest covering. On these slopes there is a distinct soil and a thin loess, while the exposed tops and windward slopes are treeless, and without surface soil. (See p. 58.)

Fig. 2. A sand dune on which plants (chiefly *Cassia chamaecrista*) have become established. The dune is now fixed and is beginning to form a finer soil. The trees are cottonwoods, and are responsible for the formation of the dune. Nearly all the plants on these dunes are leguminose, with abundant root-tubercles containing nitrifying bacteria. Harrison county, Iowa. (See p. 59.)

FIG. 1.

FIG. 2.

EXPLANATION OF PLATE VI.

Fig. 1. Section along the Interurban railway in Madison township, Johnson county, Iowa, south of the Iowa river. It shows alternating bands of sand and fossiliferous loess, especially in the upper part. The lower portion shows a thicker stratum of loess. These bands vary in thickness from a fraction of an inch to several feet. (See p. 60.)

Fig 2. A part of a section at Gladstone, Ill., showing laminated loess resting on stratified sand, the two blending more or less, and showing some interlamination. The loess is fossiliferous. (See p. 60.)

PLATE VI.

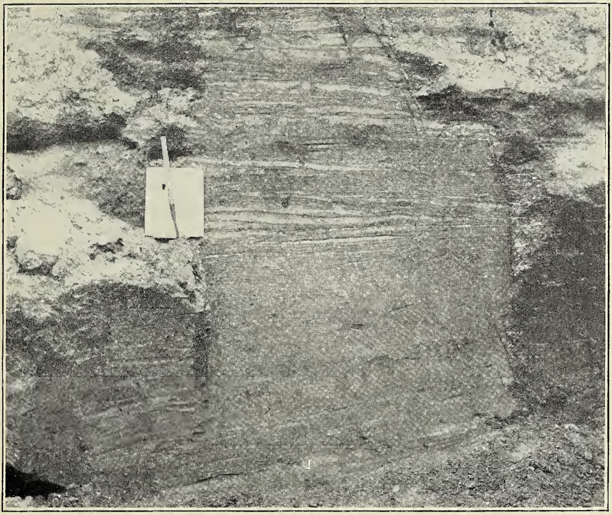

FIG. 1.

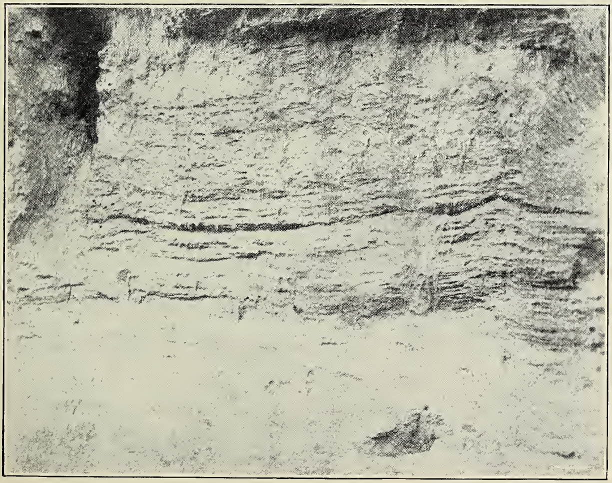

FIG. 2.

Explanation of Plate VII.

Fig. 1. Section along wagon-road southwest of Farley, Iowa. in Sec. 23. T. 88 N., R. I. W. This shows two loesses separated by an oxidized line. The lower (post-Kansan) gray loess contains large iron-stained root-tubes, which terminate abruptly at the upper limit of this loess. The upper yellow loess is stratified and contains no root-tubes. (See p. 63.)

Fig. 2. Section in Gaulocher's brickyard in Iowa City, Iowa, showing two loesses very sharply separated but with scarcely a trace of an oxidized line between them. The lower is a gray post-Kansan loess with iron tubules. The upper yellow loess has gray vertical lines or streaks which resemble the lower loess, and which were evidently formed by the roots. In some cases the gray upper streak is continuous with the iron tube in the lower loess; both having evidently been formed by the same root long after both loesses were formed. (See p. 63.)

Fig. 1

Fig. 2.

A HYBRID OAK.

BY B. SHIMEK.

The northern limit of the distribution of *Quercus imbricaria* Michx. and *Quercus palustris* Muench, in the valley of the Iowa river is reached near Hills in Johnson county. Here and southward both species occupy the alluvial bottom lands, and before the extensive clearing of the alluvial forests they were freely intermingled. In view of this fact and of the well-known tendency of oaks to hybridize it is not surprising that forms which are evidently hybrids occur.

It is obviously difficult to determine the fact that hybridization has taken place in plants which require many years to reach maturity, when they first fully display their hybrid characters, and the only criterion which may be employed is the mingling of recognized specific characters. Where species are very closely related this is manifestly difficult, if not impossible, but the task is much easier when the species are as well marked as the two here noted.

Among the two or three probable hybrids which were found in a scattered clump of *Q. imbricaria* and *Q. palustris* on the alluvial bottom land south of Old Man's creek, near Hills, the one here discussed shows this mingling of the characters of the parent species most clearly.

A probable hybrid of these species has already been reported by Engelmann.

Sargent says of it: "The leaves were broadly lanceolate, mostly acute at the apex, and entire or usually furnished with coarse triangular-toothed acute bristle-pointed teeth; they were pubescent at first, especially on the lower surface, but soon became glabrate, and lustrous above, paler below, from four to six inches long and from one to two inches wide. The fruit was mostly solitary and was borne on a stout peduncle sometimes half an inch in length; the nut was oblong, full and rounded at the apex, about as broad as it was long, light brown, and inclosed for about one-third of its length in the thin cup-shaped or turbinate cup covered by ovate scales rounded at the apex and clothed, except on the bright red-brown margins, with hoary pubescence."

It may be of interest to note that our hybrid agrees substantially with this description, but many of the leaves are quite deeply lobed, and these in some cases reach a width of more than three and one-half inches.

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* Trans. St. Louis Academy of Sci., vol. III, p. 539, 1877. Also quoted in Sargent's Silva of North America, vol. VIII, pp. 176-177, foot-note 9; 1895.

The parent oaks in this case are easily distinguished by the following characters:

Q. palustris DuRoi.	*Q. imbricaria* Michx.
Young leaves:	Young leaves:
Lower surface quite densely pubescent, with more prominent tufts of hairs in the axils of the large veins.	Lower surface more densely pubescent, without special prominent tufts in the axils of the large veins.
Upper surface with few reddish-brown or purplish club-shaped trichomes.	Upper surface with numerous reddish-brown or purplish club-shaped trichomes.
Margins red, not thickened, not revolute.	Margins green, thickened, distinctly revolute.
Petioles short.	Petioles long, often nearly equal to blade.
Mature leaves:	Mature leaves:
Quite regularly 5 to 7-lobed, each lobe long bristle-pointed.	Entire, or somewhat 3-lobed, and sometimes irregularly repand-lobate on young shoots.
Rather thin.	More leathery.
Veins rather distinct, the midrib projecting above both the upper and lower surfaces.	Veins more prominent, the midrib in a groove above, at least in its lower half.
Margin scarcely revolute, and not thickened.	Margin usually distinctly thickened, and somewhat revolute.
Lower surface smooth, except for tufts of hairs in axils of veins.	Lower surface quite uniformly pubescent.
Blade 4 to 6½ inches long and 4 to 5¾ inches wide.	Blade 3½ to 4½ inches long, and 1 to 1¾ inches wide.
Petioles 1 to 2 inches long, smooth.	Petioles ⅜ to ½ inch long, pubescent.
Flowers:	Flowers:
Stigmas recurved or spreading, terete, red.	Stigmas short, yellowish-green.
Staminate flowers with calyx of 4 or 5, mostly unequal, broad, often irregularly slightly lobed sepals, with laciniate margins, and without abruptly tapering apex.	Staminate flowers with calyx of 4, mostly equal, lance-ovate, entire sepals, with abruptly tapering tips which are laciniate-tufted at the apex.
Fruits:	Fruits:
Cup very flat below, shallow, covered with closely appressed tomentum within.	Cup somewhat obconical or turbinate, somewhat deeper, the scales rather loose, especially toward margin of cup, and its inner surface nearly smooth.
Acorns sub-spherical or even depressed at apex, and often showing slight longitudinal ribs or angles.	Acorns more conical, and terete.

With special reference to the characters here brought out the hybrid may be described as follows:

In general aspect and habit it resembles both parents, which are very similar in this respect.

The young leaves have the lower surface densely tomentose, without prominent tufts in the axils of the large veins, resembling *Q. imbricaria.* In other respects the young leaves are intermediate, having margins somewhat revolute, slightly thickened, and in part red, especially toward the base, and with medium petioles. In division of blade the young leaves are also intermediate between the parent species.

The mature leaves vary from quite entire to deeply lobed, the sinuses extending fully half way to the midrib. The lobes are rounded or acute, more or less spreading or curved outward at apex, and when distinct terminating in a long bristle point, as in *Q. palustris.* From one to three lobes may appear on each side, and they are usually unequal and irregular. In texture they resemble *Q. palustris,* but the venation is intermediate in prominence and the midrib rises to the level of the upper surface, or is sometimes slightly depressed in an imperfect groove at the base of the blade. The margin is somewhat thickened and sometimes slightly revolute. The lower surface is smooth except for tufts of hairs in most of the axils of large veins and occasional patches of scant pubescence, especially toward the base of the blade. The blades vary in length from 4¼ to 6 inches, and in width from 1½ inches in the entire form to 3⅝ inches in the deeply lobed forms. The petioles vary from ⅜ to ⅝ of an inch in length, and are smooth or irregularly pubescent.

The stigmas resemble those of *Q. palustris* in form and color. The sepals of the staminate flowers are mostly unequal, broad and somewhat lobed, in these characters resembling *Q. palustris*, but being narrower, and showing a somewhat tapering rather abrupt tip which is somewhat laciniate tufted, in this respect approaching *Q. imbricaria.*

The cup is intermediate in form and arrangement of scales and is almost smooth within. The acorn resembles some of the more spherical forms of *Q. imbricaria* and is also intermediate.

It will be noticed that in form, dimensions and division of the blade, margin, venation, and lower surface of the leaf, the surface of the petiole, the form of the sepals, the form, arrangement of scales, inner surface and depth of the cup, and in the form of the acorn, the hybrid is intermediate between the parent species, sometimes approaching one, sometimes the other. The form and color of the stigmas, and the texture of the leaves are more nearly like those of *Q. palustris*, but the length of the petiole and the lower surface of the young leaf suggest *Q. imbricaria.*

The accompanying plates I and II illustrate both the parent species and the hybrid.

The hybrid here described is a double tree growing at the eastern edge of a mixed oak grove east of the railroad, in the south half of sec. 27, T. 78, R. VI W. The following oaks were found in this grove: *Q. imbricaria*, *Q. palustris*, *Q. velutina*, *Q. macrocarpa*, and *Q. imbricaria* x *palustris*. One of the oaks may be a hybrid, *Q. imbricaria* x *velutina*, but this was not satisfactorily determined.

Fig. 1. Leaves. (See p. 81.)
Quercus palustris DuRoi. The two lobed leaves.
Quercus imbricaria Michx. The three entire leaves.

Fig. 2. Leaves. (See p. 81.)
Quercus imbricaria x *palustris*. Three leaves showing variation in form.

PLATE I.

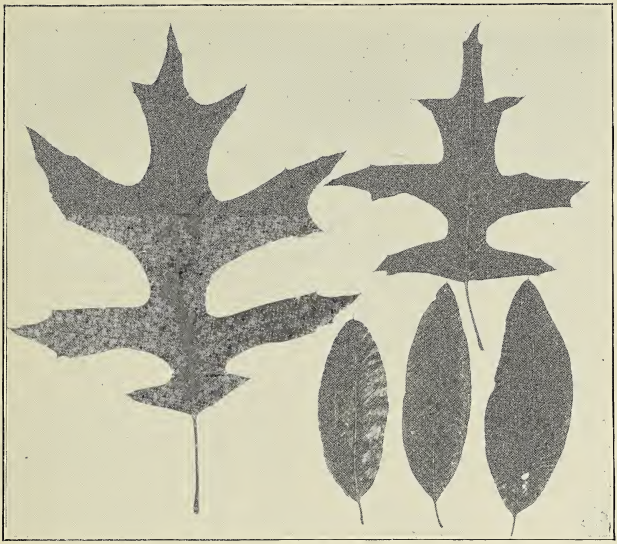


FIG. 1.

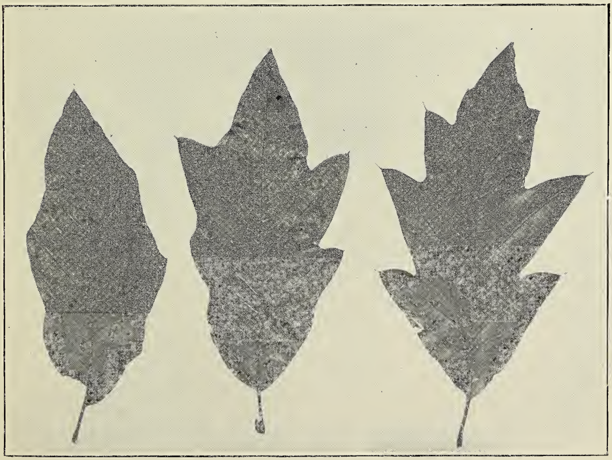


FIG. 2.

Fig. 1. Acorns. (See p. 83.)
Quercus imbricaria Michx. The four left-hand figures in the lower row.
Quercus palustris DuRoi. The four right-hand figures in the lower row.
Quercus imbricaria x *palustris.*. The upper row.

Fig. 2. Leaves. (See p. 83.)
Quercus imbricaria x *palustris.* Three leaves showing variation in form.

PLATE II.

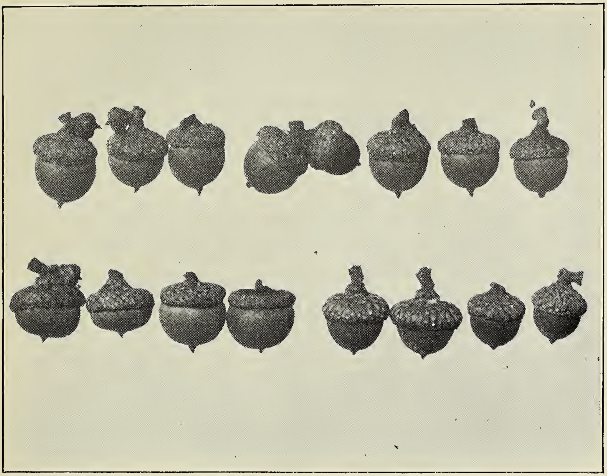


FIG. 1.

FIG. 2.

NOTES ON PERONOSPORALES FOR 1907.

BY GUY WEST WILSON.

Among the problems in the life history of the *Peronosporales* two important and interesting ones have received far less attention than they deserve. These are (1) the interrelation of meteorological conditions and the abundance and development of these fungi (2) the location of centers of seasonal distribution. While these problems have attracted the attention of a number of mycologists, they are of such a nature as to necessitate a series of observations extending over a term of years in a given locality and at the same time to require the co-operation of observers in localities widely separated in space and climate. To be of the greatest efficiency these observations, accompanied by specimens to properly authenticate them, should be communicated to some one who can study and correlate the accumulated data. In this way we may be able to arrive at some more definite conclusions concerning the problems of oospore formation.

As the papers on these subjects are of easy access, it is probably needless to review them at the present time. The most extensive series of these is by Dr. Halsted on the relation between the abundance of these fungi and the weather. These papers are based on observations made at Ames, Iowa, and New Brunswick, N. J. This series began with the data for 1886 and contained seasonal summaries of the abundance of the various species, but as a rule not taking into account either the dates of appearance or disappearance or the presence or absence of oospores, all of which would have added materially to the value of the records.

More recently another phase of the subject has been treated by Drs. Orton and Selby, who have been aided in their investigations of the centers of seasonal distribution by the facilities of the United States Department of Agriculture. These observations have been confined almost entirely to economic species, such as *Pseudoperonospora cubensis* and *Phytophthora infestans*. From these studies on the first species, the oospores of which have so persistently eluded the collector, it appears that this spore form may be elided or only produced at irregular intervals as a means of rejuvenation. The fungus is perennial in Florida and from this center is carried northward by the conidia each season.

That the same state of affairs may account for the absence from herbaria of the oospores of other species is not improbable, but such a theory will not suffice in all instances. For example, *Rhysotheca vuburnii* extends from central New York to Alabama and may be perennial at some point in the south, thus dispensing with oospores. On the other hand *Rhysotheca ribicola* extends from West Virginia through Wisconsin to Washington, with a probable northern extension of range, yet no oospores have so far been observed in America.

The accompanying notes on the *Peronosporales* during the past collecting season are based on observations made from early spring to late autumn at various localities. The season up to July 17th was spent in New York City and consequently few observations were made. The 18th and 19th of July were spent in the vicinity of Newark, Delaware, where short collecting trips were made each day. The remainder of the summer months were spent in central Indiana, the collections being made chiefly in Hamilton, Madison, Marion and Putnam counties. After arriving in Fayette in early September, but few observations were possible, as other matters made such demands as to leave but little leisure.

During the collecting season seventy-two specimens were collected and examined. Of these eight, or one in nine, contained oospores. Of the species represented a few were observed under conditions which prevented any conclusion as to their distribution through the season, while most of them showed marked seasonal development. *Plasmopara pygmaea* was observed only as an early spring form; *Albugo portulacae, A. tragopogonis, Rhysotheca Halstedii, Peronospora effusa,* and *P. polygoni* appeared during the latter part of the summer and autumn; *Bremia lactucae, Peronospora euphorbiae*, and *P. potentillae* appeared to be early summer forms. The remaining species, when observed more than once, appear to flourish throughout the season.

The abnormally cold spring and summer need no further comment than the following data from the United States Weather Bureau:

METEOROLOGICAL DATA FOR 1907.

Months	New York, N. Y.		Newark, Del.		Indianapolis, Ind.		Fayette, Iowa	
	Rain	Dept.	Rain	Dept.	Rain	Dept.	Rain	Dept.
March	3.89	−0.19	2.62	−1.22	4.07	+0.48	1.33	−0.93
April	3.89	+0.51	3.23	−9.16	2.07	−1.66	1.03	−2.17
May	4.08	+0.90	4.98	+1.09	2.85	−1.28	2.34	−2.50
June	3.29	+0.16	5.72	+2.11	4.68	+0.37	6.99	+1.14
July	1.18	−3.36	2.95	−1.39	4.41	+0.28	....	....
Aug	2.48	−2.05	3.35	−1.01	2.33	−1.00	4.18	+1.28
Sept	8.00	+4.41	8.06	+4.08	2.31	−0.74	3.58	+0.62
Months	**Temp.**	**Dept.**	**Temp.**	**Dept.**	**Temp.**	**Dept.**	**Temp.**	**Dept.**
March	40.8	+3.3	43.6	+3.0	48.0	+8.4	37.6	+7.4
April	45.0	−3.1	47.2	−3.2	43.3	−9.1	39.9	−7.3
May	55.3	−4.0	57.4	−4.5	56.8	−6.5	51.0	−6.7
June	66.2	−2.3	65.2	−4.5	68.0	−4.4	64.3	−3.9
July	74.9	+1.3	74.6	−0.5	75.1	−1.1	71.6	−0.7
Aug	72.0	−0.2	71.2	−2.1	72.4	−1.2	67.8	−1.7
Sept	67.8	+1.3	68.2	−1.0	65.8	−0.9	59.7	−2.8
Last frost of spring	April 21		May 12		April 21		May 27	
First frost of autumn	November 12		October 22		October 21		September 22	

ALBUGO BLITI (Biv.) Kuntze.

This species was first noted at Newark, Del., where it was not uncommon on *Amaranthus retroflexus* and appeared to have been fruiting for some time. The species was everywhere abundant in Indiana on the same host, as well as on *Amaranthus hybridus*, *A. spinosus*, and *Acnida canabina*. In Iowa the fungus fruited on *Amaranthus* until frost. A total of eleven specimens (Delaware one, Iowa one, Indiana nine), were examined, but no oospores found.

ALBUGO CANDIDA (Pers.) Roussel.

At the time of my visit to Newark this species appeared to be well on in its development, but rather scarce. It was observed only on *Sisymbrium officinalis*, a host upon which it was also found in Indiana. In the later state it was also observed in great abundance on *Brassica arvensis*, *B. nigra*, *Bursa bursa-pastoris*, *Lepidium virginicum*, *Raphanus sativus*, *Roripa armoracea*, and *R. palustris*. As one host passed its prime and began to cast its leaves the fungus appeared upon other hosts. Usually only the leaves were affected, but the pods of *Raphanus* and in addition the stems of *Bursa* were attacked. The only Iowa collection was on *Brassica nigra*, with a much hypertrophied stem. Fifteen collections (Iowa one, Delaware one, Indiana thirteen), were examined and oospores found in the pods of *Raphanus* (two collections), and *Bursa*, and in the stems of *Brassica nigra*.

ALBUGO IPOMOEAE-PANDURANEAE (Schw.) Swingle.

Two collections were made in August on *Ipomoea hederacea* in Indiana. While the fungus had appeared in Delaware much earlier in the season (as evidenced by both conidia and oospores collected by Dr. Cook and Mr. Jackson), the Indiana infections were very sparse and involved only a limited area of a few leaves, while no evidence of oospore galls could be found on the stems.

ALBUGO PORTULACAE (DC.) Kuntze.

During the last third of August this species was abundant in Hamilton and Madison counties, Indiana, the last collections containing oospores. Careful search earlier in the summer failed to reveal this species. It persisted in Iowa until frost, but no oospores were found.

ALBUGO TRAGOPOGONIS (DC.) S. F. Gray.

A single plant of *Ambrosia artemisaefolia* was found on July 29th near Greencastle, Indiana, with a number of the leaves affected by this fungus, which was not observed elsewhere during the season. Oospores were present.

SCLEROSPORA GRAMINICOLA (Sacc.) Schroeter.

A careful lookout was kept for this species, but it was not observed until after frost, when a single leaf of *Chaetochloa glauca* was found with oospores.

RHYSOTHECA HALSTEDII (Farlow) G. W. Wilson.

This species was first observed July 29th in the vicinity of Greencastle, Indiana, where a few infected leaves were found on one or two plants of *Bidens frondosa*. By August 13th the fungus was fairly abundant in this locality and by the 27th of that month scarcely a plant remained uninfected in all the Indiana localities visited. The infection was as complete as any seen during the season, all the leaves being affected and the lower ones killed outright, but no oospores were found. A single clump of *Erigeron annuus* was also found infected.

RHYSOTHECA VITICOLA (B. & C.) G. W. Wilson.

This species was quite abundant on both wild and cultivated species of *Vitis* when they were first examined in July. Conidia were collected on leaf, petiole, tendril, and young twigs. In some vineyards the disease was responsible for heavy loss of fruit, but none of the diseased berries were examined for oospores. Among the twelve specimens collected one was upon seedling of cultivated grapes.

PLASMOPORA PYGMAEA (Unger) Schroter.

A single leaf of *Anemone quinquefolia* was found infected with this species in New York in April.

BREMIA LACTUCAE Regel.

Collected on *Lactuca canadensis* in Hamilton and Putnam counties, Indiana, between July 23d and August 3d. All this material had the appearance of being quite old and indicated that the conidia had been produced for some time past. Of the three specimens collected none contained oospores.

PERONOSPORA ALTA Fuckel.

A single infected leaf of Plantago major was found in Hamilton County, Indiana, on August 22d. No oospores were found.

PERONOSPORA EFFUSA (Grev.) Rabenh.

Late in July leaves of *Chenopodium album* began to show the yellow spots caused by this fungus and by the middle of August scarcely an uninfected clump could be found. Of the four Indiana specimens examined one contained oospores.

PERONOSPORA EUPHORBIAE Fuckel.

During the later part of July *Euphorbia maculata* was noticeably affected with the conidia of this species which rapidly increased in abundance. The two collections from Indiana show no oospores.

PERONOSPORA PARASITICA (Pers.) Fries.

During the early spring in New York this fungus attacked great numbers of seedlings of *Lepidium virginicum*, but soon run its course. The previous summer the fruit and infloresence was frequently destroyed during midsummer, but this season no such attack was noted before reaching Newark, Delaware, where the fungus was evidently just making its appearance. The same host was found sparingly affected in Indiana. Here a single clump of *Brassica nigra* and a single bed of *Raphanus sativus* were found infected. No very robust growth of the fungus was observed this season. Of the five specimens (New York one, Delaware one, Indiana three), examined the only oospores found were intermingled with those of *Albugo candida* on a pod of *Raphanus*.

Peronospora polygoni Thum.

A clump of *Polygonum scandens* was examined on July 24th and showed rather an abundant infection of this fungus, the majority of the conidiophores being immature. The fungus increased in abundance throughout August. Of the two Indiana collections neither showed oospores.

Peronospora potentillae de Bary.

This species was first observed on *Potentilla monsepalensis* July 24th, when the infection appeared to be quite old. No more conidiophores were found after August 1st. Neither of the two Indiana collections contain oospores.

While the present paper is not devoted entirely to the Indiana *Peronosporales* the majority of the data was collected in that state. It is perhaps not remiss to add that all the species recorded from that state were collected except seven. Of these six are known only as spring forms and the seventh is confined to more northern portions of the state than were visited.

SOME FORESTRY PROBLEMS OF THE PRAIRIES OF THE MIDDLE WEST.

BY HUGH P. BAKER.

A residence of several years in one of the central prairie states and two seasons spent in studying natural conditions through a belt of prairie country from the Mississippi to the foothills of the Rockies makes me feel that the problems of prairie forestry are not only intensely interesting, but that their early solution will be of vast importance to the future agricultural and commercial development of the entire middle West.

The Region Considered.

To more clearly define the region, the forestry problems of which will be considered in this paper, a broad belt of country has been selected lying between the lines of mean annual rainfall of 15 inches on the west and 30 inches on the east and including all or large parts of the states of Minnesota, North and South Dakota, Iowa, Nebraska and Kansas. There is no part of the region, where there is sufficient soil, that forest trees cannot be grown successfully, but until there is a much greater forest covering than at present it will not be as simple a matter to make trees grow as it is farther east or west, where conditions of rainfall and wind currents are more favorable. There is really considerable similarity in the soils of the entire region and there are no soils except the acid soils of peat swamps that are not fitted for the successful commercial production of forest trees.

The entire region except northeastern Minnesota and the Black Hills country is essentially treeless, though there are numerous indications that this was not always so. There have been some desultory and incomplete studies of early surface conditions in the region, but not enough data has yet accumulated to justify definite statements as to any forest cover that may have existed in late geological times or as to the causes for present treelessness. Systematic investigations of peat bogs which exist here and there throughout the region might throw much light on the subject. We are, however, safe in believing that the treeless condition is not due to any one cause, but to a combination of causes or factors, such as annual or periodical fires, wind, lack of precipitation and fineness of soil.

Opportunities for the Practice of Forestry.

This region offers large opportunity for the practice of forestry with consequent solution of the problems of prairie forestry for two reasons. First, the large amount of non-agricultural land existing in the states included in the region. Ordinarily one thinks of this whole section of country as a rich prairie covered with grain and stock farms, and it is an exceedingly rich section. The total area of the six states under consideration is 447,425 square miles. The census of 1900 shows that of this area 237,025 square miles or 174,736,000 acres is unimproved and non-agricultural land. It is probable that since 1900 considerable areas have been brought under cultivation, but for some years to come there will be an area larger than the present area of our National Forests which may be devoted to the growing of forest trees without using an acre of cultivated or improved land. Throughout the northern portion of this section the dairy and fruit industries are developing rapidly and more and more unimproved land will be used for grazing and fruit growing. But should we take only half the amount of non-agricultural land as given by the census of 1900 there would yet be an area of 87,368,000 acres, which is nearly equal in size to Minnesota and Iowa combined. This vast amount of essentially forest land, easily accessible to the great markets of the middle West, and largely without the topographic and climatic difficulties of the forest lands of the Rockies and westward, certainly demands careful consideration in the development of a future and perhaps permanent forest policy for this country, towards which we are now feeling our way.

Second, the nearness of good markets. This factor often controls the success or failure of large commercial undertakings, especially where initial expenditures are great. Under existing climatic and soil conditions we are learning that it is necessary to use seedlings and well-developed seedlings in starting successful commercial plantings on our prairie lands. The initial expenditure in carrying on forestry work which involves planting will therefore be great, but the accessibility of the land and nearness of market will make it possible to harvest easily and often and to dispose of all of every tree.

What Lands May Be Devoted to Forestry.

The fence post question and in many instances the fuel question are just as vital to the prairie farmer as the tie and coal questions are to our railroads. With the introduction of methods of treating timber at small expense, it will rapidly become more profitable to grow as a forest crop the soft wooded species which may be grown on an exceedingly short rotation. The value of agricultural land generally in the region is too great to justify its use for the commercial production of timber over large areas. It is not a business proposition to devote land in any quantity to tree growing which will range in price from $10 to $100 per acre when there are millions of acres of sand hills and sand barrens which will grow good crops of trees and which may be purchased readily at from 50 cents to $5.00 per acre. Though it will not pay to devote large areas of valuable prairie land to tree growing, it will pay on farms of 100 acres or more to plant from 1 to 10 acres of good rich land to quick growing species producing wood durable enough for fence posts or which may be easily and cheaply treated with some preservative. Measurements taken on many groves in this region seem to prove that where good land is planted to the right species and given proper culture, that returns comparable with those from grain crops are obtained. With the present constant increase in prices of all sorts of wood material used on the farms of this section, farm owners are beginning to see that it is a business proposition to grow needed wood supplies right on the farm.

Planting Problems of the Prairies.

If we relegate the growing of forest trees on a large commercial scale to the essentially waste lands of the region there is left the vast area of good agricultural land which in the future must and will produce a large part of the posts and repair material needed on the farms. This agricultural region offers two lines of planting problems for consideration. First, planting from standpoint of protection. This phase of forestry has been an importane one to the dweller on the prairies since settlement first began. Without agitation on the part of those early interested in forestry in this country windbreaks were planted as soon as settlers began pushing out across the prairies. Seeds and cuttings of species native along the waterways were first used because easily accessible and cheap. A little later seeds of eastern species were sent out to the prairies by relatives of the settlers, and men like Prof. Parry of Davenport, Iowa; Prof. Henry H. McAfee, who was secretary of the original American Forestry Association organized in Chicago on September 10th, 1875; ex-Governor Furnas of Nebraska; Arthur Bryant of Princeton, Illinois, and Prof. Budd of Iowa were instrumental in introducing evergreens from both the east and the west. In this way all of the native species and a very large number of exotics have been given trial and it is safe to say that the problem of the species best adapted for windbreak planting in this section is pretty thoroughly solved. What we do not know and what seem very important problems to be solved during the next few years are, first, just what influences windbreaks of different species have upon wind currents of varying velocities and upon rapidity of evaporation under differences of temperature and humidity; second, just how far windbreaks of varying heights will produce a calm to the leeward under differences of topography, and, third, the influence of the nearness and denseness of windbreaks upon grain and fruit production, plant diseases and injuries by frost. Our own efficient Weather Service has done a little preliminary work along these lines and we know of the results obtained by M. Becquerel in the Rhone Valley and others, yet the problems above referred to are really unsolved and offer an extremely interesting field to the investigator.

Every year throughout this region soil erosion is causing greater injury to fields and their crops, barren ridges and bottom lands. Both the increase in price and in the crop production possibilities of the land are yearly making it more necessary that this serious damage from erosion be prevented. Many land owners appreciate the seriousness of allowing erosion to continue, while others do not, and until all know there should be a vigorous campaign of education along this one line. Such efforts as have been made to prevent erosion have been unsystematic and temporary. A few desultory studies have been made here and there, but more thorough investigations are needed with the results so presented that owners of land susceptible to erosion will not allow it to begin and upon lands where it has begun effective measures will be carried out to prevent further injury.

Within the limits of this region there are a few areas subject to soil movement by wind and in several instances actual sand dunes are forming. Throughout the country as a whole damage resulting from dune formation and movement is very much larger than ordinarily supposed. As most of the dune areas are adjacent to waterways and large bodies of water, it may be that the actual work of dune reclamation belongs to the War Department, but experience abroad, as well as in this country, has shown conclusively that grass planting alone as a means of dune reclamation cannot be otherwise than a temporary expedient. If the solution of the dune problems belongs in any scientific bureau of our government it is in the Forest Service.

Second, planting from the standpoint of production.

In the light of experience in other parts of the country and abroad it is probable that the large areas in this section previously referred to as essentially non-agricultural land, amounting to nearly 90,000,000 acres, can only be effectively and profitably handled from a forestry standpoint by the states or by the national government. As extensive studies have been made of lands of this class west of the Mississippi their problems will not be considered here.

There are, however, many millions of acres of agricultural land which should and will produce over small areas and in small quantities the posts, repair material and fuel needed on the farms of the region. The long-continued trial of species for windbreaks has shown to a certain extent the species best adapted to the requirements of farm planting. Recent studies have given considerable data of greater or less value upon growth and something as to soil and moisture requirements of the trees which have so far been successful. There are, however, some interesting problems yet to be solved. One of the most valuable trees for this region, the European Larch, is an exotic. There are other exotics which, upon thorough trial, may prove equally as valuable. Those foreigners among our trees which are partial failures, such as the Scotch Pine, may upon the introduction of seed from the best trees growing in Europe or by selection here, be made very much more profitable. Without doubt breeding and selection, though requiring a long period of time, will improve the hardiness and shape of the Hardy Catalpa, Russian Olive and Mulberry; will fix the thornless form of the Honey Locust, and produce a straight growing and thornless form of Osage Orange and last and most important produce a borer resistant Black Locust.

Under the severe conditions of winter and summer droughts on our prairies proper culture is extremely important in the successful production of a forest crop. We may profit somewhat by the experience gained in the production of fruit and grain crops by dry-farming, yet as a whole the cultural methods necessary in successful tree growing are unsolved problems. Those who have been observing results of tree growing in this great central prairie region will agree that the plantings on the prairies have so far yielded but a fraction of a per cent of what they would have yielded with proper culture and protection. In many instances the returns from groves put out on rich prairie land have been fair, but this has been in spite of proper care rather than because of it.

The early promiscuous mixed plantings made up of a great variety of species did not prove satisfactory and tree planters have gradually swung to the opposite extreme and are planting too much in pure stand. Either extreme is far from right with all species under prairie conditions, yet with our present lack of knowledge planters are probably safer in putting out their trees in pure stands than attempting mixtures. There are certain combinations of species usually advised for prairie plantings and yet we do not know what the result will be under the varying soil and climatic conditions of the prairies. We cannot give advice for the western country based upon results obtained here in the East. This problem of proper mixture of species demands early solution.

Who Will Solve the Problems.

A consideration of the problems suggested leads directly to the question as to who can best solve them. Whether the National Forest Service should take hold of the matter or whether the states interested are in a position to begin a series of scientific investigations requiring a long period of years and carry them to a successful completion is a difficult question to answer. At present the states are not willing to provide sufficient funds for the maintenance of organizations under which such work might be carried out. However, with the example of several eastern states before them, there is a growing sentiment throughout the entire region that the several states interested should carry on work in forestry in so far as it is confined to their limits. It seems reasonable that problems which are of vital interest and importance to the whole region should not be left to the separate states, but should be solved through the efforts of the National Forest Service. If this is not done one state through lack of interest or ability may hold back the proper forestal development of all the states interested. Upon whomsoever the responsibility of the solution of these problems falls, it is exceedingly necessary that investigations should begin soon that we may have the knowledge absolutely required to successfully practice forestry over the prairies of our great middle west in a way consonant with the intelligence and energy of her people.

A CASE OF THE ISOLATION OF DIPHTHERIA BACILLI FROM A POST MORTEM.

By L. S. Ross.

(Abstract)

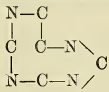
Records seem to show that diphtheria bacilli are not often found in the blood of the patient, but that they may be occasionally after death. Probably at the time of death the bacilli may enter into the circulation, but not as a usual occurrence. On the 20th of January, 1908, the writer was asked to assist at a post mortem of a child, the cause of death presumably being cerebrospinal meningitis. The post mortem appearances seemed to indicate that as the cause of death. Bacterial cultures were taken from the spinal canal, from the brain and from the serous fluid about the heart The cultures from the spinal cord were all sterile, one from the brain showed some cocci, and the culture from the serous fluid of the heart showed a mixed culture of cocci and diphtheria. Sub-cultures produced a pure growth of diphtheria.

THE URIC ACID FERMENTS.

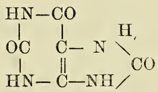
ELBERT W. ROCKWOOD.

Within a few years our knowledge of the formation and destruction of uric acid in the body has been much broadened. For a long time after its isolation its origin, significance, place of formation and the agents active in its production and decomposition were unknown. In these respects the facts differ much in the cases of birds and mammals and only the cases of mammals will be here considered.

At the present time it is the belief of physiologists that uric acid is largely formed in the liver through the action of ferments upon the nucleins. A synthetic formation of uric acid in the body may take place, but convincing proof of this is wanting. The nucleins which furnish much of the material for uric acid belong to the conjugate proteins. They contain 5 per cent or more of phosphorus and, in addition to a simple protein, the purin ring,



found likewise in uric acid,



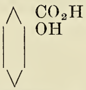
The relationship of the purin bodies to uric acid may be seen from the following:

$C_5H_4N_4$	Purin
$C_5H_3N_4NH_2$	Amino-purin (Adenin)
$C_5H_3N_4NH_2O$	Amino-oxypurin (Guanin)
$C_5H_4N_4O$	Oxypurin (Hypoxanthin)
$C_5H_4N_4O_2$	Dioxypurin (Xanthin)
$C_5H_4N_4O_3$	Trioxypurin (Uric Acid)

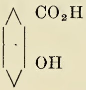
From the liver have been extracted ferments which will destroy nucleins and will oxidize hypoxanthin and xanthin to uric acid. The uric acid thus formed is referred to as of two varieties, the endogenous—that derived from the nucleins of the tissues—and the exogenous—that coming directly from the nucleins of the foods. Of the uric acid which is produced in this manner a considerable part, varying in different animals, appears to be destroyed before elimination, so that the uric acid found in the urine represents merely the difference between the amounts produced and destroyed. This decomposition appears to be, at least in part, due to a ferment, the uricolytic.

This paper may be regarded as a report on some uncompleted work which is being carried on in our laboratory. Its purpose it to throw more light upon the nature of these ferments and the conditions which may modify their action in the human body. In order to simplify the problem the exogenous uric acid was excluded by limiting the subjects to a purin-free diet. This consisted of the wheat foods, milk, eggs, cheese, butter, with no potatoes or very little. The kinds and amounts were practically the same each day of the experiment. As has been found by a number of investigators the endogenous uric acid of the same individual, although there may be variations from day to day, has a remarkably constant average amount. Hence on such a diet as the above the effect of changing the other conditions can be readily seen. The experiments here described were made in the attempt to learn of the modification of the action of the uricolytic and uric acid forming ferments from the administration of drugs.

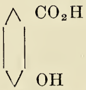
As is well known, salicylic acid (ortho-hydroxy-benzoic acid),



markedly increases the output of uric acid in the urine, where it makes up about nine-tenths of the total purins. Not only the free acid, but also its salts and some other derivatives like aspirin (the acetic acid ester of salicylic acid) do this. Among the drugs used were the isomers of salicylic acid, meta-hydroxy-benzoic acid,



and para-hydroxy-benzoic acid,



The endogenous uric acid was determined for a drug-free period, usually of several days, then the amount eliminated during the administration of the drug and also in an after period when no drug was taken. The uric acid was determined by Folin's method, as was the creatinin; nitrogen by Kjeldahl's method and phosphoric acid by titration with uranium acetate. The results are shown below:

TABLE I.

Subject A.

Date	Conditions	Volume, cc.	Creatinin, grm.	P_2O_5, grm.	Nitrogen, grms.	Uric acid, grm.
May 23	Endogenous					0.388
24	Endogenous					0.289
	Average, endogenous					0.328
25	1.7 grms. aspirin					0.328
26	3.7 grms. aspirin	980	1.04	2.42	10.12	0.601
27	2.0 grms. aspirin	950	1.07	2.33	10.12	0.481
28	2.0 grms. aspirin	980		2.48	10.41	0.446
29	2.3 grms. aspirin	1085	1.14	2.50	12.03	0.413
30	2.6 grms. aspirin	1580	1.23	2.84	12.92	0.465
31	2.6 grms. aspirin	780	1.01	2.30	8.62	0.414
June 1	3.3 grms. aspirin	730	1.17	2.28	10.89	0.341
2	4.0 grms. aspirin	1480	1.09	2.10	11.75	0.411
3	1.3 grms. aspirin	800	1.09	2.40	10.89	0.360
4	2.6 grms. aspirin	950	1.07	2.26	10.96	0.366
5	3.7 grms. aspirin	1116	1.03	2.55	11.67	0.458
	Average, aspirin period		1.07	2.41	10.22	0.424
6	Endogenous	1025	1.06	2.60	10.57	0.096
7	Endogenous	1130	1.13	2.74	9.24	0.278
8	Endogenous	1130				0.268
	Average, endogenous		1.10	2.67	9.91	0.214

From Table I can be seen the response of the organism to the administration of salicylic acid. Folin has shown that the creatinin can be taken as a measure of the bodily metabolism. If we note the amount of creatinin and total nitrogen eliminated we find that the general metabolism was very little affected; whereas in general the uric acid increases with the drug. Since there was no increase in the phosphorus output the indication is that the increased elimination was due to an inhibition of the uricolytic or destructive ferment rather than to an increased destruction of the nucleins through a stimulation of the oxidizing ferment. The great decrease in eliminated uric acid in the after period with no corresponding change in the other protein decomposition products has been observed in other experiments. Possibly the uricolytic ferment becomes under these circumstances more than ordinarily active, although some more satisfactory explanation may be found.

TABLE II.

Subject B.

Date	Conditions	Volume, cc.	P_2O_5, grm.	Creatinin grm.	Nitrogen, grms.	Uric acid, grm.
Feb. 13	Endogenous	1350	1.90	1.62	11.07	0.361
14	Endogenous	1100	2.35	2.08	12.90	0.424
15	Endogenous	1025	2.13	2.20	11.32	0.434
17	Endogenous	1030	2.00	1.78	10.09	0.436
18	Endogenous	1250	1.89	1.56	9.36	0.413
	Average, endogenous period	----------	2.05	1.85	10.95	0.415
19	3¾ grms. para-hydroxy-benzoic acid	950	1.58	1.97	9.59	0.446
20	Endogenous	1070	2.80	1.68	10.70	0.503
23	Endogenous	1175	2.44	1.83	11.26	0.478
24	Endogenous	850	1.43	1.84	--------	0.417
	Average endogenous	----------	2.22	1.78	10.98	0.467
25	1 grm meta-hydroxy-benzoic acid	1075	1.75	1.90	9.70	0.310
26	3 grms. meta-hydroxp-benzoic acid	1150	1.89	1.58	--------	0.380
27	9 grms. meta-hydroxy-benzoic acid	2200	2.29	1.85	11.96	0.396
	Average meta-hydroxy-benzoic acid	----------	1.98	1.78	10.83	0.362
28	Endogenous	1180	2.18	1.67	10.30	0.376
29	Endogenous	700	----------	--------	--------	0.357
	Average endogenous	----------	----------	--------	--------	0.367
Mar. 1	4 grms. sodium salicylate	1250	----------	--------	--------	0.588

A comparison of the results from Subject B shows that the para and meta compounds cause no apparent increase in nuclein cleavage; the oxidizing ferment does not appear to be stimulated. At least if it is there is a corresponding decomposition of the uric acid. That this is improbable is proved by there being no marked variation of the phosphorus; that the subject was susceptible to the ortho compound is seen from the action of the salicylate. Similar results were obtained from the use of the meta-hydroxy-benzoic acid with Subject A.

TABLE III.

Subject C.

Date	Conditions	Volume, cc.	P_2O_5, grm.	Nitrogen, grms.	Uric acid, grm
Jan. 14	Endogenous	725	----------	9.43	0.419
15	Endogenous	720	1.94	10.25	0.448
16	Endogenous	680	2.09	9.72	0.453
17	Endogenous	755	1.73	9.70	0.496
	Average endogenous	----	1.92	9.70	0.454
18	0.7 grm. para-hydroxy-benzoic acid	855	1.50	9.63	0.139
19	2.0 grm. para-hydroxy-benzoic acid	810	2.20	9.09	0.439
20	3.0 grm. para-hydroxy-benzoic acid	1020	1.77	9.11	0.340
	Average para-hydroxy-benzoic acid	----------	1.82	9.28	0.306
21	Endogenous	775	1.74	10.29	0.439
22	Endogenous	900	1.37	10.34	0.398
23	Endogenous	810	1.75	----------	0.356
24	Endogenous	905	1.99	10.61	0.432
	Average endogenous	----------	1.71	10.41	0.406
26	2 grms. sodium salicylate	805	1.95	11.26	0.534
27	3 grms. sodium salicylate	805	1.74	10.39	0.586

Again with Subject C susceptibility to salicylic acid is evident while the para compound actually decreases the urinary uric acid. A possible explanation is the decreased nuclein cleavage, but in view of there being no such drop in the total nitrogen nor in the uric acid eliminated under similar conditions by Subject B, also of the danger of drawing too positive conclusions from a single experiment in physiological chemistry, final decision should be postponed. The experiments seem to clearly indicate that neither of the hydroxy-benzoic acids affect nitrogen metabolism except in the case of uric acid. Furthermore, when the side chains are in the ortho position the uric acid is increased in the urine; when in the meta or para positions this is not true. If Emil Fischer's hypothesis be correct that in order to produce decomposition a ferment must have a configuration corresponding to that of the compound which it changes, we can apply it here to explain the different effects of these three isomeric substances; otherwise we must await the discovery of additional facts to devise a more rational theory.

THE DETERMINATION OF FERROUS IRON.

BY NICHOLAS KNIGHT.

Robert Mauzelius, in the Geological Survey of Sweden (Sveriges Geol. Underseekning), calls attention to a universal defect in the estimation of ferrous iron in minerals and rocks. He finds that a considerable error arises from grinding the rock in the ordinary way to a fine powder, owing to the oxidation of ferrous to ferric iron. If the specimen is reduced to a coarse powder instead of being finely pulverized, a more accurate result is attainable. This source of error has hitherto escaped the attention of analysts.

We have investigated specimens of siderite with a view to determine the oxidation effect when the mineral is finely pulverized. In each case only the ferric oxide was estimated, and the method of Berzelius as modified and improved by Bunsen was employed.

About a grm. of the specimen was weighed each time in a 200 cc. flask which was fitted with a bulb tube and Bunsen valve. The substance was dissolved in a small quantity of hydrochloric acid, and a crystal of sodium carbonate was introduced to make an atmosphere of carbon dioxide. The flask was cooled as quickly as possible with water, and the ferric iron was precipitated with barium carbonate. The precipitated iron was at once filtered with suction and washed twenty or thirty times with cold water. The ferric carbonate was dissolved in hydrochloric acid, the excess of barium removed with sulphuric acid, and the iron precipitated with ammonia. The ores contained only about 1½ per cent of residue insoluble in hydrochloric acid. Two different specimens of the mineral were studied.

1. The specimen was run through a Taylor hand ore-crusher, and came out as a coarse powder. The mean of several fairly concordant results was 2.68 per cent Fe_2O_3. The coarse powder was next so finely ground in an agate mortar as not to feel gritty when placed between the teeth. It gave 3.26 per cent Fe_2O_3.

2. This specimen was enveloped in heavy paper, and reduced to a coarse powder in an iron mortar; 2.67 per cent of Fe_2O_3 was obtained. This coarse powder was finely ground in an agate mortar, when 3.11 of Fe_2O_3 per cent was obtained.

The oxidation is due to the heat caused by friction, and possibly in a lesser degree to the greater surface exposed to the air when the mineral is in a very finely divided state. The coarse powder is easily acted upon by the hydrochloric acid, and there is no necessity for making the determination with a very fine powder.

Our thanks are due to Mr. Robert H. Lott for making the analyses herein described.

THE DECOMPOSITION OF DOLOMITE.

BY NICHOLAS KNIGHT.

The dolomites of Iowa and other sections of the country, belonging to the Niagara period of the Upper Silurian, in the course of centuries apparently undergo decomposition. The rock loses its massive structure and becomes crumbly and mealy in appearance. In the vicinity of Mount Vernon, Iowa, the top layer to a depth of 3 or 4 inches seems to be quite thoroughly disintegrated and powdery. The same phenomenon is observed in lower strata where a layer projects, by which it is especially exposed to the elements. A similar disintegration is observed in many other localities.

It seemed reasonable to suppose that some constituent or constituents of the rock are more soluble than the others, or more easily acted upon by atmospheric agencies. The analysis of a more or less disintegrated air-dried specimen resulted as follows:

SiO_2	0.56 per cent
Fe_2O_3 and Al_2O_3	0.74 per cent
$CaCO_3$	48.43 per cent
$MgCO_3$	50.56 per cent
Total	100.09 per cent

The analysis of a typical massive specimen gave:

SiO_2	0.83 per cent
Fe_2O_3	0.59 per cent
$CaCO_3$	53.62 per cent
$MgCO_3$	44.96 per cent
Total	100.00 per cent

It is thus seen that about 10 per cent of the calcium carbonate has been removed, and the magnesium carbonate is relatively stable. Other portions of the rock would doubtless show greater disintegration.

Immediately above the disintegrated layer referred to are found portions of what appears like a ferruginous clay. In all likelihood it formerly existed as a distinct layer, but was largely removed by the ice sheet. It has accumulated in various cavities and depressions in the rock. This formation is quite widely extended. In Northeast Iowa it is several feet in thickness and in Southwestern Wisconsin, on broad uplands, where it has been but little disturbed by the ice-sheet, it has a thickness of 13 feet.

An analysis of the ferruginous clay resulted as follows:

SiO_2	16.68 per cent
Fe_2O_3	60.87 per cent
Al_2O_3	6.18 per cent
CaO	0.22 per cent
MgO	0.03 per cent
H_2O	17.14 per cent
Total	101.12 per cent

This clay probably resulted from the dolomite by the slow solution of the calcium and magnesium carbonates. The typical specimen of the rock referred to above contained 0.25 per cent Al_2O_3 and 0.34 per cent Fe_2O_3; therefore the alumina seems to have been removed much more rapidly than the ferric oxide.

If this deposit resulted from the decomposition of dolomite it must have been very slow in forming, and the accumulation of as great a quantity as 13 feet must have required a very long time.

Our thanks are due Mr. Merle S. West for assistance in this investigation.

SOME IOWA WATERS.

BY NICHOLAS KNIGHT.

1. *The Springville Water Supply.*

The source of the supply is an artesian well one hundred and fifty feet in depth. The water is quite free from organic contamination, and quite soft for an Eastern Iowa water. The numbers express the different amounts in one million parts of the water.

Total Solids	240.0
$CaCO_3$	101.4
$MgCO_3$	93.6
$CaSO_4$	20.4
Fe_2O_3 and Al_2O_3	19.4
$Si'O_2$	0.4
NaCl and KCl	4.8
CO_2 free and partly united	63.0
Free ammonia	0.05
Albuminoid ammonia	0.07
Nitrates	0.10

2. *The Spring at the Palisades.*

This is a well-known spring at the Palisades on the Cedar river. The figures express great freedom from organic contamination. The low temperature of the water indicates a deep-seated origin. The taste is agreeable and altogether the spring is a valuable one.

Total Solids	316.4
$CaCO_3$	175.8
$MgCO_3$	97.2
Fe_2O_3 and Al_2O_3	6.8
$Si'O_2$	9.8
NaCl and KCl	26.8
CO_2	168.00
Free ammonia	0.012
Albuminoid ammonia	0.00
Nitrates	0.634

3. *The Lisbon Water Supply.*

The supply comes from two sources: A spring twenty-four feet in diameter anu twenty-four feet in depth; and from a well one hundred and forty-four feet deep. The water is pumped from the well into the spring, and thence into a standpipe, from which the town is supplied. The first analysis is of the water direct from the main, which is, therefore, a mixture of the spring and well water.

The results are as follows:

Total Solids	266.00
$CaCO_3$	119.6
$MgCO_3$	108.1
$CaSO_4$	36.4
Al_2O_3	4.06
NaCl and KCl	13.40
Si'O_2	9.86
CO_2	201.0
Free ammonia	0.056
Albuminoid ammonia	0.088
Nitrates	0.296

The water from the spring:

Total Solids	255.0
$CaCO_3$	117.4
$MgCO_3$	74.08
$CaSO_4$	33.60
Al_2O_3	4.46
Si'O_2	10.06
NaCl and KCl	14.40
CO_2	172.0
Free ammonia	0.00
Albuminoid ammonia	0.032
Nitrates	0.06

The water from the well:

Total Solids	288.20
$CaCO_3$	123.90
$MgCO_3$	106.20
$CaSO_4$	20.20
Al_2O_3	4.66
Si'O_2	5.00
NaCl and KCl	28.20
CO_2	388.70
Free ammonia	0.064
Albuminoid ammonia	0.088
Nitrates	0.296

THE LIFE OF PORTLAND CEMENT.

BY G. G. AND A. J. WHEAT.

Perhaps just a word in explanation of the title of this paper will not be amiss. We speak of Portland Cement as possessing life. We do this because the duration of its existence as Portland Cement is measurable. In contradistinction we might speak of a material such as the Sioux Falls Quartzite as being dead, since no appreciable change takes place in the body of this Quartzite, all of the elements of the Quartzite being practically at a state of rest and resisting all disintegration by the ordinary weathering agencies. Perhaps our distinction may be somewhat arbitrary and we cheerfully invite helpful criticism.

This subject has interested us for a number of years. We have taken interest in the advance in engineering construction made possible by the widespread production of Portland Cement. We have anticipated the conditions which have arisen and through the throes of which we are now passing. Portland Cement, one of the most valuable materials known to the engineering world, is being heavily overworked and is being crowded into fields of use where it is not fully competent to endure the conditions which it must meet.

Without further preliminary we will give the results of some laboratory work and some suggestions concerning lines of research which to us seem to promise valuable results. We shall consider as our most sincere friend any fellow member who can or will show us that we are doing work in our investigations that is not correct.

Early in this year we appeared before the Iowa Clay Workers at Des Moines. There we presented the following facts and suggestions: Portland Cement construction or concrete does disintegrate with age. The places or conditions where this disintegration occurs are found to subject the concrete to one common agent of destruction. Where protected against the action of this agent and also not subject to some other destructive agent the concrete proves durable. The obvious explanation of the disintegration of the cement is the action of this one common agent, water.

Disregarding the commonly advanced theory that concrete grows continually better under the action of water, we stated that the work of engineers and chemists shows plainly that there is a point of maximum strength reached in a very few months in light walled construction and in more massive work possibly in a matter of a few years. Following this point of maximum strength the concrete is found to grow gradually and steadily weaker.

Now in explanation of these facts we turned to the crystallization theory for a partial explanation of these phenomena of maximum strength followed by a decrease. The theory of crystallization offered as an explanation of the process of Portland Cement in setting seems to us inadequate to explain fully the process.

But the microscope shows clearly that the theory is true, at least in part. The theory of crystallization states practically that each tiny particle of Portland Cement is incased in a thin envelope of water and passes into solution in part. Then it crystallizes to its neighboring particle or to the grains of grog or sand.

If this theory be correct then the obvious explanation of the phenomena of reaching maximum strength and later decreasing in strength can be explained at least in part, by the slow completion of this process of crystallization; during this process there being a steady loss of a small part of the cement, removed in solution by percolating waters, this process continuing steadily after the process of crystallization is completed.

In continuation of our work we sent pieces of well cured cement construction to Dr. Knight at Cornell College. These were treated with distilled water and a considerable percentage of solids was dissolved. Analysis of these solids revealed the presence of silica, calcium and aluminum in about their ratio in Portland Cement. This strongly indicated that we had secured solution of the Portland Cement as a whole and that we were not securing merely free lime. By these experiments and others conducted at the University of Illinois we justified ourselves in the belief that a very appreciable part of Portland Cement is soluble in pure water. Before the Clay Workers of the state we presented our conclusions that the thin wall construction of Portland Cement drain tile, being very porous and subject to continuous action of water, would be short lived and to all practical intents and purposes would entirely dissolve away.

Since that time we have conducted further experiments at Cornell College and the University of Illinois, the results of which we wish to give you now.

Mr. L. R. Ernest, University of Illinois, finds that one gallon of water will dissolve about one gram of the material of a Portland Cement drain tile. (We use Portland Cement drain tile and sewer pipe in our investigation, as in these uses the cement is subjected to very severe conditions and disintegration will work most injury, as it is out of sight and would not be observed until the damage done compelled investigation.) Mr. Ernest further treated a weighed amount of the material with distilled water and the alkalinity was titrated with standard acid. The per cent of dissolved lime after one day was 0.9 per cent. After two weeks 1.9 per cent. After one month 2.1 per cent. It would appear from this that the saturate solution would be reached somewhere between two and three per cent.

Mr. C. J. Derrick of the University of Illinois has done work practically duplicating this and the additional work with the Soxhlet extractor. A small piece of tile was broken in two pieces, which would fit in a large size extractor. The dust was carefully removed from the two pieces in order that only a piece of the undisturbed tile would be acted upon. The idea was to duplicate the conditions of nature as far as possible where the water comes in contact with the unbroken tile. The Soxhlet extractor was employed in order that pure, fresh water would constantly wash the tile. Of course the difference here was that the water was pure, being condensed from steam, while it is not pure in nature, but contains organic acids. The tile was subjected to the action of water in this way for 72 hours with the following results: Weight of piece No. 1, 24.9185 grams; weight of material extracted, 0.5097; weight of piece No. 2, 18.2227; weight of material extracted, 0.4281; per cent of material extracted from No. 1 was 2.08 per cent; from No. 2 was 2.34 per cent. This tile being one-fifth Portland Cement, this would show that an average of over eleven per cent of the Portland Cement had been dissolved and removed by the extractor. The piece of tile No. 2 was again subjected to the Soxhlet extractor for 72 hours and the amount of solids secured was 0.4498. This time the percentage amounting to 2.55 per cent.

Mr. Layton Gouldin, assistant to Dr. Knight, has made analysis of these solids and finds the percentages to be: Ferric iron, 0.97 per cent; Alumina, 2.08 per cent; Magnesia, 0.21 per cent. The remainder of 96.74 per cent being calcium carbonate, silica and calcium sulphate. The work is not yet complete on the analysis, but the qualitative tests show the presence of the elements not determined.

Mr. Layton Gouldin has questioned the reliability of work done on a sample of the concrete tile as being open to the suspicion that contamination might result from the sand and gravel which forms four-fifths of the body of the tile. He has, therefore, made a number of preliminary tests upon various samples of neat cement, containing no grog whatever. The results of these tests, which I cannot give in detail, show clearly that the Portland Cement is by far the most soluble part of the concrete and that we are justified in believing that the elements of the gravel are practically insoluble, as compared with the Portland Cement.

Another line of approach to a solution of this question has been to take cement that has not been set and subject it to the action of distilled water. These two flasks contain 5 grams each of standard high grade Portland Cement in 200 cc of distilled water. You will notice that the cement has passed entirely into solution or remains in suspension. Work at the University of Illinois by Mr. L. R. Ernest warrants us in believing that the water has the power to dissociate the elements of the cement into calcium oxide, aluminum hydroxide and silicic acid. You will see that the Portland Cement five grams in 200 cc of water has swelled to more than thirty times its original bulk. We further treated pulverized samples of hydrated Portland Cement with distilled water in like manner. While the results are not nearly so marked in the case of the hydrated cement as they are in the former, the results parallel the first results, but are much slower.

At the end of thirty days the hydrated cement has swelled to more than eight times its original bulk. This swelling of bulk and practical dissociation of the elements is slowly continuing, showing that the process of hydration or setting when completed has not removed cement beyond the power of water to dissociate its elements. In these tests, while not a complete solution can be accomplished, the very marked dissociation of the elements, amounts to the same results practically in the destruction of concrete work as though the silica, aluminum and calcium were entirely soluble and would pass through the filter paper. In connection with these experiments and our other work, all of which show the power of water, either to dissolve or dissociate the elements of concrete, we wish to spend a brief moment in theorizing. If water will dissolve or dissociate any considerable part of the Portland Cement, then it will necessarily follow that perfectly hydrated and completely set Portland Cement can be induced to reset and develop a very appreciable degree of tensile strength by pulverizing it finely and subjecting it to conditions similar to those under which it was first set. We state, therefore, today, that it will be found to be true that Portland Cement, thoroughly hydrated and completely set, can be pulverized and subjected to the action of water, a new plasticity can be developed in it and it would eventually set, developing a very considerable degree of strength. On the basis of the tests with the Soxhlet extractor we venture the assertion that as over 24 per cent of the cement was removed from concrete in less than 150 hours, 24 per cent of the original strength of a bricquette of neat cement can be redeveloped by perfectly natural means such as we have just suggested.

Let us pass for a moment the chemical investigation of the nature of Portland Cement to an inquiry of the nature of calcium upon which the nature of Portland Cement must necessarily rest. Investigations of all the calcium substances known to mineralogy and also these silicates which contain calcium in any degree, we find them all subject to the attack of simple acids, hydrochloric, acetic, carbonic, the carbonic and acetic, almost without exception having a steady power over all those which hydrochloric will attack. And we further find that this solvency increases as the percentage of calcium increases. While no thorough investigation of this problem has ever been made so that there is any law established to say that the solvency is in direct ratio to the per cent of calcium, yet the practical results thus far obtained and entered into mineralogy literature show, without exception, solvency increasing when the per cent of calcium increases. This shows that calcium will readily combine with the acids, that it is restless and active wherever we find it. This being the case, the calcium will also take the acid atom away from the neutral salt that contains an acid the calcium has an affinity for. A step further shows us that calcium does come away from combination in Portland Cement in the presence of sodium chloride or magnesium sulphate and water. Metathesis occurs and we have a calcium chloride or calcium sulphate as the result.

Some very valuable work has recently been done at the Agricultural Experiment Station of Bozeman, Montana. Prof. E. T. Tannat, C. E. of the experiment station, and Prof. E. Burke, of chemistry, both working in connection with City Engineer Swearingin of Great Falls, Montana. Briefly stated, their work shows that the ordinary white alkali, so common in that state, attacks and destroys cement concrete and probably some kinds of sandstone. The importance of this discovery is recognized when one considers the important part which cement plays in the construction of foundations, drains, sewers, irrigation work an other constructions, and the fact that nearly all of the soil of Montana contains more or less alkali. A bulletin soon to be issued by the experiment station will contain reports of these investigations. The result of this discovery means that it is unsafe for people to use cement in the construction of any foundation or other structure coming in contact with the soil in the alkali regions of the state unless some method is devised to protect them from the chemical. The men interested made a thorough investigation of several of the large sewers and found that several of them had been completely destroyed, and that others were fast decaying. Some of the sewers examined had only been in use for a short time. This bulletin on the action of alkalis will be awaited with the greatest of interest. It will be very important to know whether the destructive action is due to the free alkali or the action of alkaline salts.

I have in my hand letters from Chauvenet & Bro., leading chemical engineers, of St. Louis; also from G. B. Frankforter, dean of the School of Chemistry of the University of Minnesota, and Leverett Means, professor of chemistry of Williams College, Williamstown, Mass., dated 1906, 1907, and a large number of letters dated back to 1870 and 1880 from city engineers of leading cities in the United States. The gist of all these letters being that Portland cement readily decomposes in the presence of the acids of sewers; that the substance is porous or becomes so to the extent that it allows water to pass through it in a very short time. The findings of the chemists indicate that disintegration would take place; the letters from the city engineers show that disintegration does take place.

Now we find that by this that Portland Cement is attackable by acid solution and alkali solutions and our work, the work of my brother and myself, shows a marked power of distilled water to dissociate the elements of cement. These reveal great instability of the calcium compounds as found in Portland Cement. And the instability of calcium in the natural combination of our native minerals merely presists in the artificial compound called Portland Cement. Apparently water is the great vehicle in the presence of which chemical reactions with calcium of Portland Cement take place.

We hope that with these few suggestions we point the way toward investigations of great scientific interest. The nature of calcium upon which the nature of Portland Cement rests is a subject of so great industrial importance that it is worthy the combined efforts of the geologists, mineralogist and the chemist in the study to establish definitely and dependably the nature of calcium.

Just a word concerning the magniture of the interests involved and of the reasons why an investigation of this subject should be made. Several hundred of millions of dollars will be invested in farm land drainage and in city sewerage systems in the next fifty years in Iowa, Minnesota and the Dakotas. The chief among the materials used for these purposes stands burned clay products. The field is so great that other materials, chief among them Portland Cement, are entering into the construction of some of these drainage systems. The failure of a material to be permanent when put in place would work incalculable loss to the land owners and tax payers, many of whom might not survive the financial hardships which it would work to them. In sewerage systems for the sewerage to penetrate the walls of the sewer and contaminate the surrounding soil would be fatal to the health of those in the locality.

We do not wish to theorize and speculate beyond reasonable limits. But it does seem to us that it is possible for laymen like ourselves who meet with the actual problems to suggest lines of research which will guide the student helpfully and will appeal to you who have both the opportunity and facilities for the needed research.

THE LOESS OF THE PAHA AND RIVER-RIDGE.

BY B. SHIMEK.

The term paha was first applied to isolated knobs and ridges within what we now know as the Iowan drift border by McGee,* who refers to them as "loess-capped eminences, sometimes elongated to ridges miles in length, sometimes shortened to elliptical hills," and again** describes the individual paha as an "elongated swell of soft and graceful contour, standing apart on the plain or else connected with its fellows sometimes in long lines, again in congeries, and locally merging to form broad loess plateaus."

He describes the paha as typically made up substantially of the following members:***

4—Loess.
3—Loose sand.
2—Drift.
1—Indurated rock.

Of these members (1) may not be discernible, and (3) may be wanting.

In the present paper special attention is directed to the fourth member of this series, the appearance of which on isolated knobs and ridges has long attracted attention, and has given rise to the belief that it is in some way different from the great body of more continuous loess in other sections of the Mississippi valley. With it McGee also included the loess of the river-ridges in that part of the state which he described as follows:†

"The area within which this phase of the loess is developed lies southwest of the driftless area and northwest of the Iowa River, except about its great elbow * * * It includes in its southeastern portion the loess belt skirting the Iowa River toward and about its great elbow in northern Iowa and Johnson counties, the similar belt fringing the Cedar and Wapsipinicon, the upper half of the Maquoketa and their tributaries, and the various outliers over the divides separating these rivers."

It is evident that McGee had in mind both the loess capping the paha within the Iowan border, and that which covers the uplands at and near the border of the Iowan drift, though he included‡ the writer's list of fossils collected in the loess near Iowa City, south of the territorial limits set by himself.

Incidentally it may be noted that McGee's separation of his southern loess from the loess of the paha and river ridge§ cannot be maintained, as the

*11th An. Report U. S. Geo. Sur., pt. I, 1891, p. 220.
**Ibid., p. 307.
***Ibid., pp. 222, 455, 457, 460, etc.
†Ibid., p. 450.
‡Ibid., pp. 460-461.
§Ibid., p. 461.

lower gray (post-Kansan) loess extends far beyond the limits of the Iowan border, and the upper yellow member (chiefly post-Iowan) also clearly extends into the territory designated as forming the "southern loess" area.

McGee ascribed the formation of the paha and river-ridge, together with its cap or covering of loess, to melting ice,* and his explanation may be all sufficient so far as concerns the drift core, but the inclusion of the loess is unfortunate, as the ice-theory postulates conditions under which the mollusks, which are more or less abundantly represented in the loess, could not have existed.

Since the publication of McGee's great paper, the paha has received frequent mention, especially by Calvin, Norton, and Savage, in the Reports of the Iowa Geological Survey.

The most detailed of these references are those of Norton,** who, notably in the Bremer county report, attempts to find support for the fluvio-lacustrine hypothesis of loess-formation in the loess of the paha.

In general Norton's observations and conclusions, so far as they concern the structure of the paha, and the position and origin of its loess-covering, are substantially the same as those recorded by McGee, though they are somewhat more extended and detailed.

In the Bremer county report he observes that the problem of the paha "resolves itself into two parts, that of the origin of the nucleus of till and of similar pahoid drift hills and ridges on which loess is absent, and second, the origin of the loess cap."

With the first part of this problem this paper has little to do, excepting as it bears on the second part. However, attention should be called to the fact that the drift core of the paha, when present, is Kansan, and in nowise different from the mass of Kansan drift found elsewhere, and that it represents only the higher parts of the Kansan sheet, portions of which have been covered with thin Iowan, leaving these paha ridges mere islands near the border of the Iowan area.***

But the identification of the paha as detached ridges or knobs has not always been accurate. It must be borne in mind that large islands of Kansan drift are found within the Iowan border in a number of counties. McGee reported† such Kansan islands from Floyd, Mitchell, Chickasaw, Jones and Bremer counties; Calvin from Chickasaw‡ and Buchanan§ counties; Savage from Benton county;|| and Arey found a similar area in Black Hawk¶ and another in Butler county.°

All these areas, now for the most part well known to the students of surface geology in Iowa, are bordered by outlying isolated knobs and ridges which are true paha.

*Ibid., pp. 254-5, and p. 572, et seq.

**Especially those in the county reports of the Iowa Geological Survey, on Linn county, vol. VI, 1895; Cedar county, vol. XI, 1901, and Bremer county, vol. XVI, 1906.

***This fact has been recognized by Norton himself, among others, in the Rep. Ia. Geol. Sur., vol. XI, 1901, p. 356, who says that "the paha are so closely associated with the Kansan on this border that they may be treated as detached portions of it, even when entirely surrounded by the younger drift."

†Ibid., pp. 402 and 450.

‡Ia. Geol. Sur., vol. XIII, 1902, p. 326.

§Ibid., vol. VIII, 1898, p. 246.

||Iowa Geol. Sur., vol. XV, 1905, pp. 139-145.

¶Iowa Geol. Sur., vol. XVI, 1906, p. 445.

°Not yet published.

Other similar ridges have been classed as paha, though their continuity with the larger Kansan mass is unbroken. This has arisen from the difficulty which has been encountered in identifying the Iowan, for in some cases certain phases of the Kansan undoubtedly have been referred to the Iowan. For example the Farley plain in Dubuque county, formerly mapped as Iowan, is now regarded by Calvin as Kansan, and the sandy areas adjoining or forming a part of this plain are clearly Kansan.

Similarly the paha area southeast of Waverly, mapped by Norton in the Bremer county report, is in large part Kansan in which the ridges platted as paha are separated by more or less sandy plains on which no Iowan appears, at least in a large part of the area, as for example in sections 5, 6, 7, 8, 17 and 18, T. 91 N., R. XIV W. In portions of this area elevated meadows or small plains are covered with boulders, thus presenting an Iowan aspect, though the boulders are clearly Kansan unmixed with fresher drift, and inbedded in a well developed oxidized zone such as frequently forms the uppermost part of the Kansan. (See Plate VIII, fig. 1.)

In this portion of the state any comparatively flat area in which boulders appear at the surface has been referred to Iowan, especially if loose sand is also present. But flat areas of Kansan are not uncommon in the southern part of the state, as near Corydon, etc., and in the western part, west of the Wisconsin drift border. On some of these areas boulders appear at the surface, and Kansan surfaces without loess are not uncommon in the Kansan areas within or near the Iowan drift territory. (See Plate VIII, fig. 2.)

Sandy areas likewise appear on undoubted Kansan surfaces, as for example on the uplands in Dubuque county southeast of Farley, Iowa (see Plate IX, fig. 1), and the equally rough territory in sections 17 and 18, T. 91, R. XIII W., in Bremer county.

These sands do not mark the Iowan, as has sometimes been assumed, but appear on true Kansan, sometimes presenting a sand dune structure, as in the territory represented in part in Plate IX, fig. 1, or they form a sandy surface soil. In either case no trace of loess appears, and it is very probable that in such areas no loess was ever formed.

These sands may have belonged to the original Kansan, or they may have been washed or blown upon the areas on which they now lie from the plains covered with sandy Iowan debris. In either event they are genetically the same as the sands which are found near the Iowan drift border in Iowa, occupying either the surface immediately above the Kansan, or a position between the Kansan drift and the upper yellow loess.* These sands were probably formerly more widely spread over the old Kansan area, or they may represent finer Iowan material. In either case they are older than the upper yellow loess, but younger than or contemporaneous with the Kansan. This is shown in the cut along the Cedar Rapids and Iowa City electric line in Jefferson township, northwest of Iowa City, in Iowan border territory.**

In this case the sand lies between the lower gray post-Kansan loess, and the upper post-Iowan loess. Other cuts nearby show Kansan drift below this lower loess. Here, therefore, the succession of deposits above bed rock is as follows:

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* See Plate IX, fig. 2, and Plate XI, fig. 1.

** See Bull. Lab. Nat. Hist., State Univ. of Iowa, vol. V, p. 366, Plate XII, fig. 2.

4—Yellow post-Iowan loess.
3—Sand.
2—Gray post-Kansan loess.
1—Kansan drift.

In the northern part of the pahoid ridge northeast and north of North Liberty the following strata appear:

3—Yellow loess.
2—Loose sand.
1—Kansan drift.

In some places 2 and 3 are interlaminated, as shown in Plate VI, fig. 1.

This section represents the relation which would exist where post-Iowan loess was deposited on sand-covered Kansan areas such as have been noted in Dubuque and Bremer counties.

Again the arrangement may be that shown in Bremer county along the wagon road on the west side of section 7, T. 91 N., R. XIII W. Norton represents* this cut as follows:

4.—Loess, typical yellow ....11 feet.
3.—Loess, ashen in color, sparingly fossiliferous with small molluscan shells, etc............................ 3 feet.
2.—Red loam ....½ foot.
1.—Geest, red—with a few pebbles of the northern drift....½ foot.

This ridge which Norton maps as a paha surrounded by Iowan drift is a part of a continuous Kansan area. The writer's careful examination of this cut revealed the following section:

4.—Yellow loess 7 to 14 feet deep, the depth greatest near the top of the ridge through which the cut is made.

3.—Gray post-Kansas loess, 1 inch to 2 feet.

2.—Chocolate or reddish dark compact clay which in position, texture and color is like the "gumbo" overlying some of the Kansan in southwestern Iowa,—from a mere trace to 9 inches.

1.—Oxidized Kansan drift, 1-2 feet exposed. Northward toward the foot of the slope local material is mingled with the drift, which shows pebbles and small boulders.

(See Plate X, figs. 1 and 2.)

This section shows that the Iowan ice did not reach this ridge, for the post-Kansan loess, which certainly antedated the Iowan drift, is here in its normal position, and was evidently not disturbed.

To the loess which sometimes, though not always, covers the paha and larger Kansan areas in the territory under discussion, McGee ascribed an origin in streams and lakes in ice banks** and assumed that where loess was absent it had been eroded.†

Norton adopts this view of loess-origin,‡ but records the fact that in Linn county hills which are essentially paha in form have no loess, and expresses the well-founded opinion that upon them "there is no reason to believe that loess was ever deposited."§

*Ibid., p. 379.
**Ibid., pp. 254-5.
†Ibid., p. 453.
‡Iowa Geol. Sur., vol. XVI, 1906, pp. 382 and 385.
§Iowa Geol. Sur., vol. IV, 1895, p. 182.

In seeking to account for the presence of loess on the paha, Norton thus accepts McGee's glacio-fluviatile and fluvio-lacustrine hypothesis, and attempts* to meet the arguments advanced by the writer in recent years in support of the aeolian hypothesis, without, however, specifically giving their source.

He offers a number of objections to the aeolian hypothesis in its special application to the loess of the paha, which should not go unchallenged.

He contends that it does not explain the presence of isolated masses of loess on the paha and its absence from intermediate areas. To those who are in the habit of considering physical forces only in relation to the subject this may appear a serious objection, but in the light of the study of surface condition as related to floral development and distribution, this objection disappears. Indeed the application of plant ecology to the problem constitutes one of the strongest supports of the aeolian hypothesis.

The elevations were the first to be drained and to present conditions suitable to the development of continuous carpets of vegetation which could receive and hold the fine dust descending upon them. They also formed an obstacle which operated much as does a snowdrift or sand dune, either of which may be gradually built up by fine material driven upward along the surface. Winds, strong or gentle, would shift much dust in the same manner, carrying it upward to greater elevations, where it would lodge in the well-developed vegetation.

The flat intermediate areas, being poorly drained, were alternately flooded and exposed, the latter condition providing a source of much of the dust required for the upbuilding of loess. Such undrained areas may be seen in many sections of the state on the Wisconsin, Iowan and even Kansan drifts. They are now uniformly without loess, and usually without much accumulation of soil, the increment of fine materials due to decay of plants, dust, etc., evidently being fully equalled by the loss sustained during dry periods, when these areas are in part exposed.

The suggestion that the accumulation of loess on the uplands below Waverly, adjacent to the narrowest part of the Cedar valley, and the absence of loess from the borders of the broad part near Horton, militates against the probability of the river-bars being the source of loess materials, and the further statement that if elevations accumulate loess dust all should be covered with loess, are merely efforts to employ single causes in the explanation of phenomena which are dependent upon several causes.

The fact is that under the aeolian hypothesis several coincident conditions are called for, and it is the sum total of these which determines the final result:

1.—It is necessary that there be a source of material. This may have been in river-bars, or in the Waverly territory in the surrounding Iowan plain, or even in the adjacent sandy Kansan areas.

2.—There must further be the agency, wind, the action of which is materially modified by local topographic and floral conditions. In some situations the exposure would result in wind erosion, while in others under protection an accumulation of dust would result, and this difference could exist in closely contiguous areas.

3.—There must then be an anchorage, furnished in part by local topographic features, but chiefly by plants. The surface must be sufficiently rough

*Iowa Geol. Sur., vol. XVI, pp. 383-386.

to furnish good drainage, but not so much exposed to sun and hot winds that a continuous plant covering is impossible.

The combination of the favorable results of all these conditions can alone bring about the accumulation of dust, and this fact is sufficient response to the statement that "it would seem that the loess, if of eolian derivation, should be as widespread over the country as the channelless currents of the air which laid it," a statement which would have significance only if nothing besides wind was necessary to form loess!

The drifting of snow furnishes an illustration of the manner in which this combination of circumstances operates. (See Plate XI, fig. 2.) The snow is blown from flat exposed places, and lodged where there is anchorage—either plant or otherwise. Snow falls equally over a forest surface, but drifts in unequal masses in more open territory. In this there is certainly suggestion to the student of loess.

Further suggestion is offered by sand dunes. If Professor Norton has trouble in understanding how one elevation might be loess-covered and another in the same general territory bare, he might consider why in a given sand dune area one dune is often covered with vegetation, and sometimes a veneer of soil, while another nearby is bare, or nearly so, and why the intermediate depressions are sometimes quite or nearly devoid of sand, as in the White Sands desert in New Mexico, and elsewhere.

The fact is that the very conditions which seem to have troubled Professor Norton are so consistent with those of areas undoubtedly materially influenced by wind that they furnish strong support to the aeolian hypothesis.

Another objection is made, in the paper cited, to the suggestion that loess is in part accumulated in forests, on the ground that there are forests on the Wapsipinicon bottoms which have no loess. Here sight was lost of the fact that these forests are much more modern than the latest drift; that the bottom lands are subject to frequent overflow, this introducing an important element which does not operate on the uplands; and that the combination of circumstances already noted is necessary to form loess. Loess materials are no doubt gradually carried into these forests, but the accumulation is so slow that through the agency of floods, even when occurring at long intervals, this is lost in the mass of alluvium transported by the stream.

However, it should be noted that at no time has it been claimed that loess was formed in forests alone. Any vegetation will serve as a holdfast, but in the forest the accumulation will be more uniformly blanket-like, as already stated.

The final objection that if the loess had been formed in a forest rapidly there should be an accumulation of carbonaceous material, and if slowly that it should have been decalcified through the action of humous acids, etc., is of little weight. The aeolian hypothesis postulates a very slow accumulation of loess, hence the first part of this objection need not be considered. The second part would be more valid if water acted only downward in the soil, and if calcium carbonate was not soluble in water. But so long as such a mobile agent as water, often laden with calcareous material in solution, can now be drawn upward by capillarity, the presence or absence of calcium carbonate in the soils and subsoils can have little bearing on the question of the origin of the loess. But again it should be remembered that at no time has it been argued that all the loess was formed in forests, and that on dry prairie hillsides very little humus is developed. Furthermore, the possibility of the return of calcareous material with the dust from the bars of streams is worthy of consideration.

Professor Norton further states "that the presence of loess over the prairies of southern Iowa shows that neither forest nor hilly country is a necessary condition to loess accumulation." He here again assumes that only forests and hills can accumulate loess. No such claim has been made by the writer. He has simply based certain definite conclusions on the fact that the loess is quite uniformly thickest in hilly country near streams, and that in such place the forest and other dense vegetation is usually best developed. There is nothing to prevent the accumulation of some loess on plant-covered prairie surfaces, but this would be in small amounts, and it is noteworthy that where loess does occur on the prairies it is in relatively small quantities. Such an accumulation of loess on the prairies of Iowa has already been noticed by Calvin* and by the writer,** and may be observed both on Iowan (see Plate XII, fig. 1), and Wisconsin areas. It is also found on the Kansan prairies in the southern part of the state, but not in quantities comparable with those found along streams, as might be inferred from the statement quoted. The fact is that the accumulation of loess on the southern prairies is very slight; indeed, there is none on large areas. The cut west of Afton Junction, Iowa, represented in Plate XII, fig. 2, shows a characteristic veneer of loess, overlying a drift clay, which in turn rests on a typical Kansan drift. The drift clay has usually been confused with loess, and is evidently the same as the drift clay at Sioux City and South Omaha, which is discussed on p. 61 of the Proceedings. The delimitation, vertical and horizontal, of the loess of the southern part of the state in sections remote from larger streams will show that it is much less in both volume and area than might be inferred from the statement quoted.

After presenting the foregoing objections to the aeolian hypothesis, Professor Norton reiterates McGee's explanation of the presence of isolated masses of loess on the paha, the substance of which is contained in the following statement:*** "The fluvio-lacustrine theory may be able to explain the insularity of the loess tracts by affording ice-barriered water bodies for its deposition and the absence of the loess over other tracts by the presence of overlying ice." And in the following additional conclusion:† "In crevasse-like openings in the stagnant ice which covered Bremer county we may entertain the theory that the paha received their cap of loess." As heretofore,‡ the author quoted here again wholly ignores the evidence of the fossils which occur in the loess. Fossiliferous loess is not as abundant on the loess islands within the Iowan area as in other parts of the state, but it does occur. Modern mollusks are today less abundant in the same territory than in many other sections of the state, probably because of the relatively large amount of sandy or poorly drained surrounding surface, and the same conditions evidently existed throughout the period of deposition of the loess.

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*Iowa Geol. Sur., vol. XIII, 1903, pp. 70 and 329-330.

** Proc. Iowa Acad. Sci., vol. IV, 1897, pp. 68-72.

***Ibid., p. 385.

†Ibid., p. 382.

‡See reports in Iowa Geol. Sur., on the following counties: Linn, vol. VI, 1895; Scott, vol. IX, 1899; and Cedar, vol. XI, 1901.

But fossils are abundant in the corresponding loess along the Iowan border and we have no reason to believe that this is genetically different from the loess of the paha and larger Kansan islands.

These fossils are widely distributed in the loess. With few exceptions they are species now abundantly inhabiting the same area. Their terrestrial habits are well-known and readily ascertained. In their distribution they bear a clearly defined relation to the modern fauna, made up, let it be clearly understood, of the same species. They give us the only definite tangible clue to the conditions which existed during the deposition of the loess, and their evidence cannot be suppressed by slighting references to "small molluscan shells," or by being wholly ignored.

These shells prove the presence of large land surfaces and an abundant terrestrial vegetation. Where could they have found such conditions in McGee's and Norton's largely ice-covered areas? There is absolutely nothing in this fossil fauna to suggest glacial or sub-arctic conditions; and there is nothing in it to suggest the presence of large bodies of water.

On the contrary, the shells offer indisputable proof that the conditions under which the deposit in which they occur was formed were not essentially different from those which prevail in the same regions today. Indeed, they point rather to a somewhat drier climate, as shown by several species identical or affiliated with those of the dry western regions, such as *Oreohelix ioensis*, *Pupa muscorum*, *Succinea grosvenorii*, *Pyramidula shimekii* and *Sphyradium edentulum alticola*, and by the depauperation of such species as *Succinea ovalis*, *Polygyra multilineata*, *Helicina occulta*, etc.

McGee, basing his conclusions on Call's erroneous deductions, argued that these depauperate forms indicate a cold climate. But corresponding depauperation may be observed in the modern representatives of these same species as we go westward from the moister eastern regions to the drier sections of the west, while no such depauperation is noticeable in northerly forms of those species which extend northward. It may also be added that this fauna does not extend far enough northward to reach climatic regions like those called for by McGee's hypothesis, and that several of the species found in the loess of the southern states are subtropical, and do not even extend into our northerly temperate regions.

The depauperation suggests merely a short growing season, the length of which was probably limited by drouths.

It is useless to consider the loess a glacial deposit, or one formed in large bodies of water, so long as the presence of these shells is not explained on rational grounds consistent with the conditions called for by these hypotheses. Absolutely no such explanation has yet been offered by the opponents of the aeolian hypothesis, and the latter still stands as the only hypothesis consistent with the ecological and faunal conditions which are involved.

EXPLANATION OF PLATE VIII.

Fig. 1. A meadow with large Kansan boulders strewn over the surface. In north half of Sec. 17, T. 91 N., R. XIII. W. Appears like Iowan, but is evidently Kansan. (See p. 119.)

Fig. 2. A ridge of Kansan drift northwest of New Hartford, Iowa. Boulders appear on the surface quite to the summit, the soil covering being scant. (See p. 119.) A part of a Kansan island in Iowan territory.

PLATE VIII.

FIG. 1.

FIG. 2.

EXPLANATION OF PLATE IX.

Fig. 1. A denuded Kansan Area with much sand, even on the highest surfaces. Near center of Sec. 6, T. 87 N., R. I. E. (See p. 109.)

Fig. 2. A section in sand pit at Gladstone, Ill.. showing loess resting upon laminated sand. The loess is fossiliferous, and grades downward into fine sand which shows the laminated structure which may be found in sand dunes built up by gentler winds. It is evidently a sand dune capped with loess. Sand rune topography is evident in the vicinity. (See p. 109.)

PLATE IX.

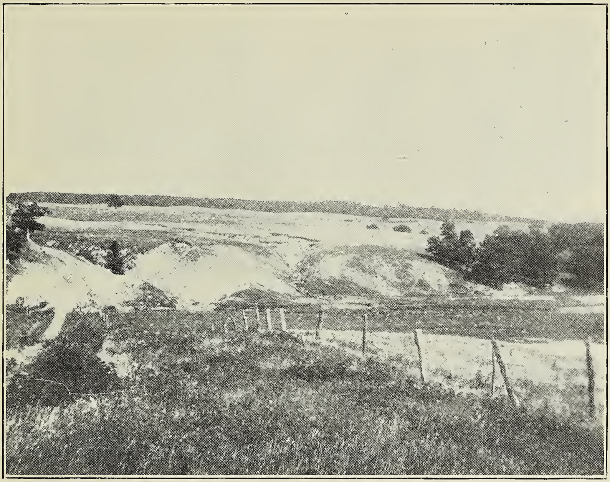

FIG. 1.

FIG. 2.

EXPLANATION OF PLATE X.

Fig. 1. Section of "paha" along wagon road on west side of the SW¼ of Sec. 7, T. 91 N., R. XIV W., in Bremer county, Iowa. Looking east. The light band near the base of the section is gray loess. (See p. 120.)

Fig. 2. A part of the same section. The gray loess tapers toward the left. (See p. 120.)

PLATE X.

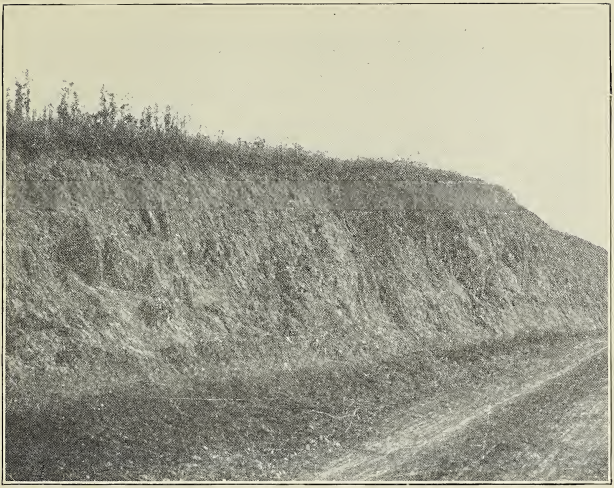

FIG. 1.

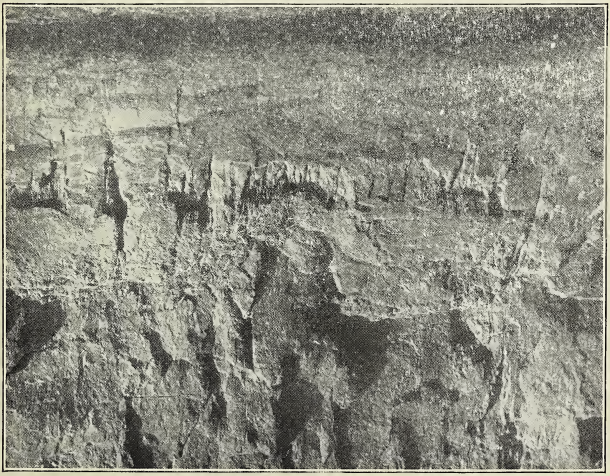

FIG. 2.

EXPLANATION OF PLATE XI.

Fig. 1. A loess-covered paha ridge northeast of North Liberty. Iowa. The part to the left (north) is sandy below yellow loess. In part to right, and southward, Devonian limestone forms the core, and is capped with Kansan drift and two loesses. the lower gray, the upper yellow. (See p. 119.)

Fig. 2. A stubble field to the left which has caught the snow and some fine soil from the plowed field to the right. Shows the retaining power of vegetation. Calmar, Iowa. (See p. 122.)

PLATE XI.

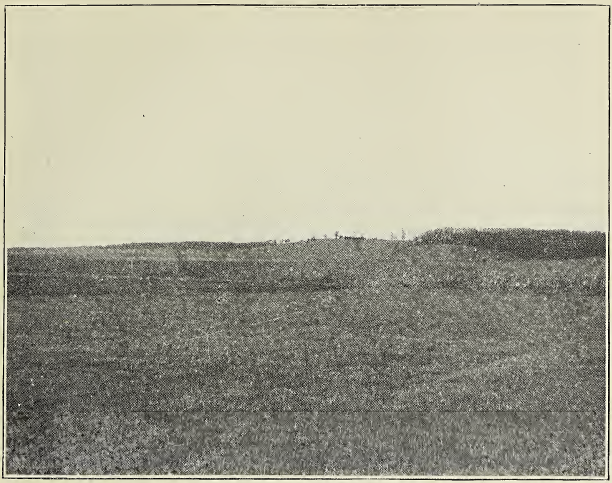

FIG. 1.

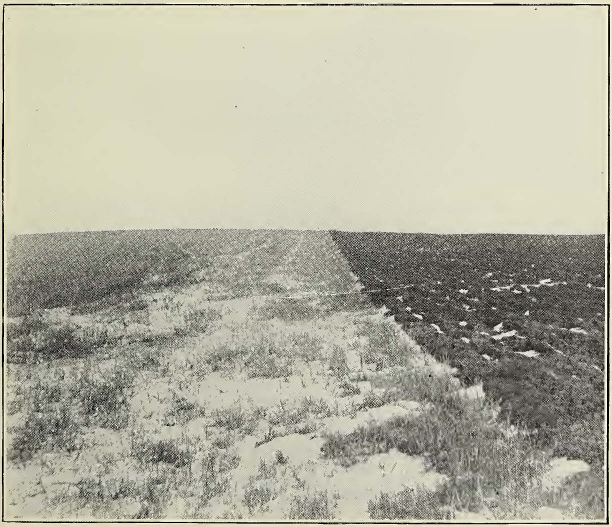

FIG. 2.

EXPLANATION OF PLATE XII.

Fig. 1. A cut west of Denver Junction, Iowa, showing Iowan drift below (about 9 feet exposed), with a line of boulders in its upper part and a covering of 1-4 feet of loess and soil. (See p. 123.)

Fig. 2. Third cut west of Afton Junction, Iowa, along the C., B. & Q. R. R. The uppermost layer is loess (?), 3-5 feet thick, grading below into glacial clay, which rests on Kansan drift. (See p. 123.)

PLATE XII.

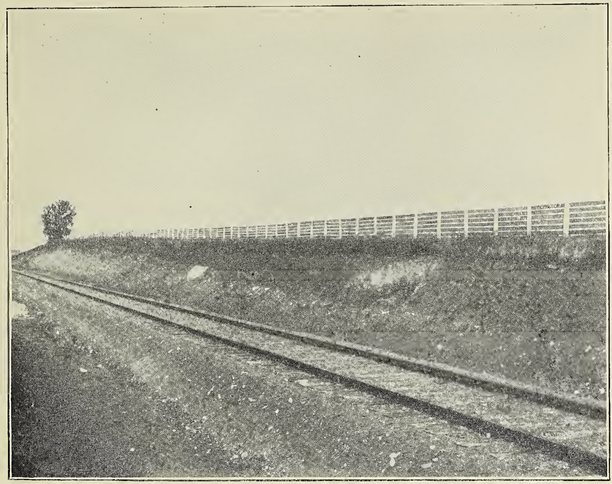

FIG. 1.

FIG. 2.

EOLIAN ORIGIN OF CERTAIN LAKE BASINS OF THE MEXICAN TABLE-LAND.

BY CHARLES R. KEYES.

The arid region of western United States and northern Mexico is a vast expanse of plain out of which abruptly rise a multitude of lofty mountains. The landscape has been aptly likened to a sea bedecked with volcanic isles. Of the entire area the desert-plains occupy about four-fifths; the mountains one-fifth. Between the different mountain ranges the plains-surface is usually slightly inclined towards the middle. These intermont plains are commonly designated as valleys.

Over much of this country the rainfall is so deficient that the surface waters never reach the sea. In all this vast region the through-flowing rivers are few in number and of comparatively small consequence, for they receive little or no lateral drainage of a perennial character. Little opportunity is given for the development of great drainage systems such as are found in other and moister parts of the world. Most of the waters that enter the plains from the mountains thus drain into what are practically enclosed basins. In the middle of many of the basins are broad mud-flats, or playas, and not infrequently lakes. Some of the lakes may be regarded as permanent bodies of water; but more often they are more or less ephemeral in character.[1]

Most of the enclosed bodies of water which lie in the middle of the intermont plains appear to be readily accounted for in the usual manner of lake formation. There are, however, many of the lakes and lakelets which are not situated in the lowest parts of the valleys, but are found well up on the more elevated portions, even near the foot of the mountains. Throughout the arid region there is constant recurrence of these phenomena.

In the case of the last mentioned class of lakes the question naturally arises whether the lake-basins may not have been formed in other than in the usual way. In the arid country wind is now known to be the most efficient of the geologic agencies; water is quite secondary. In dry regions, also, wind is the chief planation process. It has been recently urged that wind mainly has sculptured the desert and given it most of its peculiar physiographic expression. The query then is: May not eolian influences have fashioned some of the minor lake-basins on the high parts of the plains; and if these, may they not have been also the principal agency in forming the playas and lake-basins in the middle of the valleys? There are strong reasons for believing that wind has actually been the most potent agency in this work.

1. Am. Jour. Sci. (4), Vol. XVI, pp. 377-378, 1903.

In central New Mexico there is an extensive chain of saline lakes lying on the Estancia plains, that admirably illustrate the case in hand. Viewed from a distance of five or six miles the Estancia lake-district appears as a group of prominent hills rising like islets out of the broad expanse of level plain. Upon approaching the hills there is suggestion of low volcanic ash-cones with their characteristic truncated tops. The hills rise abruptly a hundred to a few hundred feet above the level of the surrounding plain. The materials composing the hills is white or gray, yielding, and of the appearance of volcanic ash. On ascending these flat-topped elevations the central portions of each are found to be depressed as deeply as the level of the plains outside. To all appearances each is a crater-lake. But there are not the slightest traces of volcanic action either in or near the lakes, not even in the neighborhood within a distance of many miles. There are no outlets to any of the lakes. The inner walls of the lake-basins are very steep, frequently forming cliffs.

The bottoms of the basins are usually covered by snow-white films of alkali or salt, the water having completely evaporated, so that one may even walk across from one shore to the other. At times the water is said to be eight to ten feet deep; but this only happens once every three or four years.

The "craters" are essentially sand-dunes, or rather clay-dunes, formed under unfamiliar conditions. A stiff breeze blows most of the time over the plains. As the bottom of the lakes become dry after rain, the gypsum, alkali or salt coating cracks in the sun into sandy material. The moist clay beneath does the same thing, first curling up into thin leaf-like plates. This material the winds blow about over the dry lake bottom and finally carries it up and out of the basin over the rim, where it falls on the leeward side. Almost any time one may see the sands and pulverent loam stream up over the inner walls of the depressions, which have an angle of about 40 degrees, and form a drift a foot thick in an interval of a few minutes. As the winds come from every quarter of the compass during the month and year each truncated hill develops in a fairly even manner. If anything the northeast side shows some advantage.

No vegetation grows within the depressions. The sands and loams are light and loose whenever the lakes become dry, and most of them are in this condition for the greater part of the year. Outside of the rims plant-growth, which abundantly covers the surface of the plains, also reaches up the hillsides to the summits and protects the dry pulverant materials from the free action of the winds. Within a short distance there are contrasted the extremes of differential wind action upon areas well protected by vegetation and those not thus protected.

The noteworthy fact to be taken into consideration in the present connection is the crater-like character of the loam-dunes in the middle of a broad, open plain. These conspicuous hills are rarely more than a mile across, though they may be sometimes several miles in length, as in the case of the Laguna del Perro, four miles east of the town of Estancia. In a similar manner irregular dunes are formed of enormous size on the alkali flats of other parts of New Mexico. The famous white sands district, in the Hueco bolson, 100 miles to the south of the Estancia region, may be cited. These dunes are of pure gypsum-sand and have the appearance of huge piles of granulated sugar. They are often fifty to sixty feet high.

Another phase of lake-basins of the arid regions and one that is now thought to be mainly formed through agency of the wind is the playa. There are many transitions, among these intermont basin-plains, from those holding extensive and permanent bodies of water to those which are perfectly drained. The stage known as the playa is one in which there is a broad expanse of barren, silt-covered flats. "Dry-lakes" they are often termed. Waters are only brought down once or twice a year from the surrounding mountains. At such times the mud-flats are covered by water to depths of a few inches or a foot or two. Lakes of the playas are very short-lived and last only a few weeks at a time. For nine to ten months out of the year the areas occupied by them are parched and dry and support no vegetation whatever.

Playas and similar mud-flats of the arid plains are areas of great degradation as well as of aggradation. It is probable that in the majority of cases the first mentioned process lags a little behind the latter. When the waters are finally evaporated the playas are mud-flats in every sense of the word. The bottom-mud as it dries curls up into thin leaves a millimeter or two in thickness. The first strong wind that comes along blows these away as dead leaves before the first blast of winter. Much of the material is carried bodily out of the playa-area, often a distance of many miles, or gathers in great windrows about the margins. Much of the dried mud is ground to dust in the moving and is carried off in the air as other dusts of the plains. With every summer shower that falls over the playa there is a new mud layer formed and further exportation.

When old playas have been exposed in section through recent stream action the soft deposits appear, in a number of observed cases at least, to have no very great thickness. In the Meadow valley, in southeastern Nevada, for example, 100 feet beneath the surface of the old playa the hard rock floor of the plains appears; ancient limestones, sandstones and shales highly inclined and horizontally bevelled evenly. The Armagosa river valley of southeastern California presents similar phenomena. In the remnants of the old bolson surfaces along the Rio Grande there are often displayed the ancient rock-floor surface high above the present level of the river channel.

Many salinas exhibit similar conditions. The great Hueco bolson of central New Mexico has already been mentioned. The central flats of the intermont plains of the arid regions are not then always areas of constant aggradation, as has been commonly regarded, but they are areas of most rapid degradation as well.

Eolian erosion, even in dry regions, has been generally overlooked. In the arid parts of the globe wind is probably not only the most potent of the gradation agencies, but its efficiency is greater than all other geologic processes combined. Its main activity is manifestly degradational in character. The constructional effects are very local. It is now believed that in the arid regions of western America the wind has been a levelling agent, the importance of which has been little considered. Its general effects in this role has been second only to that of normal base-leveling.

Throughout the dry regions "dust-storms" are violent and frequent. While they endure their effects in producing personal discomforture have commonly blinded all, even the trained geologist, to their real geologic significance. During their progress and even for several days afterward the air is so filled with fine soil that it is often impossible to see objects more than very short distances. The sun is frequently obscured as by a heavy rain-cloud. The dust floats upwards thousands of feet above the surface of the ground and remains suspended for many days. The amounts of fine materials that are thus carried away must be enormous.

The tremendous effects of the dust-storm, or sand-storm, on the Sahara and Arabian deserts have been known since earliest historic times; but they have been looked upon as merely those of idle, shifting sands, rather than as a powerful and persistent geologic force. Some of the geologic effects of the wind as a denuding power have been recently ably discussed by Walther,[1] whose observations were made on the northern African deserts. Similar wind effects on bare sand-bars of the Missouri river reproduce on a small scale in a humid climate the conditions of the great desert regions.[2]

Dust alone is not transported by the winds. Sands and pebbles are swept along with considerable force. On the bare rocks these act as a sand-blast, polishing the harder ledges until their exposed surfaces appear as if they were actually fused. Under the influence of streaming sands all rock-outcrops are worn rapidly away, at a rate many times faster than when corroded by running waters. During a single "storm" large areas of bare rock may be uncovered, exposed to the triturating action of the moving sands, and become again covered before the winds die down. Shallow basins from a few hundred yards to several miles across may be hollowed out of the surface of the plains that may afterwards fill with storm-waters, producing lakes of temporary character. To some such cause Gilbert[3] has ascribed the origin of certain ponds in western Kansas. In desert regions the eolian genesis of minor lake basins is very much more prevalent than is commonly supposed.

The formation of lake basins by means of the wind must be regarded after all only a special phase of a more general process. Among the larger effects of eolian action is general planation, a process holding in the arid region the same position as base-levelling does in the normal humid region. Under conditions of an arid climate shallow rock-floors could be expected in the basin-plains. Under conditions of a humid climate the intermont plains would be deeply filled with detritus. In perfect accordance with this suggestion the surfaces of the intermont deserts are actually found to be worn out on the bevelled edges of the strata composing the substructure, in the same way that the peneplain is formed by water near sea-level. The process of general levelling without base-levelling in the arid country is probably more rapid on the whole than that producing penplanation. Much of the supposed leveling effect in the arid districts ascribed to sheet-flood erosion is doubtless more properly the result of eolian action.

General levelling without base-levelling of elevated regions under conditions of an arid climate has been recently widely recognized. In southwestern United States the vast plains of New Mexico and Arizona, especially the Jornada del Muerto and neighboring deserts, were lately described in some detail.[4]

1. Abhand. Konigl. f. Sach. Gesellsch. d. Wissensch., XVI Bd., 1901.
2. Am. Jour. Sci. (4), Vol. VI, pp. 299-304, 1898; also Bull. de la Soc. Belge de geol., du pale., et hyd., t. XII, pp. 14-21, 1901.
3. Journal Geology, Vol. III, pp. 47-49, 1895.
4. Am. Jour. Sci. (4), Vol. XV, pp. 207-210, 1903.

McGee[5] has shown the general plains-surface of northwestern Mexico to be worn out on the bevelled edges of strata composing the substructure, although he ascribed the planation to sheet-flood erosion. In South Africa Passarge[6] has recognized the whole of the elevated interior tableland as a surface of the same kind. Davis[7] has appeared lately to be inclined to believe that some of the high plateaus of central Asia belong to this same class rather than to that of normal peneplanation.

In the arid region many of the principal planation phenomena which are displayed and which are attributed to normal hydric erosion should be doubtless referred to other geologic agencies. Of all these eolian influences appear to be far most effective.

5. Bull. Geol. Soc. America, Vol. VIII, pp. 87-112, 1897.
6. Naturw. Wochensch., N. S., III Bd., pp. 657-665, 1904
7. Journal of Geology, Vol. XIII, p. 405, 1905.

STRATIGRAPHIC POSITION OF WESTERN RED-BEDS.

BY CHARLES R. KEYES.

In Iowa some very important parts of the general Carbonic section are missing. Of these unrepresented portions none is so widely interesting at the present time as the part commonly called the Red-Beds. The very name is itself indicative of the uncertainties surrounding the proper geologic affinities of the formation. Until very recently the Red-Beds formation has been one of the enigmas of American geology. The Red-Beds have steadily resisted all attempts to unravel the secret of their geologic age. The key to the puzzle appears finally to be found in the far-off Mexican tableland.

If the doubtful Fort Dodge gypsum beds are excepted, and special attention will be directed to them later, the nearest localities to Iowa where undoubted Red-Beds are definitely known to occur are in central Nebraska and Kansas. In the last mentioned state no mention has ever been made of any evidence suggesting that the Red-Beds follow the other Carbonic strata in any other than strictly unbroken sequence. In the southern Rocky Mountain region and in the northern part of the Mexican tableland, in eastern New Mexico, the beds in question have been found of late to have unconformable relationships with the other Carbonic beds beneath.[1]

The geologic age of the Kansas Red-Beds has long been a matter of controversy. By some authors they were considered as all of Permian age; by others all of Triassic age. But in New Mexico, quite recently, it has been discovered that the lower part of the Red-Beds section is really Late Carbonic (Oklahoman series) in age; while the upper part is of Triassic age; and that the two divisions are separated by a well-marked unconformity.[2] It has been also found in the New Mexican region that there are other extensive Red-Beds which belong neither to the Carbonic nor the Triassic ages, but to the Devonian, Cretacic, and even Tertiary ages.[3]

The so-called Permian[4] Red-Beds of Kansas are now called the Cimarronian series.[5] In Nebraska, Kansas, Oklahoma and Texas this great series immediately follows, without as yet recognized unconformity, as has been stated, the Oklahoman series, which succeeds the Missourian series, so well represented in southwestern Iowa and northwestern Missouri by our Upper Coal Measures. Far to the southwest, in southern New Mexico, in a lofty range known as the Guadalupe mountains, there lies above a great section of blue limestone which

1. Am. Jour. Sci. (4), Vol. XXI, p. 296, 1906.
2. Am. Jour. Sci. (4), Vol. XX, p. 425, 1905.
3. Journal of Geology, Vol. XVI, p. 445, 1908.
4. Journal of Geology, Vol. VII, p. 321, 1899.
5. Colorado College Studies, Vol. VI, p. 3, 1896.

is correlated with the Oklahoman series of Kansas, a sequence, over 3500 feet in thickness, of sandstones and limestones, which carry the only organic forms known from this country representing the original Permian faunas of eastern Russia.[6]

As at present understood the Red-Beds, which succeed the thick Guadalupan series on the backslope of the tilted block forming the Guadalupe mountains, are the true southern extension of the Cimarronian Red-Beds, that a little farther to the eastward, in the Pecos valley, are followed by Triassic Red-Beds. If this interpretation of the stratigraphy of the southern New Mexico region be correct then the entire Guadalupan series, representing at least 3500 feet of strata, are missing in the central Kansas section, and there are probably unconformable relationships existing between the Cimarronian and Oklahoman series of that section.

In central Kansas no one, so far as I am aware, has ever before intimated that the Cimarronian series rest unconformably upon the Oklahoman series. At best it would be in that region very difficult to make out such relationships. Passing now to north-central Iowa it is possible that we have a clew to the true situation in the isolated area of the Fort Dodge gypsum deposits. If the gypsiferous beds of Fort Dodge are really Late Carbonic in age instead of Cretacic age, as Wilder[7] has recently attempted to show, we have right here in Iowa unexpected data for the solution of the Red-Beds problem. It has been shown[1] however, that Wilder's argument for considering the Fort Dodge gypsum deposits earlier than Cretacic in age is not supported by adequate facts derived from his observations on the region, that there are general stratigraphic considerations which he did not touch upon that make the suggestion more worthy of special and exact inquiry than any which he has discussed. It must also be remembered that the gypsiferous beds at Fort Dodge are not Red-Beds in any sense of the word, nor does their slight pinkish tinge at all suggest the true Red-Beds of Kansas.

Of the other great "Red-Beds" formations of the southern Rocky Mountain region special mention should be made of the Bernalillo shales,[2] nearly 1000 feet in thickness, which immediately overlie in the typical locality in the Sandia mountains the dark blue and black limestones. These shales carry abundant fossils which correspond faunally with those found in the upper part of the Oklahoman series of Kansas. Besides these Red-Beds there have been recognized in the region other great red colored terranes in the Cretacic section, in the Tertiary section and in the Devonic section, as already stated.

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6. Journal of Geology, Vol. XIV, p. 296, 1906.
7. Iowa Geol. Surv., Vol. XII, p. 63, 1901.
1. American Geologist, Vol. XXX, p. 99, 1902.
2. Rept. of Governor of New Mexico to Secretary of the Interior, for 1903, p. 339, 1904.

SOME RELATIONS OF THE OLDER AND YOUNGER TECTONICS OF THE GREAT BASIN REGION.

BY CHARLES R. KEYES.

(*Abstract.*)

The Basin ranges of western America stand for a distinctive type of mountain-building. Their characteristic structures are regarded as unique because of their extreme simplicity and because their genesis is ascribable to normal faulting on a gigantic scale. Of late years many of the earlier notions concerning the formation of these mountain ranges are being called into question; and the structural problems themselves appear to be farther than ever from satisfactory solution. As landscape features it now seems probable that instead of being regarded as strictly structural phenomena the present mountains are to be considered mainly remnantal erosional effects produced under the peculiar conditions of an arid climate during the progress of general desert-leveling.

The desert region of the West includes several extensive regions other than the Great Basin, which is in reality only a minor part. The other districts are known as the Colorado dome, or plateau, the Californian gulf basin, and the Mexican tableland. In the present connection the history of opinion regarding the tectonics of the desert region need not be referred to.

The results of recent investigation may be summed up as follows:

1. The folded structures displayed in some of the Basin ranges, perhaps most of them, belong mainly to an ancient system of tectonics (Triassic or Jurassic), in no way genetically connected with the rearing of the existing mountains. This is true not only of the Great Basin region, but of the other grand divisions of the desert region.

2. The tectonic effects discernible in the landscape are only the most recent simple faultings; all others have been more or less completely mastered by general desert-leveling.

3. The discovery of extensive thrust-planes in various ranges, such as have been described as occurring in the Caballos mountains, may have far-reaching significance, and may demand an entirely new scheme of origin for the majority of the desert ranges, at least for their initiation.

4. The rearing of the present mountains and the greater effects of mountain sculpture in the desert region is to be ascribed largely to the differential effects of general desert-leveling, that is, mainly to powerful and constant eolian influences, under conditions of aridity, in which water plays a very minor role.

5. The chief effects of ordinary tectonics have been largely to produce alternate belts of resistant and non-resistant rocks and to accentuate them in the topographic expression of the region.

6. Nine distinct hypotheses have accounted for the larger orographic features of the desert region of western United States. They are: (a) Gentle folding, as advanced by King; (b) simple, normal faulting on a grand scale, as urged by Gilbert and others; (c) complex block-faulting as suggested by Lauterback; (d) sharp, asymmetric folding, as postulated by Spurr; (e) great erosion under former conditions of a moist climate, as also urged by Spurr; (f) block-faulting accompanied by great dissection through stream action as suggested by Davis; (g) general desert-leveling, locally interrupted by deformation and dislocation; (h) thrust-faulting, mainly during the period of aridity; (i) general desert-leveling, chiefly through wind erosion, with the grander geographic features accentuated by faulting, either normal or reversed, and directed somewhat by the local character of the ancient tectonics.

SOME PECULIARITIES IN THE ELASTIC PROPERTIES OF CERTAIN SUBSTANCES.

BY K. E. GUTHE.

All solids deviate more or less from the theoretical perfectly elastic body and though many experiments have been undertaken in order to explain these deviations, we can hardly claim that any of the numerous theories proposed by the different investigators has yet cleared up the intricate relations involved.

The best known of these deviations is the so-called elastic after effect. It was first discovered in silk fibers in 1835 by W. Weber and consists in a lagging of the establishment or disappearance of a strain behind a distorting force. Thus if we twist a wire at one end while the other end is kept fixed, then upon releasing the wire there will be at first a rapid return towards the original shape, followed by a slower change in the same sense, extending sometimes over considerable time. The longer the original deformation has lasted the stronger will be the after effect. Of course the deformation is supposed to remain always below the value at which a permanent set occurs, so that after a sufficiently long time the return to the original condition is complete. Many experimental and theoretical investigations have led scientists to believe that elastic after effect may be considered as a kind of viscosity. It must, however, be remembered that it differs in its nature from the viscosity of fluids because in the latter case there is no tendency to return to the original shape after the stress is removed.

The elastic after effect is especially apparent in soft metal wires, while the same wires hardened show it to a much smaller degree. Quartz fibres, carbon filaments and wires of hardened steel, phosphor bronze and platinum-iridium have very small elastic after effects.

Another deviation from the demands of the theory has received the name "elastic fatigue." Lord Kelvin[1] observed that a wire which had been kept under torsional vibrations for some time has a larger period of vibration and a larger logarithmic decrement than a wire which has been at rest. J. O. Thompson[2] has later demonstrated that as long as the amplitude and temperature remain constant there is no such change, even if the wire is kept vibrating for days. It is, however, a well known fact that when the amplitudes decrease from larger values to smaller the period, as well as the logarithmic decrement, decrease somewhat. So far only cases were known in which the variations of these quantities are quite small; in the course of some experiments with platinum-iridium wires which show almost no elastic after effect I found such remarkable

1. Kelvin, Math. and Phys. Papers, III, p. 22.
2. J. O. Thompson, Phys. Rev. VIII, p. 141

deviations from the behaviour of ordinary wires that I decided to investigate the matter further.

The wires which carried at their lower end cylinders of Tobin bronze were suspended from the top and inside of a large hollow brass cylinder having a glass window at its lower end. The whole brass case could be rotated around a central pivot and thus the suspended cylinders set in vibrations. The glass window allowed the observation of a small mirror attached to the lower end of the vibrating system. The period was determined by chronographic records and the amplitudes by a telescope and scale placed at a distance of 100 centimeters from the mirror.

A platinum-iridium wire containing 25 per cent of iridium, when hardened by drawing a period of 6.7766 sec. with an amplitude of 5°, which decreased to 6.7745 sec. with an amplitude of 0.°5, while its logarithmic decrement decreased between the same amplitudes from 0.0012 to 0.00091. A still more surprising behaviour was found in a 40 per cent platinium-iridium wire whose period of vibration changed through the same range of amplitude from 12.060 sec. to 11.890 sec., while its decrement decreased from the enormous value of 0.012 to 0.0030.

The period, as well as the logarithmic decrement, are very nearly proportional to the amplitude, though the increase is slightly smaller than that of the amplitude. The decrease of amplitude between successive swings is very nearly proportional to the square of the preceding amplitude. Since such enormous variations have never before been observed in other wires, a great many observations were made, but in every case the same effect was found. In the following tables I have picked out at random a few of them and the values are plotted in figures 1 to 3.

TABLE I.
Forty per cent Platinum—Iridum Wire.
Moment of Inertia: 372.4.

Amplitudes, 1st, 5th, 9th, etc.	△ A	A^2	δ	Double Period
48.7	------------	2372		
42.5	6.2	1806	0.0133	14.700 sec.
37.9	4.6	1436	0.0121	14.620
34.0	3.9	1156	0.0114	14.565
30.7	3.3	942	0.0105	14,545
28.0	2.7	784	0.0099	14.525
25.6	2.4	655	0.0092	14.508
23.65	1.95	559	0.0084	14,497
21.95	1.7	482	0.0079	14.485
20.45	1.5	418	0.0076	14.475
19.10	1.35	365	0.0072	14.465
17.85	1.25	319	0.0068	14.455
16.88	1.02	283	0.0065	14.446
15.88	0.95	252	0.0062	14.439
15.02	0.86	226	0.0059	14.432
14.22	0.80	202	0.0056	14.426
13.55	0.67	184	0.0053	14.420
12.93	0.62	167	0.0053	14.415
12.30	0.63	151	0.0051	14.412
11.76	0.54	138	0.0048	14.408
11.27	0.49	127	0.0045	14.405
10.82	0.45	117	0.0045	14.402
10.38	0.44	108	0.0043	14.399
10.00	0.38	100	0.0041	14.396
9.62	0.38	93	0.0042	14.393
9.26	0.36	86	0.0041	14.390
8.22	0.34	80	0.0039	14.388
8.62	0.30	74	0.0038	14.386
8.33	0.29	69	0.0035	14,384
8.09	0.24	65	0.0034	14.383
7.82	0.27	61	0.0035	14.381
7.58	0.24	57	0.0034	14.380
7.34	0.24	54	0.0035	14.378
7.11	0.23	51	0.0034	14.377
6.90	0.21	48	0.0032	14.376
6.70	0.20	45	0.0032	14.375
6.50	0.20	42	0.0032	14.373
6.32	0.18	40	0.0029	14.372
6.16	0.16	38	0.0029	14.370
5.99	0.17	36	0.0029	14.368
5.84	0.15	34	0.0030	14.366
5.67	0.17	32	0.0028	14.364
5.54	0.13	31	0.0028	14.363
5.40	0.14	29	0.0026	14.361
5.26	0.14	28	0.0028	14,359
5.13	0.13	26	0.0028	14.358

TABLE II.
Forty per cent Platinum—Iridium Wire,
Moment of Inertia: 987.7.

Amplitudes, 1st, 5th, 9th, etc.	△ A	A²	λ	Double Period
35.4	------------	1253		
31.8	3.6	1011	0.0104	24.120
28.9	2.9	835	0.0097	24.060
26.6	2.3	708	0.0091	24.020
24.45	2.15	598	0.0086	23.980
22.7	1.75	493	0.0080	23.965
21.1	1.6	445	0.0077	23.940
19.7	1.4	388	0.0074	23.925
18.4	1.3	339	0.0070	23.910
17.35	1.05	301	0.0066	23,898
16.3	1.05	266	0.0063	23.886
15.45	0.85	239	0.0058	23.874
14.65	0.80	215	0.0056	23.868
13.94	0.71	194	0.0054	23.856
13.27	0.67	176	0.0053	23.848
12.65	0.62	160	0.0050	23.840
12.10	0.55	146	0.0048	23,832
11.58	0.52	134	0.0046	23.826
11.12	0.46	124	0.0045	23.818
10.67	0.45	114	0.0043	23.812
10.27	0.40	115	0.0042	23.806
9.88	0.39	98	0.0042	23.800
9.49	0.39	90	0.0040	23.796
9.17	0.32	84	0.0038	23.793
8.86	0.31	78	0.0037	23.790
8.56	0.30	73	0.0036	23.787
8.29	0.27	69	0.0033	23.784
8.04	0.25	65	0.0033	23.782
7.8	0.24	61	0.0033	23.780

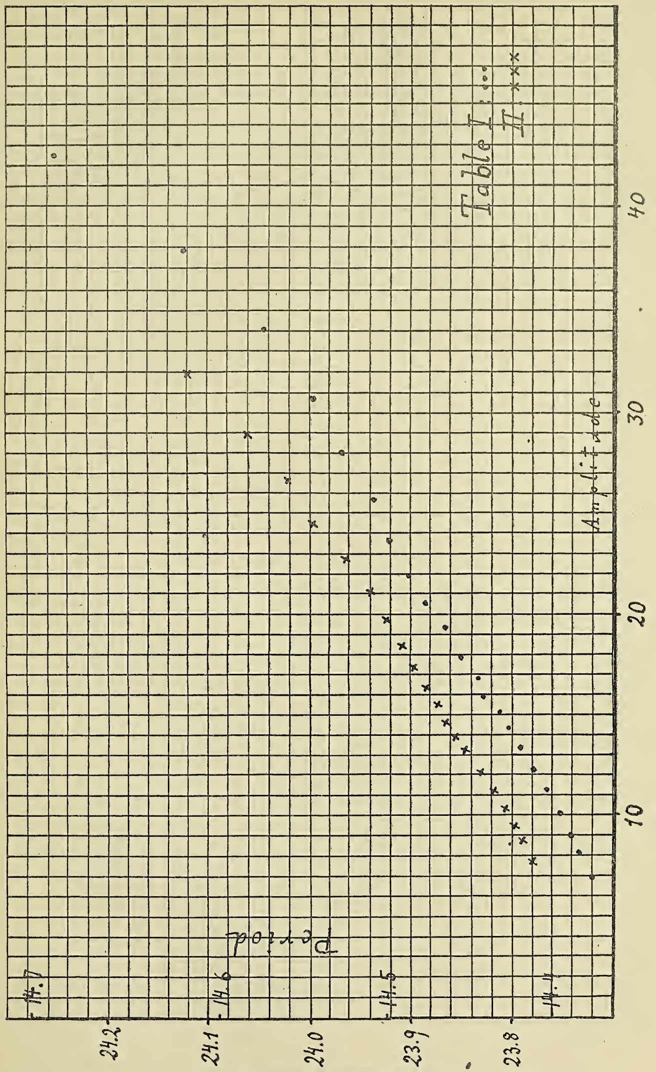


FIG. 1. Period and Amplitude.

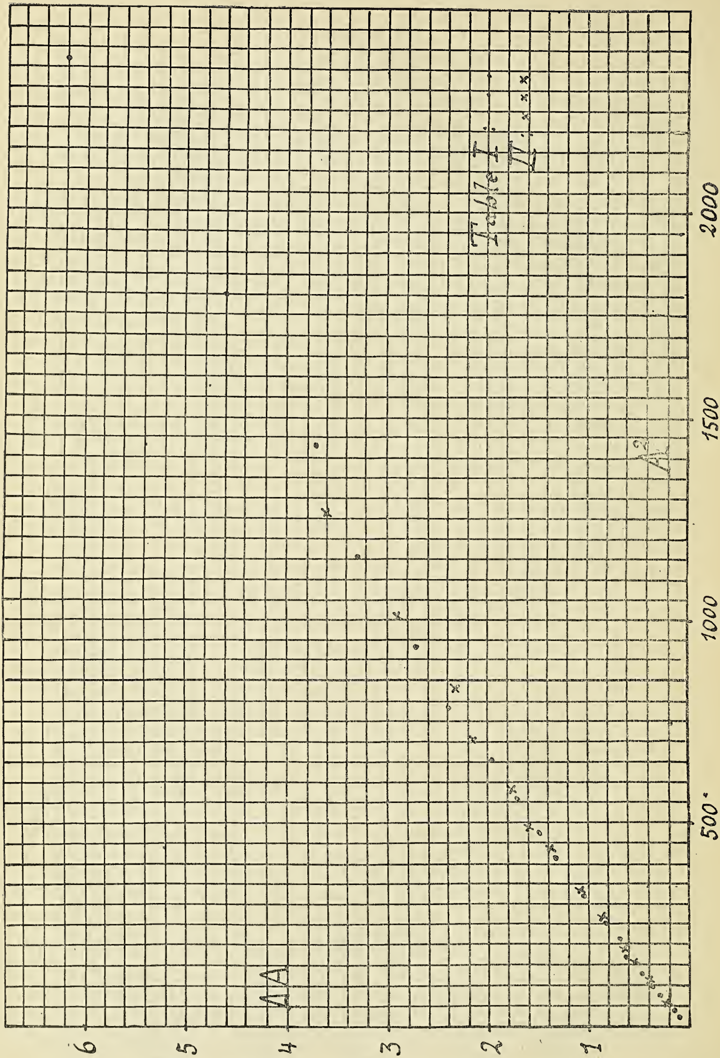
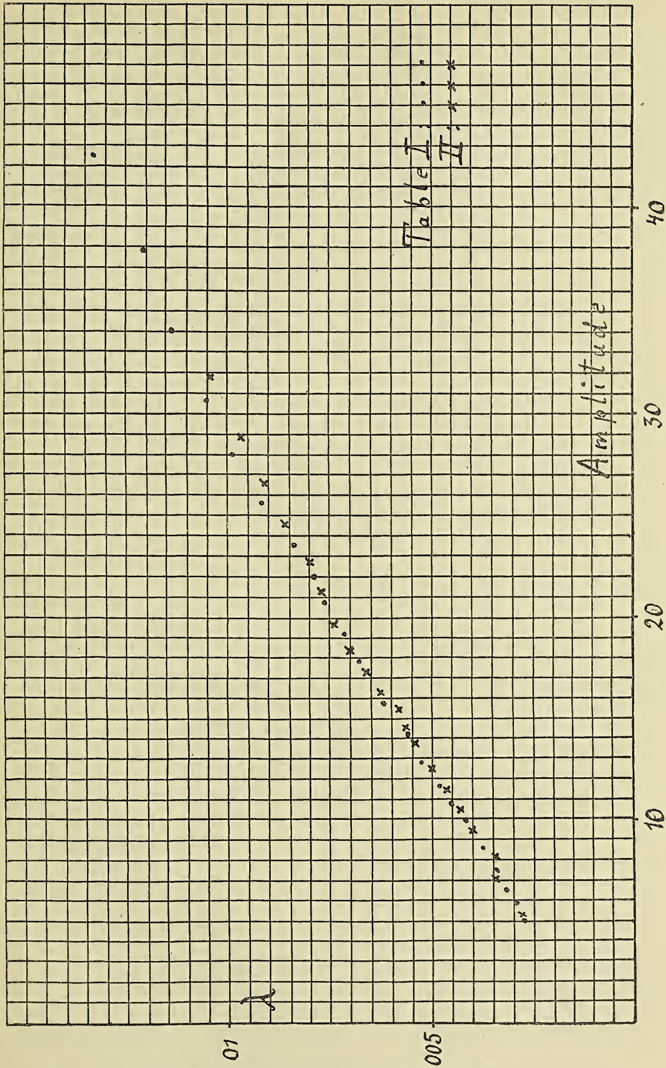


FIG. 2. Decrease in Amplitude and Square of Amplitude.



15 Fig. 3 Logarithmic Decrement and Amplitude.

Having thought at first that the property of iridium to absorb oxygen might be the reason for the observed anomalies, I experimented with the same wire under different pressures. The changes in the period and decrement were as large as before, even when the pressure was only 2.5 cm. A further decrease in pressure could not be obtained because the large brass case was not perfectly airtight.

The observations were repeated with a different moment of inertia suspended from the wire. The time of vibration was now only 7.274 sec. for the larger amplitude and decreased to 7.105 with the smaller amplitude. But most surprising of all was the fact that values of the logarithmic decrement when plotted as a function of the amplitude fell closely upon the same curve which was obtained with the larger period, and seems, therefore, to be independent of the velocity with which the system moves.

It made no difference whatever with how large an amplitude I started, whether or not the wire had been kept swinging for some time, and if it was swinging under atmospheric or decreased pressure; for the same amplitude always the same large logarithmic decrement was found.

The phenomenon which this wire exhibits in such an exceptional degree has usually been considered as closely connected with elastic after effect, but the fact that the wire shows almost no after effect when tested by the usual method seems to indicate that there is little or no connection between the two.

My first thought was that the wire did not follow Hooke's law and I therefore connected one of its ends rigidly to a steel wire of equal length and at the connecting point a small mirror was sealed to the wires. The lower end of the steel wire was securely fastened and the upper end of the platinum-iridium wire clamped in a torsion head. It was found that equal deflections of the mirror were produced by equal angular displacements of the torsion head. This shows that the wire followed Hooke's law within the limits of the experiment.

I am unable to explain at the present time the results obtained with the platinum-iridium wire, but hope to continue the investigation with wires of different length and diameter and possibly also with alloys of platinum with other rare metals.

While the elastic after effect may have some influence upon the rate of dissipation of energy in a wire in torsional vibrations, there can be no simple relation between the after effect and the logarithmic decrement, even in the case of ordinary wires, because frequently wires with smallest after effect show very large values for the decrement. I have shown this to be true in all cases. Drawn wires have a considerably larger logarithmic decrement than softer wires. I have made a large number of experiments on this point, using first hard drawn wires and repeating the experiments after the wires had been annealed by drawing them through the flame of a Bunsen burner. In every case the soft wires show the smaller decrement and the larger moment of torsion.

Thus copper wire, hard drawn, had a period of 5.780 sec. and a logarithmic decrement of 0.0057. After annealing its time of vibration with the same moment of inertia and at the same temperature was 5.702, decreasing with amplitude to 5.692, and the decrement had decreased to 0.0022, more than one-half.

New light has recently been thrown upon the physical process taking place during the drawing of a wire. Beilby[3] arrives by very interesting microscopic

3. Beilby, Nature, 76, p. 572, 1907.

investigations at the result that all crystalline substances can also exist in a noncrystalline or amorphous form and that these two forms are so distinct from each other that they must be regarded as definite allotropic modifications. Further he showed that in the pure ductile metals the crystalline state is actually the soft state, while the hardened metal is a complex structure built up of crystalline and noncrystalline substance. During the drawing some of the crystals pass into the amorphous state and during the sudden congealing after the removal of the pressure the crystals are bound into a rigid mass irrespective of any orientation. When this mass is heated to a temperature far below the melting point of the metal recrystallization of the amorphous part takes place and the wire becomes soft.

This theory explains many peculiarities of hard drawn wire. Gray and Mees and more recently Wassmuth have shown that the density of wires drawn under great pressure is smaller than before drawing. Applying this theory to the results discussed in this paper, we have to assume that the amorphous state has a smaller rigidity than the crystalline state and we must expect a larger logarithmic decrement in amorphous solids. If the elastic after effect is due to a slipping of crystals with respect to each other the after effect should become smaller when the crystals are closely surrounded by the amorphous mass.

To test these conclusions experiments were made with fused quartz and carbon filaments, both amorphous substances. The quartz fibre was very thin and 480 mm. long. The elastic after effect was very small, the time of vibration very constant and no decrease of the decrement with amplitude could be observed. The decrement was 0.000572, a value twice as large as was obtained with much thicker metallic wires.

The thin carbon filament, 20 cm. long, had the very large decrement of 0.00548, the amplitude decreasing in 176 swings to one-tenth of its original value. But the decrement remained perfectly constant.

A similar effect to that of hardening by drawing can be produced in a palladium wire if hydrogen is deposited upon it by electrolysis. With a palladium wire this treatment produced an increase of the decrement from 0.0006 to 0.003, while the period was decreased from 7.954 sec. to 7.778 sec. The absorption of hydrogen is considered as a solution of hydrogen in the metal and it is quite reasonable to suppose that the crystalline structure of the wire is greatly impaired by such a treatment. With the 25 per cent platinum-iridium wire mentioned above, annealing reduced the logarithmic decrement from 0.00124 to 0.000327 without showing any other noteworthy effects.

The same treatment failed, however, completely with the 40 per cent platinum-iridium wire. Thinking that perhaps the temperature of the Bunsen burner was too low to raise the wire to the point of recrystallization, I sent through the wire, not under tension, an electric current sufficiently large to heat it to bright yellow heat. The point of recrystallization was undoubtedly reached and the crystals must have arranged themselves in any imaginable way; for placing the wire again in the torsion apparatus I was unable to get any zero point at all, though the wire was kept in continuous vibration for two days in the hope to have the crystals fall in line. They absolutely refused to do so and during each attempt of making a measurement the zero point shifted at least 10 cm. over the scale in the direction in which the torsion had first been applied.

Then the wire was heated again by an electric current to red heat, but this time under a load which it was to carry in the torsional experiments. No higher temperature was attempted for fear that the wire might permanently stretch under the load. The zero point after this treatment was again quite steady, but at the same time all its former peculiarities reappeared.

Apparently the conditions under which the annealing of the wire takes place has a great influence upon the elastic properties of the wire, and in future experiments this point shall receive special attention.

DETERMINATION OF THE CHARGE OF AN ELECTRON BY WILSON'S METHOD, USING RADIUM.

BY L. BEGEMAN.

The following discussion of the experimental determination of the charge e of an electron may prove interesting inasmuch as the conditions of the experiment were in many respects more favorable than those of previous attempts. As is generally known, determinations of e have been made by J. J. Thomson and H. A. Wilson at the Cavendish-laboratory, England. Their methods were quite different, although both obtained their data from observations of ionized clouds produced by the rapid expansion of supersaturated air in a fog chamber.

A description of the apparatus employed by J. J. Thomson will be found in his work entitled "Conductivity of Electricity Thru Gases," 1906 edition; also in the Phil. Mag., Vol. 5, page 346. To secure a constant source of radiation J. J. Thomson used radium instead of X-rays. The radium was suspended at a given distance above the fog chamber and maintained continuously in the same position during the observations. C. T. R. Wilson's device for rapid expansions was used to produce the clouds in the fog chamber. The clouds were produced between two plane electrodes maintained at a constant difference of potential. Now if n is the number of droplets in the cloud and e the charge on each, then the total charge of the cloud will be $n\ e$. Furthermore, if u is the mean velocity of the positive and negative ions in a given electric field, then the current thru unit area of the ionized gas in the field will be $n\ e\ u$. Hence, it is only necessary to measure the current u to determine the value of $n\ e$. Thomson used the method of Zeleny and Rutherford to get the value of u; i. e., the velocity of ions in a field of known strength. The method of C. T. R. Wilson was used to determine the number of particles of water vapor in a unit volume of the cloud. Knowing the current velocity and the number of particles it is a simple calculation to determine e the charge of an electron. J. J. Thomson's average determination gives the value of e as 3.4x10-10 E. S. units.

In the light of more recent investigations of ionized cloud phenomena, J. J. Thomson's determination is certainly open to serious criticism. For instance, he states that when the expansion is greater than 1.31, positive as well as negative ions are caught, and that the number is about twice as many as is obtained at expansions varying from 1.27 to 1.29. He says also that when the expansion is greater than 1.33, the number of nuclei caught by the cloud does not depend upon the amount of the expansion. We understand that Thomson's observations were all taken at an expansion of about 1.33, where he assumed that every droplet in the cloud carried but one ion either positive or negative. In this assumption we see the probable error of his work.

According to Carl Barus in the May publication of the Carnegie Institute entitled "The Condensation of Vapor Induced by Nuclei and Ions," the nucleation induced by radium increases rapidly with increasing expansions from 1.33 to 1.4. Above 1.4 the nucleation gradually increases and a maximum is not attained until the dp. is 34 cm. (dp. is the difference of pressure between that in the fog chamber after expansion and the ordinary atmospheric pressure. A dp. of 34 cm. corresponds to an expansion of 1.7.) Fig. 1 is a graph by Barns showing the nucleation due to radium at various pressures. In this graph the ordinates represent the nucleation (the number of condensed particles per cubic centimeter in the cloud in units of 1000); while the abcissae represent the dp. in centimeters. As will be noted, the nucleation begins at a dp. of 19 cm. and gradually approaches a maximum after a dp. of 22 cm. is reached. Now if Barus' observations are correct then J. J. Thomson's assumption that every water particle in the cloud at an expansion of 1.33 carries a single ion can hardly be accepted since such a result would only be likely at expansions giving the maximum nucleations. Barus observed that at the lower expansions nuclei carried a variable number of ions. My own determinations at an expansion of 1.33 also indicate this fact.

Fig. 2 shows a curve very similar to Barus', but one which was obtained in an entirely different manner. In this figure the ordinates give the time it took for the cloud formed in the fog chamber by expansion to fall a distance of 2 millimeters under the action of gravity. It will be seen that as dp. increased from 16 cm. to 24 cm. the time increased from 3 second to 5.2 second. At the low expansion the droplets were heavy, falling rapidly. As the dp. increased the droplets became smaller with a corresponding diminished velocity. The density of the clouds also increased enormously with the high pressures. Comparing the curve of figure 2 with that of Barus in figure 1, we note that the velocity of an ionized cloud under the action of gravity varies, approximately, inversely as the nucleation.

An account of H. A. Wilson's method of determining *e* in the Phil. Mag., Series 6, Vol. 5, 1903, page 425. The method has the advantage over J. J. Thomson's in that it is not necessary to know the number of particles in the ionized cloud. All that one needs to know is, first, the velocity of the cloud under the action of gravity, and, second, the increased velocity under the combined action of gravity and a static field of known strength. For instance, if the force of the static field is X and the charge of the particles in the cloud is *e*, then the total force acting when the field is on is equal to $mg + xe$; where m is the mass of each particle. When the field is not on, the force acting is mg. Since the rate of uniform motion of a sphere in a viscous fluid is proportional to the force acting, we have:

$$\frac{mg}{mg+xe}=\frac{V_0}{V_1}$$

$$\text{Solving } e=3.1\times10^{-9}\ \frac{g}{x}\ (V_1-V_0)\ V_0^{1/2}$$

$$\text{And } m=3.1\times10^{-9}\times V_0^{\frac{3}{2}}$$

Wilson's determinations varied from $2\text{x}10^{-10}$ to $4\text{x}10^{-10}$ and his average was $3.1\text{x}10^{-10}$. All of his determinations were taken at a dp. of 17 cm.

The correctness of Wilson's result might be questioned for several reasons. First, he used X-rays as his ionizing source, which we know may be extremely variable. It is probable that this lack of uniformity of X-rays as an ionizing source accounts for the marked differences in the velocities of his clouds for successive observations. In a series of eleven sets of observations we find that the timing of his clouds varies from 12 seconds for a distance of 5 millimeters to 33 seconds for a distance of 5 millimeters. In my own work with radium as a source of ionization, the timing of the clouds, as will be observed from data later, was practically constant for any given difference of pressure.

Again, as has been stated above, Wilson worked at a dp. of 17 cm., which, according to Barus, is right within the region of persistent nuclei. Barus observes that these persistent nuclei induced by X-rays are ionized, carrying a variable number of ions; one, two or three, perhaps. He notes also that their number in the fog chamber varies with the time of exposure and also with distance of the X-ray bulb from the fog chamber. Their masses, accordingly, vary considerably, which no doubt accounts for the different layers witnessed by Wilson in his clouds. A serious objection to Wilson's work is seen in the fact that the number of persistent nuclei vary with the time of exposure. If the time of exposure was not the same in all determinations his velocities would necessarily vary considerably, as his data shows. X-rays were first used as the ionizing source for the determination of e at the Ryerson laboratory, but the results were so unsatisfactory that radium was substituted.

The data for the determination of e given in this paper were obtained under conditions which preclude in a measure the criticisms on Wilson and Thomson. A one per cent compound of radium was used as the ionizing source. Barus shows conclusively in his experiments that the gamma rays of radium are the source of nucleation in the fog chamber. These rays are productive of fleeting nuclei or ions and not of the persistent type arising from X-rays described above. Of course, the persistent type of a dust-like nature would still occur, even with radium, where the air is not filtered, as was the case in these experiments. As was stated above, the X-ray persistent type are cumulative with the time of exposure. This cumulative effect, accordingly, does not occur with radium and any slight variation in the time of exposure between observations would not be a source of error.

All observations were taken at dp. varying from 22 cm. to 24 cm., which it will be observed, is well within the region of maximum nucleation as given by Barus for an expansion apparatus that is subject to some resistance, as is the case of the Wilson type. During successive observations the radium was continuously kept in position very close to the fog chamber. The nucleation within the fog chamber was very uniform. This was evident from the fact that the coronnas due to the beam of light penetrating the fog chamber were of uniform width throughout their extent. The surfaces of the clouds were usually sharply defined, permitting good time observations.

Although the apparatus used was entirely different from that of Barus, yet in the course of the work all of the phenomena of nucleation described by Barus were experienced and renderd familiar. The velocity of the dust-like persistent nuclei were frequently timed at dps. varying from 16 cm. to 18 cm. These velocities were usually found to be about five to six seconds for a distance of five millimeters, showing that their masses were relatively large. The radium, of course, was not in place in timing the persistent nuclei. With radium in place denser clouds made up of smaller particles were obtained at a dp. as low as 16 cm. Furthermore, the particles in these clouds were ionized, negatively charged, since their falling velocities were markedly increased when the electrodes between which the cloud was produced were charged. In all observations with a field the upper electrode was charged negatively and the lower positively. As the dp. for the expansions gradually increased the velocities of the clouds diminished, as is shown in fig. 2. At dps. from 22 cm. to 24 cm. a practically constant velocity was attained which was invariably between 5 and 6 seconds for a distance of 2 millimeters. It was because of this constant velocity that all observations for the determination of *e* were taken at these differences of pressures. It is very probable that at these expansions practically all of the droplets carried but one ion.

It might be interesting to note further that on several occasions while expanding at as high a difference of pressure as could be attained with apparatus, colloidal clouds were distinctly observed. These clouds consisted of very minute particles, as was evident from the fact that their falling velocities were very slow. In timing them it was found that it required 15 to 18 seconds for the surface of the cloud to fall through a distance of two millimeters. This indicates that the droplets of the colloidal nuclei are three to four times smaller than those of the fleeting nuclei. Barus' pamphlet did not come to my hands until the close of work and I was much impressed with the coincidence of phenomena observed under such different conditions.

Below is given a series of preliminary determinations of *e* taken during the first weeks of the work. The mechanism used for producing the expansions in the fog chamber and for throwing on the battery terminals to charge the field was crudely mechanical, so that the conditions of the successive observations could only be duplicated in a rough way. In taking these observations Wilson's method was followed. First, successive expansions were produced to get rid of the dust-like persistent nuclei. These were followed by two observations with the radium in place, one with the field off and the other with the field on.

Each determination represents the average of a series of eight to ten alternate readings taken in the manner described. The calculations were made by means of Wilson's equation. The difference of potential between the electrodes of the fog chamber was in every case supplied by a storage battery of 1600 volts.

3.87×10^{-10}	E. S. Units
4.65	" " "
3.82	" " "
4.10	" " "
4.20	" " "
3.64	" " "
4.27	" " "
4.43	" " "
3.73	" " "
4.03	" " "
4.55	" " "
4.40	" " "
Mean 4.14×10^{-10}	E. S. Units

The data which follow were obtained under decidedly improved conditions of the apparatus. The mechanical device for producing the expansions was discarded and electrical contrivances were substituted so that by the closing of a key the expansion in the fog chamber could be produced—instantly followed, when desired, by the connection of the poles of the storage battery with the electrodes. The method of observation were also slightly changed. Some were taken by what might be termed a group method. First, one or two expansions were produced to get rid of the persistent nuclei. These were followed by three observations without the field and then by three with the field. The times between the different observations were as nearly equal as could be obtained by a single experimenter under the conditions of work. It is not likely that the small differences of the intervals affected the results to any extent. By making the observations rapidly so that compressions in the fog chamber would quickly follow the expansions it was frequently possible to take as many as six or eight observations before any diminution of the supersaturation in the fog chamber became apparent.

About one-half of the observations were taken by grouping alternate readings. After expansions to get rid of persistent nuclei a series of four to six alternate readings were taken in succession. The results of the two methods were practically the same as indicated by the data.

On examining the data it will be found that the velocity of the cloud with the field off is practically the same in every case. It will also be noted that the difference between the velocities with the field off and field on varies directly as the voltage. When the voltage is double the difference is approximately double. We should expect this since the velocity due to gravity is always the same.

During all observations the distance between the electrodes in the fog chamber was invariably 5 millimeters. The timing of the clouds, however, was taken through only a distance of 2 millimeters. This was necessary for several reasons. By timing through a short distance the error due to evaporation would be small. Again, it was found on expansions that the upper electrode, the terminal of which passed through a rubber stopper, would project the surface of the cloud, giving it an accelerated motion which it would maintain for a distance of approximately two millimeters. All observations were made with a micrometer microscope adjusted to a cathetometer support. Owing to the projection due to the electrodes it was found necessary to bring the first cross hair of the microscope near the middle of the space between the electrodes so as to get the time of the cloud when moving at a uniform speed.

One of the greatest difficulties encountered in timing the clouds, especially when high voltages were used, was the breaking up of the sharply defined surface of the cloud by the action of field. Under the circumstances it was frequently impossible to time the surface cloud for the second cross hair of the microscope. When 3000 volts were used the surface of the cloud on approaching the positively charged electrode would exhibit a phenomena somewhat analogous to the scintillations that take place inside of the spinthariscope. Particles would be projected upward in all directions, giving the cloud a hazy appearance. As a rule the main body of the cloud could be seen descending toward the positively charged electrode, while the scintillations were taking place. The best observations for the velocity determinations of the clouds were obtained at voltages varying from 2000 to 2400 volts. The electrodes in every case were charged with a storage battery of 1600 cells, which enabled a variation of the static field. All time observations were taken with a stop watch. The temperatures given with some of the determination have reference to the room in which the experiment was conducted. For two or three days in November the heating was not good in the laboratory, the temperature maintained being about18°C. At that temperature it was found impossible to get well defined clouds for observation. An electric heater was brought into service and the temperature was brought to 23°C, when good clouds were again obtained. After that the temperature of the room was taken with each series of observations. Owing to space the complete data for only two determinations are given to show how they ran:

Field 2,400 volts=16 E. S.	Field 2,950 volts=19.67 E. S.
V_0=.0387 cm.	V_0=.0387 cm.
V_1=.0497 cm.	V_1=.053 cm.
Temp.=26°C	Temp.=26°C
$e=4.1\times10^{-10}$	$e=4.25\times10^{-10}$

	Field off	Field on	Field off	Field on
	5.4 secs.	4.0 secs.		
	5.2	4.0	5.2	3.8
	5.2	4.0	4.8	3.8
	5.0	3.8	4.8	3.6
	5.0	4.4	5.2	4.0
	5.4	4.0	5.6	4.0
	5.2	4.0	5.6	4.0
	4.8	4.2	4.8	3.2
	5.4	4.4	5.2	4.0
	5.2	3.6	5.2	4.0
	5.2	4.0	5.2	3.6
	5.2	4.0	5.2	3.6
	5.0	3.8	5.2	3.6
Mean	5.17	4.02	Mean 5.17	3.77

Summary:

3.81×10^{-10}
3.89
4.10
4.25
4.34
3.66
4.10
3.94
4.37
3.84
Mean 4.03×10^{-10} E. S. Units

Since the charge of the hydrogen atom is the same as the negative ion, the above determination gives on computation a mass of 1.3×10^{-24} for an atom of hydrogen and a mass of 2.6×10^{-24} for a molecule or hydrogen. Taking the mass of a cubic centimeter of hydrogen at O°C. and 760 mm. as 9×10^{-5} grams we get for N the number of molecules per cubic centimeter, 3.4×10^{-19}. This is lower than Wilson's or Thomson's determination, but nearer the best estimates according to the kinetic theory of gases, which I find to be as low as 2.1×10^{-19}.

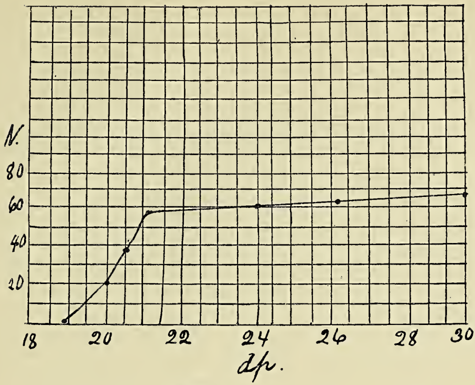


Fig. 1

Determination of the Charge of an Electron—Begeman.

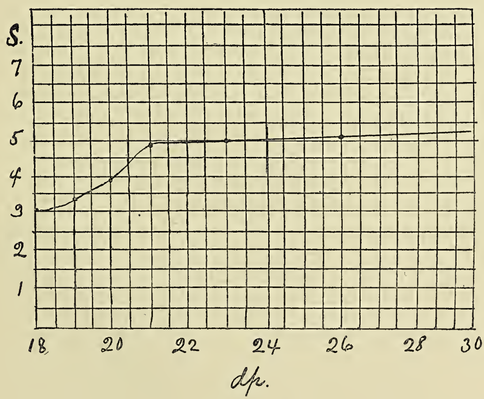


Fig. 2.

Determination of the Charge of an Electron—Begeman.

NUCLEATIONS ACCORDING TO BARUS.

BY L. BEGEMAN.

No doubt all students of science have read more or less about Barus' work on condensation phenomena as produced in a specially constructed fog chamber. As is known, his work has been done under the direction of the Carnegie Institution of Washington, founded particularly for the solution of research problems, involving much time and considerable expense. The prime purpose of his work, so far as I can interpret it, is to determine the part played by various kinds of nuclei in the atmospheric condensation of vapor. This, of course, is a very interesting problem to the student of physiography, as well as to the physicist.

It is very difficult to read Barus' notes and I would not commend his style to anyone. In fact, I doubt whether anyone who has not had some experience in the experimental production of such phenomena could get much out of his writings. His literature is apparently intended for the few who have the courage to attack something exceedingly dry. In my experimental work to determine the charge of an electron I had occasion to refer to his work to help interpret my own phenomena. In the discussion of my work I have made frequent reference to Barus and it is for this reason that I present this sketch with the hope that it will make the other paper more intelligible.

Barus' fog chamber is sketched in a simple manner without detail in Fig. 1. It consisted of a cylindrical vessel made either of glass or wood and sealed air tight. The lower part of the vessel contained a layer of pure water which kept the air or gas above in a state of supersaturation. The vessel contained also a number of wet muslin partitions placed parallel to its length. The purpose of these was to prevent cross currents in the vessel when the exhaustions were made, thus keeping the clouds uniformly compact. The tube *E* leads to a vacuum chamber cut off by an intervening plug valve. By the sudden opening of the plug valve an exhaustion of the fog chamber is made, producing a consequent lowering of temperature which results under the proper conditions when nuclei are present in the formation of a cloud. A bright beam of light is admitted into the fog chambers so that when a cloud is produced a coronna, generally of a green-blue-purple type, is plainly visible. The angular diameter of the coronna is measured by a pair of goniometers suitably placed and from this the number of efficient nuclei are determined in a manner described in Barus' publication of the Smithsonian Institute, published in 1905.

Barus describes three kinds of nuclei which at given pressures are able to induce the condensation of vapor in a fog chamber by exhaustion. First, "the ordinary dust-like persistent nuclei which require the smallest degree of supersaturation to induce condensation. Ordinary air, particularly of cities, contains at all times multitudes of minute dust particles. When such air is admitted into the fog chamber saturated with vapor, the dust particles on exhaustion become the nuclei of small droplets of water which taken together constitute the cloud. As Barus states, such particles induce the condensation of vapor. These dust like nuclei are persistent. By the term "persistent" used so much by Barus, is meant that they will remain suspended in the gas of the fog chamber indefinitely until an exhaustion is made. Several successive exhaustions, however, will bring them down in droplets and thus purify the air. These persistent nuclei are particularly efficient for nucleation at a difference of pressure of 16 to 18 cm. By difference of pressure is meant the difference between the barometric pressure in the fog chamber produced by exhaustion and that of the outside atmospheric pressure.

The second class of nuclei denoted by Barus are called "fleeting nuclei." They are produced by some ionizing source, such as X-rays or radium. "They carry a charge of electrification and are called ions." These fleeting nuclei are most efficient for nucleation at a dp. of 19 cm. or higher. When a weak radium compound is brought near the fog chamber, the interior is instantly surcharged with fleeting nuclei. Barus does not attempt to describe how these are produced. The experimental work of Rutherford has abundantly proven that the Alpha and Beta rays of a radio active compound are the principal sources of its ionizing power when they are not intercepted by some intervening solid. The Alpha rays are by far the best ionizers, but unfortunately they are easily cut off by the slightest obstruction, such as a thin piece of celluloid. It is evident then that the Alpha or Beta rays are ineffective as ionizers of the interior gas of a fog chamber having such thick walls of glass or wood as that used by Barus. Barus rightly concluded that the interior of his fog chamber was ionized wholly by the Gamma rays and their secondary effects on the walls of the vessel. The Gamma rays of radium, as we know, are like the X-rays, although decidedly more penetrating and more uniform in intensity. According to modern theory, the ionization of a gas by means of X-rays or Gamma rays is due to the fact that these rays have the power of disintegrating its atomic structure. A stable atom consists of a multitude of negatively charged electrons moving with high velocities inside of a positively charged sphere, the whole in static equilibrium. The action of the Gamma rays is to set free a negative electron leaving a surplus positive charge on the atom. Such a freed electron and its corresponding positively charged atom from which it has been delivered constitute the fleeting nuclei mentioned by Barus. They are fleeting because when the ionizing source, radium or X-rays, is removed, they at once recombine and disappear in very small intervals of time.

Barus found also that persistent nuclei similar to those of a dust-like character mentioned first could be induced by X-rays even in thoroughly dust free air. These persistent nuclei varied in number with the nature of the solid material thru which the X-rays past. They are probably disintegrated particles of matter carrying one or several ions. Like the dust nuclei, they produce large droplets on exhaustion at small differences of pressure. Those who have read the account of Wilson's experiments to determine the charge of an electron by means of X-rays will remember that his clouds broke up into a succession of layers. Barus' notion of persistent nuclei evoked by X-rays gives a simple and reasonable explanation of these layers.

The third class of nuclei mentioned by Barus are the colloidal type. Stated in his words, "they are a structural part of the body of gas and are reproduced as soon as removed. They require the highest degree of supersaturation and are without electrification." To produce condensation on the colloidal nuclei, Barus carefully filtered the air thru a plug of cotton-wool before admitting it into the fog chamber so as to have it entirely free from any dust nuclei. No energizing source such as X-rays and radium was brought near the fog chamber.

With exceedingly rapid exhaustions at a dp. of 26 cm. clouds were produced consisting of exceedingly small droplets, much smaller than those induced by even the fleeting nuclei. Owing to the smallness of the droplets Barus seems to infer that the nuclei are also smaller than those of any other kind. Barus speaks of the colloidal nuclei as if they were perhaps the molecules or the normal atoms of either the gas or vapor in the fog chamber.

It is not the purpose of this article to go extensively into the vast amount of work performed by Barus and his assistants, but it might be well to mention a few of the facts determined.

Comparing X-rays and radium as sources of nucleation Barus found that the X-rays are very variable, while the radium is decidedly constant. This fact is also abundantly verified in the experimental work of radio-activity. The number of efficient nuclei induced by X-rays varies rapidly with the strength of the rays and also with the suddenness and ease of exhaustion. When the exhaust tube was enlarged to one and one-half inches in diameter, as many as 400,000 efficient nuclei per cubic centimeter were obtained.

The term "efficient nuclei" is applied only to those that induce the condensation of vapor to form the droplets of the cloud. There are no doubt many others besides those that get the moisture. In fact, it was proven that when a mixture of nuclei of different electrical magnitudes were present in the fog chamber, the larger ones on the first exhaustion received all the moisture. A second exhaustion following rapidly would bring down a greater number of nuclei than the first one. The maximum number of nuclei induced by radium was about 60,000 per cubic centimeter, increasing some on the higher differences of pressure and the enlargement of the exhaust tube. The maximum number of colloidal nuclei varied from 80,000 to 100,000 per cubic centimeter.

Barus carried on a series of experiments covering a period of two years on the nucleations of the ordinary atmosphere. Two stations were establisht, one at Providence, Rhode Island, and the other on Block Island, off the coast. Observations were taken at regular intervals each day. It was shown that the nuclei, dustlike and ionized in the atmosphere is far greater in the winter time than in the summer. The maximum is reacht in December at the winter solstice and the minimum in July at the summer solstice. It was also found that the nucleation is usually greater early in the morning, gradually diminishing during the day until the middle of the afternoon, and increasing again towards evening. Rains were always followed by a markt decrease in the number of nuclei. It was also inferred that light pressure decreast the nucleation, causing in a measure the diurnal variations. There was a markt difference in the atmospheric nucleations of Providence and Block Island. The latter place lies well out at sea, where the air is not affected by local contaminations. The number of nuclei at Providence ran as high as 60,000 to 80,000 per cubic centimeter; at Block Island 10,000 to 15,000. It is evident that the products of combustion of a large city furnish a vast number of nuclei and in this way supply the material necessary for the condensation of moisture. It might be askt why is the nucleation of the atmosphere so enormous in the winter time? The reason, of course, is that there is very little watery vapor in the air at low temperatures for condensation on the nuclei to bring them down. The result is that the nuclei gradually accumulate as the weather grows colder and colder, reaching a maximum at the winter solstice.

In his later work Barus carried on a series of experiments to determine whether or not the ionized nuclei of the atmosphere at Providence were due to local causes. To do this, the air before being admitted into the fog chamber was past thru a tubular condenser, one surface of which was charged. In this way the charge given up by the ions in a given time for a given quantity of air was accurately measured. Dividing this charge by 3.4×10^{-10}, J. J. Thomson's determination of the charge of an electron, gave the number of ions per cubic centimeter. From this work Barus concluded, quoting his own words, "that the ionization of a given region is independent of artificial local contributions, however abundant these may be." We would infer from this that the ionization of the atmosphere results from cosmical rather than local conditions.

SOME PROTOZOA FROM FAYETTE, IOWA.

BY GUY WEST WILSON.

During the past autumn several cultures were made from ponds, springs and streams in the vicinity of Fayette for the purpose of providing material for class use. As the number of species of Protozoa represented appeared to be much greater than the author had observed elsewhere, a record of their identity and abundance was kept. A partial result of this work is the present list of thirty-three species, in addition to which several others were observed, but not identified. Inasmuch as Dr. Edmundson's "Protozoa of Iowa" formed the basis of the taxonomic portion of the work, the Euglenidae are included in the list, although the author is by no means convinced of their animal nature.

RHIZOPODA.

Family Amoebidae.

1. AMOEBA PROTEUS Leidy.

Found abundantly and of large size in several cultures from ponds, especially those which contained an abundance of semi-decaying vegetation.

2. AMOEBA RADIOSA Ehr.

A very few specimens were found in company with the preceding species.

3. AMOEBA VILLOSA Wallich.

A few specimens were observed in cultures of pond water.

Family Arcellidae.

4. DIFFULGIA PYRIFORMIS Perty.

Common in cultures containing *Algae* and *Naias*. A careful search failed to reveal the presence of other species.

5. ARCELLA VULGARIS Ehr.

Not uncommon in ponds and streams, often in company with diatoms.

HELIOZOA.

Order Aphrothoracidae.

6. ACTINOPHRYS SOL Ehr.

In ponds and springs, rather rare, and usually in company with Diffulgia.

FLAGELLIDA.

Family Heteromonadidae.

7. ANTOPHYSA VEGETANS Muhl.

This interesting collonial form appeared in great abundance in cultures in which *Nymphaea advena* and *Naias* occur.

Family Euglenidae.

8. Euglena viridis Ehr.

Very common in cultures which later developed an abundance of *Amoeba proteus*.

9. Euglena spirogyra Ehr.

Equally common and in cultures from the same source as the last specimen, with which it frequently occurred.

10. Euglena acus Ehr.

Only a few specimens were found in cultures of pond water.

11. Phacus sp.

Observed sparingly in company with *Euglena viridis*, but not satisfactorily identified as to species.

Family Astasiidae.

12. Astasia trichophora Ehr.

Rare in old cultures among *Algae*.

Family Paranemidae.

13. Anisonema ludobundum SK.

Common in cultures from various sources.

INFUSORIA.

Family Echelinidae.

14. Coleps hirtus Ehr.

Common in cultures in which *Paramaecium caudatum* appeared later.

15. Trachelophyllum trachyblastum Stokes.

Rare in old cultures of pond water.

16. Didinium nastum Muell.

Common in company with *Paramaecium caudatum*, upon which it feeds.

17. Lacrymaria olor Muell.

Rare in cultures of pond water.

Family Trachelinidae.

18. Dileptus gigas C. & L.

Rare in old cultures of pond water.

19. Lionotus fascicola Ehr.

Very common among bacteria in old cultures of pond water which previously contained *Coleps*, *Paramaecium*, *Didinium*, etc.

Family Chiliferidae.

20. Frontonis lucas Ehr.

Common with bacteria in cultures of pond water, appearing with the last of *Paramaecium caudatum* and before *Lionotus*.

Family Urocentridae.

21. Urocentrum turbo Muell.

Very common in company with *Paramaecium*, *Frontonia*, etc.

Family Paramaeciidae.

22. Paramaecium caudatum Ehr.

Very common in cultures of pond water.

23. Paramaecium bursaria Ehr.

Rather rare in old cultures in which *Euglena* and *Amoeba* were beginning to appear. The green coloring matter of this species is due, according to European algologists, to the presence within the animalcule of numerous individuals of a Protococcoid Alga, *Chlorella vulgaris* Beyer, and not to a pigment of the *Paramaecium* itself. So far as I was personally able to study the form this view of a duality of species appears to be the correct one.

24. PARAMAECIUM TRICHINUM Stokes.

Rare among the bacteria in an old culture of pond water.

Family Stentoridae.

25. STENTOR CAERULEUS Ehr.

Common in old cultures after the bacteria had disappeared, and frequently in company with *Amoeba proteus*.

Family Oxtrichidae.

26. OXTHRICHIA PELLIONELLA Muehl.

Common in old cultures of both pond and spring water.

27. STYLONYCHIA MYTILUS Ehr.

Very common in old cultures from which *Paramaecium caudatum* had almost disappeared.

28. STYLONYCHIA PUSTULATA Ehr.

Common, in similar cultures to the last, but not always associated with that species.

Family Vorticellidae.

29. VORTICELLA CAMPANULA Ehr.

Very common in colonies in pond water, especially from ponds where there was an abundance of semi-decaying vegetation.

30. VORTICELLA NUTANS Mull.

Rather rare in pond water.

31. VORTICELLA ALBA From.

Rather rare in pond water.

32. VORTICELLA LONGIFILUM SK.

A solitary form which is rather common in pond water.

33. EPISTYLIS FLAVICANS Ehr.

Rare in cultures from which *Vorticella* had disappeared.

A STUDY IN WING VEINATION.

Family Aphididae.

BY C. E. BARTHOLOMEW.

The purpose of this paper is to give the results of a study of the wing venation in the family Aphididae with a view of replacing the arbitrary nomenclature as applied to this family by the general nomenclature of wing venation.

If the venation of the wing as found in the more generalized Aphid (fig. 2) of the subfamily Aphidinae is compared with the arrangement of the veins of a hypothetical wing (fig. 1), it will be seen that there is little or no resemblance. If, however, the wing of the developing nymph (fig. 3) is studied the resemblance is so close that but slight chance for mistake exists and the key to the venation of the adult wing is found.

In the wing of the young nymph the venation is nearly the same as in the hypothetical wing. In this case the subcostal vein (Sc) is two branched. The radical vein (R) is four branched, branch one (R_1) is not very well developed and branches four (R_4) and five (R_5) have coalesced. The medial vein (M) is three branched instead of four, but this loss is common when there is a reduction of this area of the wing, for instance, as in the Diptera. The cubital vein (Cu) is normally two branched, as it is in the hypothetical wing. There is but one anal vein (A).

In studying the wing of the mature nymph (fig. 4) the venation will be seen to be the same as in the mature wing except that the coalescence of the bases of the veins has not taken place.

This points out the veins which have been lost thru coalescence and the manner in which the reduction has taken place. The subcostal and radial areas are greatly reduced, as is also the anal area. The medial and cubital areas remain unreduced or possibly increased except in the proximal portion of the wing where all the cells have been lost. The result is that where there has been a reduction in area there has also been a reduction in the veins by coalescence. This coalescence has taken place to such an extent that all the veins have been lost either wholly or in part. The radial and subcostal veins even in the young nymph show a crowding together which in the older nymph have coalesced into a once branched vein, the main portion of which is composed of the coalesced subcostal and radius, and the branch, of the coalesced branches of the radial sector. The medial vein in the mature nymph is the same as in the young nymph. The cubital vein is bifurcated nearer the base and the anal vein lies nearer the anal margin of the wing.

In the adult wing of the more generalized Aphid (fig. 2) the venation appears as a single, much-thickened longitudinal vein from which arise four branch veins, the third of which is again branched. This thickened vein is composed of the subcostal, the radial, except the radial sector, the basal portion of the medial, and cubital veins. The first and second apparent branches are the second and first branches of the cubital vein respectively. The third apparent branch is the medial with its three branches. The fourth apparent branch is the radial sector. The anal vein in the adult wing remains as only a fold at the base of the second cubital vein and forms a thickening for the attachment of the hooks of the caudal wing.

As specialization progresses in the other subfamilies of the Aphididae a reduction of the medial vein takes place and there is first a disappearance of the branches of this vein and, in the most specialized wing, a complete disappearance of the vein itself. In the subfamily Schizoneurinae (fig. 5) the further specialization is by the coalescence of branches, one and two, of the medial vein which leaves this vein but two branched. In other respects the venation remains practically the same as in the most generalized wing.

In the subfamily Pemphiginae (fig. 6) the specialization has been carried still further by the coalescence of all the branches of the medial vein into a simple vein.

In the most specialized Aphid, such as is found in the subfamily Chermaphinae (fig. 7), all trace of the medial vein is lost. There are three ways in which it may have disappeared. It may have coalesced with the subcostal and radial veins. It may have been suppressed early in its development. It may have coalesced with the cubital vein. The coalescence of the medial vein with the subcostal and radial veins is quite doubtful as the radial sector in the wings of this subfamily still retains its relationship to the radial and subcostal veins as in the other subfamilies. The entire suppression of the medial vein is also quite doubtful for, while, in some of the less specialized Aphid wings there are apparent partial suppressions of this vein, such a suppression would be unusual. Wing veins do not entirely disappear in this manner. The union of the medial vein with the cubital vein I am inclined to consider as the most plausible for, in many of the more specialized wings, there is a reduction in the area between the medial and cubital veins. There is also a partial coalescence of the medial and branch one of the cubital in the more generalized wing as is shown in (fig. 4a). This partial coalescence has probably been completed in the Chermaphinae, and the medial and branch one of the cubital are apparently a single vein.

The study of the hind wings is more difficult than the fore wings, as they are too small and delicate to obtain mounts of. It is quite probable, however, that the condition that exists here is the same as that in the Chermaphinae, except that the radical sector has been lost by coalescence with the subcostal and radial veins. In the hind wing of the Chermaphinae all the veins have coalesced into one single longitudinal vein.

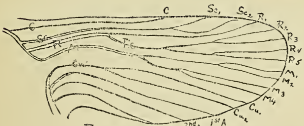
The following table gives the relation between the general and the arbitrary nomenclature:

General.	Arbitrary.
Subcostal (Sc)	Cubitus
Radial (R)	Cubitus
Radial sector (Rs)	Stigmal
Medial (M)	Third Discoidal
Medial one (M_1)	Third Discoidal, first fork
Medial two (M_2)	Third Discoidal, second fork
Medial three (M_3)	Third Discoidal
Cubital one (Cu_1)	Second Discoidal
Cubital two (Cu_2)	First Discoidal

Bibliography.

1893 Comstock, Evolution and Taxonomy.
1898 Comstock and Needham, The wings of Insects.
1899 Comstock and Kellogg, Insect Anatomy.

Exlanation of Figures.



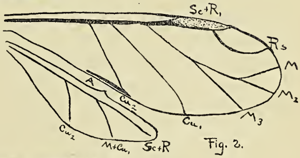
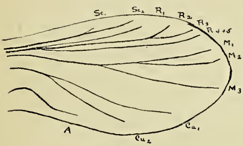


Fig. 1. Hypothetical wing, after Comstock.
Fig. 2. Wing of Macrosiphum sp.



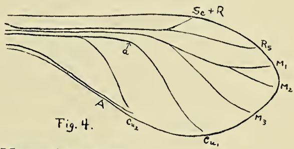
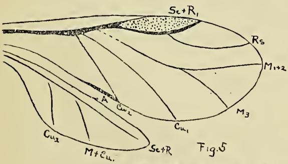


Fig. 3. Wing of young nymph. Macrosiphum sp.
Fig. 4. Wing of older nymph. Macrosiphum sp.



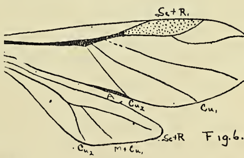


Fig. 5. Wing of Schizoneura lanigera.
Fig. 6. Wing of Pemphigus sp.

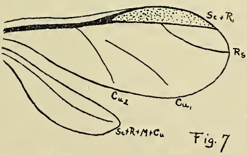


Fig. 7. Wing of Phylloxera vastatrix.

PROTECTIVE ADAPTATIONS IN THE NESTING HABITS OF SOME CENTRAL AMERICAN BIRDS.

BY MORTON E. PECK.

To the general rule that the struggle for existence among plants and animals is sharper and more exacting in the tropics than in cooler parts of the earth, birds form no exception. Moreover, so far at least as the region we are about to consider is concerned, the unfavorable or hostile elements in the environment of tropical birds differ greatly in kind or in proportion from those that must be provided against by birds of temperate climates. We should, therefore, expect to find a strongly marked difference between the habits, particularly the breeding habits, of the birds of the two regions; and this is actually the case.

In British Honduras, where the observations were made on which the present remarks are based, those conditions which perhaps more than any other influence the distribution and habits of northern birds, namely, food supply, extremes of temperature, storms, etc., are factors scarcely to be taken into consideration. In speaking of the habits and distribution of birds we are, of course, considering natural conditions only, leaving out of account changes wrought by the intervention of man. While the number of avian species in the above named region is large, the individuals are not abundant; on the other hand insects, fruit, etc., are extremely plentiful; the food supply, therefore, in most cases, is practically unlimited, while violent storms are unknown. The comparative scarcity of birds, in fact, in a land apparently so favorable for rapid increase, is at first puzzling to the observer, but a closer study of conditions reveals an infinite multitude of enemies, whose ravages, especially during the nesting season, preclude the possibility of such an increase. It would be but a moderate estimate to say that through two seasons of observation by the writer one-half of the nests found while being built were robbed by natural enemies before the incubation period was half over.

These enemies may be divided into four classes: First, predatory birds, which comprise a comparatively large proportion of the avian fauna; second, reptiles, of which species and individuals are extremely numerous; third, small mammals, of perhaps a dozen species; fourth, insects, especially several species of ants. These four classes differ greatly in degree of importance, the reptiles—snakes and lizards—being probably the most destructive.

As regards their structure and location, the nests of birds may be placed under four groups, as follows: First, open above and supported from beneath, on the ground, in grass-tufts, bushes or trees; second, in cavities of trees, rocks or banks; third, open above and pendant from a horizontal branch or leaf tip; fourth, roofed over, that is, entered by a hole at the side, either on the ground, on a horizontal branch, in an upright fork, or pendant from some support. The first group is the simplest in form, the last most highly specialized.

For the sake of illustration we may compare the nests of the birds breeding within our own state with those of British Honduras, so far as the latter are known, making the comparison in accordance with the above classification. Placing it in tabular form, and letting the numbers express the per cent of the total number of species whose nests fall within each group, we have the following:

Location	Nests open above supported from below	Nests in cavities	Nests open above, pendant	Nests with side entrance
Iowa	69	20	6	5
British Honduras	54	28	7	11

These per cents, it is true, are not exact, as the nesting habits of a considerable number of British Honduras birds are totally unknown. It is doubtful, however, if a knowledge of the life history of all would materially affect the proportions given.

If now we leave out of account the nests of Raptorial, Gallinaceous and Anserine birds, the Herons and a few other large forms whose size, warlike disposition or nidifugous habit place them largely out of danger of such enemies as smaller and weaker species must provide against, we obtain still more suggestive results:

Location	Nests open above, supported from below	Nests in cavities	Nests open above, pendant	Nests with side entrance
Iowa	65	21	8	6
British Honduras	43	32	10	15

It is evident that nests of the first type, though the most numerous, are more exposed to danger from enemies than any of the others; therefore, the much smaller proportion of nests of this form in the tropics than in temperate regions doubtless indicates that the abundance of these enemies has brought about numerous instances of modification of what is plainly the most primitive type of nest.

Protective adaptations in nests of the first class are numerous among British Honduras birds, as they are also among ours, and in many cases there is a strong similarity; this class, therefore, calls for little comment. The following may be noted: The nests of many Flycatchers and Hummingbirds are covered with lichens in imitation of the branches on which they rest; those of certain Tanagers are made to resemble masses of green moss; the curious Manikin *Scotothorus veraepacis* builds a nest that closely resembles a small mass of half-decayed leaves lodged in a tussock of sedge; the large Rail *Aramides albiventris* builds a loose nest of shreds of palmetto leaves and coarse sedges, and places it on a low branch over a stream, so that it can hardly be distinguished from a quantity of such material left there by a freshet; and many more examples might be given.

Several birds that build nests of the ordinary type frequently choose a situation that is inaccessible to reptiles and small mammals. For example, the two Tanagers *Phoenicothraupis salvini* and *Eucometis spodocephala,* and the Grosbeak *Cyanocompsa concreta,* favor certain small palms which are densely clothed with long, slender, needle-like spines.

Nothing need be said in regard to nests placed in cavities, either natural or excavated by the birds, except in those curious instances where the nest of a species of termite or "white ant" is used for this purpose. These nests are conical to nearly spherical in form, and from a few inches in diameter to the size of a barrel. They are commonly built on large branches some distance from the ground. In these structures, which are composed mainly of fine particles of wood cemented together to form the walls of small, intricately winding passages, the two Trogons, *T. massena* and *T. melanocephalus*, excavate holes for their nests. The hole is begun near the bottom and leads upward to about the center of the cone, where it expands into a large chamber. The birds are absolutely dependent on the insects for their nesting cites, which are remarkably safe from the attack of enemies. Without some such fortunate means of securing a rapid increase it is difficult to see how birds so feeble and of such low intelligence as these Trogons could long survive. The nest of the same species of termite also furnishes homes occasionally for certain Parrots and apparently always for the Paroquet, *Conurus aztec*, though these species excavate from the top instead of the bottom of the nest, and it is doubtful whether they do not sometimes occupy holes made in the termites' nests by other animals.

Most nests of the third type, such as those of the *Vireonidae* and species of *Icterus*, require no special mention. Though not precisely of this type, we may place here the wonderful nests of the Oropendolas, *Gymnostinops* and allied genera. Perhaps no birds' nests of tropical America are better known than these; it is, therefore, sufficient to say that probably they are absolutely untroubled by enemies, if we except the parasitic Rice Gracle, *Cassidix.*

Manikins of the genera *Manacus* and *Pipra* make small shallow nests of extremely slight structure, and in the case of *P. mentalis* several dry leaves are hung loosely on the outside, which serve as a very effectual disguise. In both instances the nest is usually suspended near the end of a long, slender branch, inaccessible to most reptiles.

Two Hummingbirds of the genus *Phaethornis* suspend their nest from the under side of a drooping palm leaf near the tip of one of the terminal pinnules. These are somewhat concave, so that the nest is attached by about one-half its circumference along one side, the other side remaining free. In such a position even the nimblest lizard would find it very difficult to reach; yet a further precaution is taken by attaching to the bottom of the delicate structure, by means of spider webs, shreds of coarse bark, dry leaves, bits of rotten wood, etc., so that the whole nest is sometimes more than half a foot long, and closely resembles a bit of loose rubbish caught on the end of the leaf.

It is in nests of the fourth class that we find the most striking examples of protective adaptation, and these for the most part in the great family of *Tyrannidae.*

The nest of the splendid Royal Flycatcher, *Onychorhynchus,* is no less remarkable than the bird. It is a fusiform structure, sometimes two feet in length, suspended by the top from a long drooping branch or trailing liana, usually over a stream, from four to fifteen feet from the water. The greatest diameter is a little below the middle, and at this point the cavity is situated, which is entered by a small hole. The nest is composed of coarse fibrous material and covered over the outside with dry leaves, leaf stems, and large twigs, some of the last a foot or more in length. The whole affair in almost every detail so closely resembles a small mass of debris left by a retreating flood, as to deceive the keenest enemy. Furthermore, the location assists greatly in the disguise, the nest appearing to be but one among thousands of such masses entangled in the vegetation overhanging the stream. Add to this the difficulty any reptile or mammal would experience in reaching it, even were its nature known, and we have a most striking example of protective adaptation.

Todirostrum cinereum and some other *Tyrannidae* make nests of precisely the same style as that of *Onychorhynchus*. That of *T. cinereum* is much less frequently built over a stream and is composed of finer material, often with so much cottony substance interwoven as to give it the appearance of a colony of "tent-caterpillars."

The nests of two other small Flycatchers, *Todirostrum schistaceiceps* and *Oncostoma cinereigulare*, are also suspended by the top from small branches and entered by a hole at the side, but are somewhat pear-shaped. They are built but two or three feet from the ground, and if they are as inconspicuous to the reptilian as to the human observer, they are comparatively safe.

Rhynchocyclus is a genus of small Flycatchers of obscure coloring and ordinary habits, noteworthy only for their curious nests, which are, perhaps, among the most remarkable examples of protective adaptation known. The nest of *R. cinereiceps* is built from ten to thirty feet above the ground, or water, as it frequently overhangs a stream. In shape it resembles an old shoe, or rather moccasin, suspended by the top with the entrance at the toe, and a narrow passage leading over the instep to the heel, where the main cavity is situated. It is composed of some kind of aerial roots—long, fine, black fibres resembling horse hair. It usually hangs from a long slender branch of one of those myrmecophilous Acacias, whose stout double spines are hollow and inhabited by ants. The thorns are very numerous and the ants are extremely irritable and armed with formidable stings, equal in effectiveness to that of the bumble bee. The thorns alone would make the ascent of the tree by an animal of any size very difficult, but the presence of the ants renders it absolutely impossible. But this is not all. A species of hornet frequently makes its nest, a large conical or oval structure, in the same tree, and the nest of the bird and that of the insects may often be found within three or four feet of each other. The protection, however, is not always so complete. A curious variation of the situation occurs when a tree with leaves closely resembling those of the Acacia is selected, and the nest is placed beside that of a species of ant, which at first sight would probably be mistaken for a hornet's nest, so similar are the two in appearance.

The nest of the Beardless Flycatcher, *Camptostoma imberbe*, is built in a small species of palmetto, in the upper angle formed by the juncture of a leaf-stem with the trunk. The trunk is very shaggy with the frayed margins of the fibrous sheathes, and the nest can be reached without difficulty by any climbing animal. The danger from such enemies, however, is greatly reduced by the structure and material of the nest. Except for the soft cottony lining it is composed entirely of fibres obtained from the trunk of the palm, which are deftly interwoven with those fringing the sheathes, so that one might easily mistake the whole structure for a mere tangled tuft of loosened fibres. The small hole at the side by which the cavity is entered is turned directly away from the trunk and would not be likely to attract the notice of any reptile climbing it.

Many other instances might be cited of similar adaptations in nests of this class, as in the case of the Wood Wrens, *Pheugopedius*, the Passerine genus *Arremon*, the Cotingine genus *Pachyramphus*, a small Rail, *Creciscus ruber*, etc., but further illustrations are unnecessary.

Most of the protective adaptations thus far considered are characteristic of species inhabiting forests or dense thickets, where the principal enemies to be guarded against are reptiles or small mammals. In the more open sections of British Honduras, known as pine ridges—flat, grassy tracts with a scant sprinkling of low pines—the case is quite different. Here the chief enemies are Jays, especially *Psilorhinus*, Hawks, and probably Vultures. Several of the common species inhabiting these localities have adopted a means of protection eminently suited to their circumstances. In studying the nesting habits of the bird fauna of the pine ridges, one of the first phenomena noticed is the tendency of several species to nest in close proximity to each other. The colonies thus established are composed of widely separated forms, mostly Tanagers and Flycatchers, which may be found nesting peacefully within a few yards of each other. If a number of the colonies are examined it will invariably be found that the nests of the other species are grouped about that of the splendid Derby Flycatcher, *Pitangus*. This bird is one of the most powerful and warlike, as it is one of the handsomest of the great Tyrannine group. It is never known, however, to molest weaker species, permitting them to make their nests undisturbed within a few yards of its own. Doubtless the courage and "magnanimity" of this species have caused it to become the unconscious protector of its weaker neighbors. The most common of these are the two Tanagers, *Tanagra abbas* and *T. cana*, and the Flycatchers, *Myiozetetes similis*, *Legatus albicollis*, *Elaenia martinica subpagana*, and even the large but weak and sluggish *Megarynchus*. It is worthy of note that those forms that gather about *Pitangus* to nest are such as would be most likely to become the victims of Hawks, Jays, etc., both on account of their weakness and the exposure and conspicuousness of their nests. Many of the common pine ridge forms, for example, *Tyrannus melancholicus* and species of *Myrarchus*, do not regularly associate themselves with these little communities, for the obvious reason that a strong and pugnacious species like *T. melancholicus* is amply able to defend its own, while those that nest in cavities of trees, like *Myiarchus*, are beyond the reach of most of the common enemies. Whenever the location of one of these colonies permits of such a choice, *Myiozetetes* and *Legatus* invariably and even *Pitangus* occasionally build their nests in one of the small Acacias with hollow thorns inhabited by stinging ants; it is, therefore, not unusual to see the nests of two or three species of Flycatchers in a single small tree.

A few words may be added here regarding the relation of ants to the nesting habits of British Honduras birds. In several instances referred to their presence is employed by the birds as a means of defence from larger enemies, but they are by no means always beneficial. The writer once found a nest of *Myiarchus mexicanus* containing a newly hatched bird just breathing its last and covered with small red stinging ants that had evidently attacked it as their prey. Such cases are doubtless common. The fierce Driver Ants, of the genus *Eciton*, which move in vast hosts through the forests, destroying every living creature that remains in their path, can not fail at times to come upon nests that are placed on or near the ground. These ants do not usually ascend far into the trees nor go out to the ends of long branches; it may be partly for this reason that some of the Manikins and other small birds nesting near the ground place their nests on long, slender twigs.

To some of the foregoing examples as illustrative of protective adaptation, it may be objected that individual cases occur where the very element is wanting which renders the peculiar structure or location of the nest protective. For instance, the nest of *Onychorhynchus* does not always overhang a stream, and may even be placed far above the level of the highest flood; the nest of *Rhynchocyclus* is not always in a thorny Acacia; *Myiozetetes* and *Tanagra cana* sometimes build their nests far from that of Pitangus, etc. It can only be answered that in analagous cases of adaptation throughout nature we will find the same sort of exceptions; and that the positive evidence is so largely in preponderance of the negative as to be obvious to any ordinary observer.

Anyone who has given the slightest attention to the breeding habits of birds is familiar with the fact that there is a wide range of individual variation within the limits of almost any species; and it is no less true that in cases where highly specialized nonstructural adaptations of any kind occur, the range of individual variation is likely to be still wider. We can not, in any of the foregoing cases, regard the protective adaptations as dependent on perfectly rigid and definite laws of action, as in the case for instance with the migration of birds. Natural selection is still, doubtless, pre-eminently operative in compelling conformity to a set of peculiar conditions, whose very complicity implies immense variations in the effort, conscious or unconscious, to meet them. Whether these variations are dependent on slight structual differences, age, mere accident, or some other circumstance or combination of circumstances, is a matter very difficult to determine.

REVIVAL OF AN OLD METHOD OF BRAIN DISSECTION.

BY H. J. H. HOEVE.

Preparation of the Brain.

All authors seem to agree that the brain must be hardened by some method in order to be fit for dissection, as far as its fibers are concerned. Some have boiled the brain in oil (Spurzheim, 1834), and others have used chromic acid solution for the same purpose (Hyrtl, 1857). Some years ago zinc chloride was in general use for that purpose and of late nearly every one uses formaldehyde, 40 per cent diluted. I have employed formaldehyde in a 2 per cent solution, changed every day until the fifth day, when I put the brain in a 5 per cent solution, to which has been added a small quantity of pure glycerin, in which the specimen will keep indefinitely. I find that the formaldehyde bleaches the white matter and makes a better contrast between gray and white, and that the glycerin, if it is pure, prevents the brains from becoming brittle and it also seems to give the fibers a greater elasticity. The longer such brains are kept in this solution the better they are for dissection.

Description of Methods of Dissection.

About the year 1790 Reil dissected the brain by teasing its fibers and examining them microscopically. His method was improved and partly modified by J. F. Spurzheim, 1834, who scraped the fibers with the handle of the scalpel, at the same time following them to their origin or distribution as far as possible. With this method he seems to have made a great many discoveries, which were later accredited to other men. Hyrtl speaks of sectioning the brain in order to get a good conception of its intricate arrangement, and of late that seems to be the method followed everywhere, as far as I know. All text-books published in the four main languages advise sectioning and the latest books go even so far as to indicate the exact places where the sections should be made and these sections are named correspondingly. (See Barker.)

There are different instruments on the market which can take the place of the brain knife with the double edged blade, which look somewhat like the bread-cutting apparatus seen in restaurants, and which enable one to make very accurate slices of a certain thickness. This certainly is a great advantage, but not even with the best mechanical aids can this method of slicing be compared to a combination of the old (scraping) and the new methods (slicing).

Different Methods of Demonstrating the Brain.

As far as I know the anatomy of the brain is taught in different colleges by demonstrations and lectures over specially prepared specimens. As far as the dissection of the brain is concerned, there are only a few colleges where the student has an opportunity of doing that work himself; in the rest of the institutions the student who gets to dissect a brain during his college years can consider himself very fortunate. It is not the fault of the teachers that the brain is not dissected systematically like the rest of the body, but it is mainly due to the fact that human brains are not very abundant in the dissecting rooms because so many are needed for the preparation of specimens for demonstration. In those colleges where an attempt is made to have the students dissect the brain they are mostly told, after having finished cleaning the pia and vessels away, and having studied the sulci and gyri, that sections must be cut so and so, in order to get such and such a section, which corresponds to such and such a plate in the atlas, and then the identification of dark and light places commences.

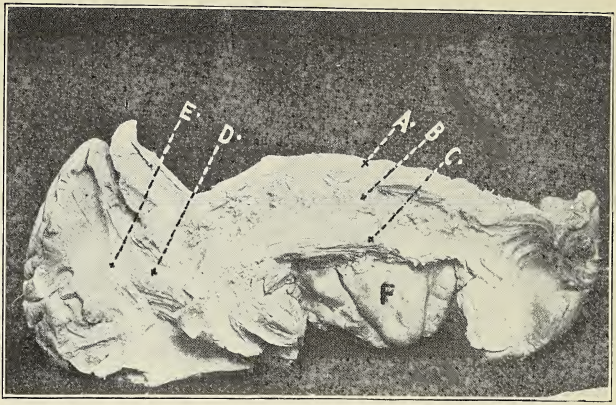
As far as the efficiency of the procedure alone, just imagine for a moment a complicated piece of machinery imbedded in a large vessel of hot parafin of about the same shade, and after the thing is cooled you are asked to study that piece of machinery in different sections, which are made by slicing it. Is it not an enormous task to try to imagine a complete piece of machinery when you can only see a small portion at the time in a slice of it? How much more easily it would be to see or get a conception of the machine by scraping and working away the parafin from its delicate parts a portion at a time?

Combined Method.

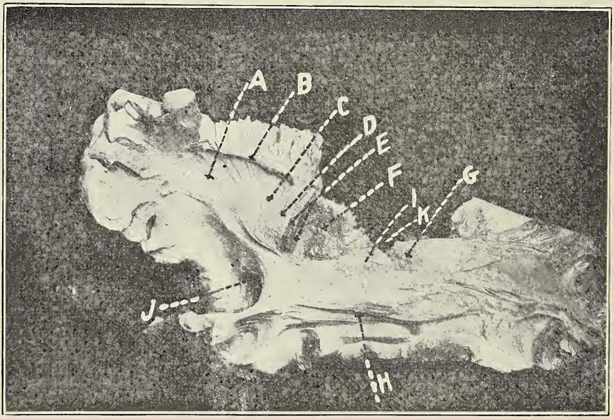
It is just so with the brain and we can much more easily form an idea of its intricate arrangement by scraping its fibers. I prefer to break the brain tissue wherever possible, without destroying anything important, for the rest I follow its longitudinal or transverse fibers, as the case may be, by rolling them off carefully with a small orangewood stick, the point of which is flattened and made smooth. The fibers must be scraped gently parallel to their longitudinal direction and in that manner all the tissue around them is removed. One of the things to be kept in mind is the difference in appearance between gray and white matter. All the ganglia of the base of the brain can be dissected by removing the white matter around them, and we certainly get an entirely different idea from the structures, as they present themselves in their real location, dimensions and relations. It is interesting to watch a student scrape the fibers of the commissura anterior, and to note the interest and fascination he shows to get the entire bundle of fibers and their communications out, without injury to them. It certainly stands to reason that the amount of attention which is required for a dissection of this kind makes a deeper impression upon the mind and also leaves a more vivid visual memory impression than the simple cold study of the brain slices. I do not mean to say that I have discarded the slicing method altogether, because I realize that in some cases slicing may reveal more than teasing, but I maintain that in the greater number of instances scraping reveals the most, even in case of the fasciculus longitudinalis posterior, which is exceedingly hard to follow up.

I always found it hard to demonstrate the capsula interna to the students in such a way that they would all grasp the whole thing, but now as I can show the exact course of the fibers between the nucleus caudatus and the nucleus lentiformis, it becomes an easy task.

I am aware of the fact that not all of the students can accomplish the same in this line of dissecting, for some of them are lacking in mechanical ability,



A. Fasc. occipito frontalis.
B. Capsula interna.
C. Fasc. longitudinalis superior.
D. Fasc. longitudinalis inferior.
E. Fasc. perpendicularis.



A. Fasc. uncinatus.
B. Fasc. longitudinalis superior.
C. Clastrum.
D. Capsula externa.
E. Nucleus lentiformis.
F. Capsula interna.
G. Radiatis occipito—thalamica.
H. Fasc. longitudinalis inferior.
I. Fasc. uncinatus.
J. Hiatus Sylvii.
K. Cornu posterius ventriculi lateralis.

but they are certainly stimulated to the utmost by the success of their neighbors, and in them the visual memory impressions will stay just the same. In closing I would like to state that I am convinced that a great deal more benefit can be derived from the combining of the two methods of dissecting mentioned than from either method alone, but of the two scraping seems to stand first.

STRUCTURES OF THE CEREBRUM MENTIONED IN THE ORDER FOR DISSECTION.

1. Corpora mamillaria.
2. Pars tectae columnae fornicis. (Also pars olfactoria columnae fornicis.)
3. The commissura anterior. (Also pars olfactoria commissurae anterior.)
4. The fasciculus thalamo-maillaris (Vico D'Azyr).
5. The pedunculus corporis mamillaris.
6. The tractus peduncularis transversus.
7. The cingulum.
8. The fasciculus occipito-frontalis.
9. The fasciculus longitudinalis superior.
10. The fasciculus perpendicularis.
11. The fasciculus longitudinalis inferior.
12. The fasciculus uncinatus.
13. The corpus callosum.
14. The ventriculus lateralis (its parts, also optic radiations and their relation to the outer wall of the cornu posterius).
15. The septum pellucidum.
16. The fornix (its part).
17. The tela chorioidea ventriculi tertii.
18. The ventriculus tertius.
19. The thalamus.
20. The claustrum (also capsula externa).
21. The nucleus amygdalae.
22. The capsula interna (its parts).
23. The nucleus lentiformis.
24. The nucleus caudatus.
25. The taenia terminalis (also pars olfactoria taeniae terminalis).
26. The commissura media.
27. The commissura posterior.
28. The corpus pineale and the corpus geniculate laterale et mediale.

I hope to show an entire series of scraped specimens in my dissector of head and neck, which is nearly ready.

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AUTHOR'S INDEX.