SEVENTEENTH REPORT

OF

THE MICHIGAN ACADEMY OF SCIENCE

PREPARED UNDER THE DIRECTION OF THE COUNCIL

BY

RICHARD A. SMITH
EDITOR

BY AUTHORITY

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LETTER OF TRANSMITTAL.

To Hon. Woodbridge N. Ferris, *Governor of the State of Michigan:*

Sir—I have the honor to submit herewith the XVIIth Annual Report of the Michigan Academy of Science for publication, in accordance with Section 14 of Act No. 44 of the Public Acts of the Legislature of 1899.

Respectfully,
RICHARD de ZEEUW,
Secretary.

East Lansing, Michigan, November, 1915.

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Dr. A. G. Ruthven, Ann Arbor.

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The Council consists of the above-named officers and all Resident Past-Presidents.

Twentieth Annual Meeting of the

MICHIGAN ACADEMY OF SCIENCE.

ANN ARBOR, MICHIGAN

March 31 and April 1 and 2, 1915.

GENERAL PROGRAM.

Wednesday, March 31

1:30 p. m. Council meeting, Geological Laboratory, first floor of Museum. Reports of committees.

2:30 p. m. General meeting of the Academy, Museum Lecture Room. Election of members.

3:00 p. m. Presidential Address, by Alexander G. Ruthven, The Zoogeographical Problem of the Guiana Sand Reefs. Including an account of the University of Michigan Expedition to Demerara in 1914, Museum Lecture Room.

7:30 p. m. Social evening, first floor of Museum.

Thursday, April 1

8:30 a. m. Council meeting, Geological Laboratory, first floor of Museum.

9:00 a. m. Meetings of sections.

1:30 p. m. Meetings of sections for the reading of papers and election of vice-presidents.

8:00 p. m. Public lecture, by Professor William Herbert Hobbs, Some Italian Earthquakes, University Hall.

9:00 p. m. Smoker, given by the Research Club in Alumni Memorial Hall.

Friday, April 2

8:30 a. m. Council meeting, Geological Laboratory, first floor of Museum.

9:30 a. m. General business meeting, Museum Lecture Room. Election of officers and members.

10:30 a. m. Meeting of sections which have not completed the reading of papers.

12:00 m. Luncheon for biologists, Botanical Laboratories, South Wing of Main Hall.

2:00 p. m. Demonstration by the Museum of Zoology, University of Michigan, of its collections and methods of work and the exhibition of zoological specimens of general interest, collected by some of the expeditions.

SECTION OF GEOLOGY AND GEOGRAPHY

Walter F. Hunt, Chairman

Russell Seminary Room, Museum Building

Thursday, April 1, 9 A. M. and 1:30 p. m.

Origin of Continental Forms, V. Howard B. Baker.
Iceberg Lake. O. W. Freeman.
Limestone Resources of the Northern part of the Southern Peninsula. R. A. Smith.
The Old Shore Lines of Mackinac Island and their Significance in the Lake History. Frank B. Taylor.
New Evidence for the Glacial Anticyclones of High Latitudes. Dr. William H. Hobbs.
The Geology of the Eastern Gogebic Iron Range. L. P. Barrett.
Correlations of the pre-Keweenawan Formations of Michigan. R. C. Allen.
Stratigraphy of the Niagara Formation in the Northern Peninsula of Michigan. R. A. Smith.
A Manganiferous Albite. Dr. E. H. Kraus and Dr. W. F. Hunt.
Ice Action in the Michigan Lakes. Dr. I. D. Scott.
The Effect of Ice Attraction on Beaches of Lake Maumee and Lake Agassiz. Frank Leverett.
Deflation and Deposition in the Libyan Desert and the Soudan. Dr. William H. Hobbs.
The Composition of Mar-Villa Marble. R. W. Clark and Dr. W. F. Hunt.
Drainage Conditions in the North Eastern United States at the Beginning of the Glacial Epoch. Frank Leverett.

SECTION OF SANITARY AND MEDICAL SCIENCE

Paul H. de Kruif, Chairman

West Lecture Room, Medical Building

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The Result of Quantitative Albumin Determinations from 3000 Cases of Suspected Tuberculosis. Dr. M. L. Holm and E. R. Chambers.
Staining of Soil Protozoa. J. Frank Morgan.
Effect of Concentration of Gelatin on Microörganisms. Miss Zae Northrup.
Purification of Water by Ozone. R. W. Pryer.
Bacterium Abortus and Its Agglutinins in Milk. L. H. Cooledge.
Trypanosomes and Anaphylatoxin. P. H. de Kruif.
The Mechanism of Agar Anaphylatoxin Formation. Dr. F. G. Novy.
Hog Cholera Eradication in Branch County. H. M. Newton.
Dr. V. C. Vaughan.
Complement Fixation and Agglutination in Contagious Abortion. E. T. Hallman.

Pathogenicity of the Avian Tubercle Bacillus. L. A. Mosher.
Attempts at the Discovery of Non-Pathogenic Ultrasomes. W. Starrin.
Action of Butter Flora on Milk. C. W. Brown.

SECTION OF ECONOMICS

F. T. Carlton, Chairman

Second Floor, Economics Building

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The Increasing Value of Land and the Rate Problem. David Friday.
Discussion.
The Equity of Profits. Rufus F. Sprague.
Discussion opened by F. M. Taylor.
Nationality in the Social Process. Charles H. Cooley.
Discussion.
The Industrial Transition in China. Henry C. Adams.
Discussion.
An interpretation of the working Rules of the Carpenters' Union. Edward M. Arnos.
Discussion opened by Frank T. Carlton.
The New Trust Legislation. I. Leo. Sharfman.
Discussion opened by James E. Mitchell.

SECTION OF BOTANY

E. A. Bessey, Chairman

Museum Lecture Room

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Cucumber Scab. S. P. Doolittle.
Septoria lycopersici. (With Lantern.) Ezra Levin.
An undescribed Bark Canker of Apple and the Associated Organism. (With Lantern.) G. H. Coons.
The Michigan Plant Disease Survey. G. H. Coons.
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Does the Movement of Air Affect the Growth of Plants. Alma Hollinger.
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The Prairies of Kalamazoo County. LeRoy H. Harvey.
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Contribution to the Botany of Michigan No. 12, Michigan Novelties. O. E. Farwell.
The Holdfasts of Marine Algae. H. Hus.
Capsella Hybrids. H. Hus.
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The Effect of Fungicides on an Apple Rot Due to Longyear's Alternaria. R. W. Gross and S. P. Doolittle.
Sterilization of Pop Corn. Reed O. Brigham.

SECTION OF ZOOLOGY

B. G. Smith, Chairman

Room 207, South Wing, University Hall

Thursday, April 1, 9:00 a. m. and 1:30 p. m.

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An Ecological Survey of the Fishes of the Douglas Lake Region, with particular reference to their Mortality. Roy J. Colbert.
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Peculiar Nesting Behaviour of a Robin. Bertram G. Smith.
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GEOLOGY AND GEOGRAPHY.

ICEBERG LAKE.

BY O. W. FREEMAN.

Iceberg Lake is located in Glacier National Park, Montana, about six miles from Many Glacier Camp on Lake McDermott, and is one of the most interesting points to visit in the Park. The chalet camp at Lake McDermott is about fifty miles from Glacier Park station and is reached by automobile and stage from there, the good roads and excellent views of lakes and mountains making the journey a pleasant one. Iceberg Lake itself may be reached from Lake McDermott over an interesting mountain trail with close views of many small cascades and waterfalls. On the way, a typical glacial eroded U-shaped valley is traversed, showing that thousands of years ago a mighty glacier, of which that at Iceberg Lake is a small remnant, had occupied the whole valley. This joined others from Swiftcurrent, Grinnell and other places forming the Saint Mary Glacier which extended north to Canada where it met the Keewatin continental ice sheet. Iceberg Lake is an unique occurence in this country and hence there is added interest to what would naturally be well worth visiting.

The lake lies in a characteristic glacial cirque, occupying a basin apparently chiefly formed by glacial gouging. It lies on the north side of Wilbur Mountain and just east of the Continental Divide, at an altitude of 6100 feet. On three sides cliffs tower to a height of over three thousand feet above the level of the lake (Pl. I) and it naturally forms one of the most impressive and beautiful scenes in the Park. Due to its location in such a deep pocket on the north side of Wilbur Mountain, the sun melts only a small part of the accumulated snow and ice. To the heavy snow fall is added that blown in by the winds, and by alternate thawing and freezing combined with the pressure of the snow above, the snow is gradually consolidated to ice forming a small glacier. This remnant of a once vastly greater one is at the head of the cirque and descends into the west side of Iceberg Lake. The glacier is easy of approach along the north side of the lake by crossing a talus slope and small moraine. Its surface is dirty with debris; many rocks can be seen that have fallen from the cliffs above and which are entirely unworn by erosion. Besides many crevasses near the front of the glacier, there is a typical gaping crevasse (bergschrund) next to the walls of the cirque, which widens with the advancing summer as the glacier melts and pulls away from the cliffs and snowfields above. The bergschrund is shown in plates I and IIB.

When viewed from across the lake the glacier exhibits a banded structure, and these bands look as though they had been folded like rock strata. These dark bands are due to greater accumulation of rock debris in the glacial ice; this was probably caused chiefly by greater melting in the summer, thus concentrating the rocky material and making a dark band that contrasts with the bluish ice formed by pressure in the winter when the amount of melting is small. If the layers were formed in this way, they might be compared with the annual rings of growth of trees. Another possibility is that much of the material in these belts was picked up by the glacier from its bed and chiefly accumulated in more or less horizontal openings or shear zones. The folding of these bands probably is chiefly the result of shearing, that is the slipping of some of the ice past adjacent portions, as a result of the pressure above combined with the forward movement of the glacier and the resistance to this motion offered by its bed. The rate of movement of the glacier was not measured but it must be quite small.

The glacier rises abruptly from Iceberg Lake to a height of thirty or forty feet; large fields of floe ice are usually frozen to its front. From time to time large blocks of glacial ice break off, forming true bergs, which frequently nearly cover the surface of the lake. (Plate IIB). Near the outlet of Iceberg Lake is a series of falls, but the water is so shallow that none of the larger pieces of ice can float out. The result is that they can disappear only by melting, which is such a slow process due to the lake's location that even in August bergs are very abundant on the lake; most of these bergs are flat topped cakes, but they often also assume various fantastic shapes. Due to the current of water flowing toward the outlet and winds in the opposite directions the bergs frequently move back and forth and often grind against each other in a manner suggestive of the polar zones.

The photographs accompanying this article were taken early in July and open water had been visible only a short time, the lake of course being frozen over solid most of the year. The water, where not ice covered, is deep blue in color; and since it is all derived from melting snow and ice is close to the freezing temperature. The lake is not large, covering probably less than a square mile of surface, much of that being ice covered; it is about one hundred and fifty feet deep in the middle. Rock debris is so constantly falling into the lake from the cliffs and melting glacier that the lake in places is being filled quite rapidly. Small lateral moraines, thirty or forty feet high, are at present being deposited at the sides of the glacier; the terminal deposits are below the level of the lake, considerable debris being carried far out into lake on the ice cakes before they melt.

On the east shore of Iceberg Lake opposite the glacier, there is a very fine example of a "wall" or ice rampart built by ice action. The beach, as shown by Plate IIA is here composed of rocks of all shapes and sizes; it is several feet in height and in many places over thirty in width. This ice rampart was chiefly formed by the stones composing it being frozen in the ice and slowly pushed up on the shore by its movement. Great changes of temperature would be one cause of this movement by causing the ice to first contract by cooling, often opening cracks into which water would penetrate and freeze thus again covering the lake's surface with a solid sheet of ice; then when the temperature increased the ice would expand and push any rocks frozen to it a little way toward and then upon the beach. The stones thus slowly accumulating would form the ice rampart or "wall." The motion of the glacier may also have been imparted to the ice floes and have caused much of this ice push.

Prof. M. J. Elrod, later in the summer of 1914, found two species of living organisms in the cold water of Iceberg Lake, a mayfly larva and a red entomastracon. As the temperature of the water is thirty-six degrees Fahrenheit it is remarkable to find any animals living under such conditions.

The walls of the cirque about Iceberg Lake appear to be unscalable, yet mountain goats are usually to be seen walking unconcernedly along the narrow ledges in search of the scanty grass which rapidly springs up as the snow melts away. In spite of the remoteness of this region and the long winters and short summers, the prospector searched here for minerals years ago and the visitor can see two of his abandoned prospect tunnels on opposite sides of the lake. All these things add to the interest of a trip to Iceberg Lake, but naturally after all the chief interest is in seeing icebergs and floes floating in a lake in midsummer, and remembering that this is the only occurence of the kind in the United States.

SANITARY AND MEDICAL SCIENCE.

THE STAINING OF SOIL PROTOZOA.

BY J. FRANKLIN MORGAN.

In the literature, several stains are mentioned for the staining of soil protozoa.

Goodey[1] for an intra vitam stain of these organisms, has found neutral red (1-100,000) very useful for showing up the food vacuoles, and methylene green very serviceable for quickly bringing out the nuclei.

Martin[2], mentions the use of iron haemotoxylen for the staining of the nucleus and blepharoplast. Later, in another article[3], he uses a strongly acid hämalun followed by eosin.

The writer has had no experience with any of the above, but would like to add another method for the staining of soil protozoa. This is used as a differential staining for other protozoa such as trypanosomes and parasites of the blood.

This stain is a modified form of the Romanowski—one that is used in the bacteriological laboratories of the University of Michigan. It consists of three stains: Polychrome methylene blue, methylene blue and eosin.

PREPARATION OF STAIN.

A. Polychrome methylene blue.

Methylene blue	1	gm.
Sodium carbonate (anhydrous)	0.25	gm.
Glycerine	50	cc.
Distilled water	50	cc.

This mixture is heated for one hour between 88-90° C with constant stirring. Five cubic centimeters of water is added every 10 minutes to make up the loss due to evaporation. Before the heating and again after the heating when cool, the beaker with its contents is weighed. The deficiency is made up with distilled water. When complete, this stain ought to be of a purplish or azure color.

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1. Goodey, T., "Contribution to Our Knowledge of Protozoa of the Soil," Proc. Roy. Soc. of London, 1911, 84 B, p. 165.
2. Martin, "Protozoa from Sick Soils," Proc. Roy. Soc. of London, 1912, 85B. p. 393.
3. Martin, "The Presence of Protozoa in Soils," Nature, 1913, Vol. 91, No. 2266, p. 111.

B. Methylene blue.	
Methylene blue	1 gm.
Distilled water	50 cc.
Glycerine	50 cc.
C. Eosin.	
Eosin water-soluble	1 gm.
Distilled water	100 cc.

All of the above should be kept in tightly stoppered bottles and away from strong light.

The amount of each one necessary has to be tried out in order to determine what proportion will give the stain desired. It will depend somewhat upon the depth of the color in the polychrome.

Distilled water	15 cc. or	15 cc. or	15 cc.
A	9 drops	10 drops	9 drops
B	7 "	8 "	6 "
C	2 "	3 "	1 "

A metallic sheen should appear on top of the mixture.

Too much eosin will make the organism too pinkish.

Method of staining: A thin smear is made on either the slide or cover slip. This is air-dried and fixed in alcohol and ether (equal parts) for 5 minutes. The fixing solution is rinsed off with tap-water. The preparation is put into the staining mixture either in a watch glass or in a staining dish (large enough for one slide) with the smeared side down and the end of the slide resting on the edge of the dish, or with the cover slip floating on the stain.

After the slide or cover slip has been in the stain for 15 or 20 minutes, it is washed and examined. If it is not stained heavy enough, the preparation is restained, but a fresh solution is used. The old one cannot be used the second time, the necessary staining ingredients have been used up in the first operation. Sometimes a third staining has to be made. Each time a new solution must be used. The depth of color is not improved by being kept in the stain over 25 minutes.

The protoplasm of the soil protozoa stains a blue, the nucleus red, and the food vacuole with its food particle a deep blue. Many of the other vacuoles appear clear; that is, do not show any color.

According to Giemsa[1], the red stain of the nucleus is due both to the methylene azure of the polychrome and to the eosin, while Michaelis[2] and McNeal[3] claim that it is due to the azure alone,

1. G. Giemsa, Farben Methoden für Malaria Parasiten, Cent. f. Bakt. 1902, I Abt. 32, p. 307.
2. L. Michaelis, Das Methylene Blau und Seine Zersetzung Product. Cent. f. Bakt, 1901, I Abt., 29, p. 763.
3. W. McNeal, Methylene Violet and Methylene Azure, Journ. of Infect. Dis., 1906, 3, p. 432.

although the eosin may play an important part.

This stain, after it is made up and its proportions determined, is easy to handle, rapid and excellent in its differentiation.

Michigan Agricultural Experiment Station, East Lansing, Mich.

ECONOMICS.

THE EQUITY OF PROFIT.

BY RUFUS FARRINGTON SPRAGUE.

That the world about us is bountifully provided with objective things whose properties and qualities are such as to fit them, or to enable them to be fitted, for man's employment as a means of ministering to his ever-recurring needs, may safely be taken for granted. This admitted, it becomes apparent that the difficulties and hindrances of various sorts, encountered by man in his struggle for existence, arise, not from the non-existence of things needful, but simply and solely from their lack of availability for his employment.

Such objective things as are endowed with capacity for man's employment, as a means of ministering to these needs, are said to have utility. While it is customary to ascribe utility unhesitatingly to certain objective things, as though the quality of usefulness was inherent in them, it is evident we mean no more than this, that the things in question are endowed with *potential capacity for usefulness to man.* Be this potential capacity for usefulness what it may, the actual development of such usefulness is contingent upon, and quantitatively limited by, the gravity of the need to which its employment ministers—the quantitative importance of the impairment of well-being its use averts. The true measure of an objective thing's utility, then, is contingent as much upon the gravity of a human need to which it can minister as it is upon the properties and qualities that fit it for such ministration.

Unfortunately, however, few, if any, of the objective things rightfully entitled to consideration as factors in economic activity are freely, and to the limit of the demand for them, available for our employment as a means of ministering to our felt or anticipated needs. As a consequence they must first be produced; that is to say, they must be brought *out*, or *forward.* This can be accomplished only by an intelligent application of productive energy, or labor,—mental or physical, one or both, it matters not, so long as it is adequate to the task of surmounting the obstacles and hindrances of various sorts that lie in the way of and obstruct the free acquisition and use of things needful, but not freely available. This labor cost is not only an inevitable attendant upon the task of surmounting the hindrances that lie in the way of the ready availability of things needful, but it affords the only intelligible data for an intelligent comparison between the quantitative gravities of widely different and apparently unrelated hindrances, upon which, in the very nature of the case, the equitable division of labor, by and through an exchange of its products, on a competitive basis, is automatically secured. The impelling power of the incentive to labor, or to make sacrifices, involving labor, to the end that the availability of objective things may be secured for our employment, is determined by an intelligent consideration of the gravity of an anticipated need to which it can minister. Hence it is that over and against the anticipated impairment that threatens to develop as a consequence of our failure to provide a means of ministering to an impending need must be set the anticipated impairment of well-being that, as labor cost, is an inevitable attendant upon the task of rendering such means available for our employment.

Balancing these two separate, distinct, and (quantitatively considered) independently variable forms of impaired well-being, the one against the other, to the end that their quantitative importance as factors in our subsequent well-being may be satisfactorily determined, we shall find this: Unless the anticipated impairment incident to the deprivation of the product under consideration materially exceeds the anticipated penalty of cost necessarily attendant upon the labor of surmounting the hindrances that lie in the way of its availability for use, no advantage, or *gain*, can result from its production; and in the absence of anticipated gain there can be no rational incentive to labor, or, for that matter, to economic activity of any sort.

It should not be difficult to differentiate sharply between these two separate, distinct, and usually alternative forms of impaired well-being, one of which must certainly afflict us. That they are of equal importance, in direct proportion to their respective gravities, as factors in our subsequent well-being, may well be taken for granted. But that there is no necessary quantitative relation between their respective gravities becomes apparent when we reflect that they are based upon separate and unrelated data. The *first*, based upon the anticipated gravity of an impending need, affords us our only reliable data for an intelligent determination of the quantitative utility of an objective thing endowed with capacity to minister to it; while the *second*, that, as cost, is no less wholly-contingent upon the anticipated gravity of the hindrance to be surmounted, in order to secure the availability of such needful product, affords us equally reliable data for an intelligent determination of the utility of a service, that, by supplying the product in question, relieves us of the specific impairment of well-being that, as *labor-cost*, must attend the task incident to its production.

Out of the marked variations in the relative capacities of each individual to surmount the obstacles and hindrances of various sorts that lie in the way of and obstruct his free acquisition and use of needful, but not freely available products, co-ordinating with the no less marked variations and differences in the relative capacities of his associates to surmount the same, like, or equivalent hindrances, has come the *division of labor*. The sole incentive to an equitable division of labor is found in profit, which, in its last analysis, is the saving in cost that by right accrues to each party to an equitable exchange as a result of his relatively higher capacity—and correspondingly lower cost—in the production of the thing parted with, when compared with his relatively lower capacity—and correspondingly higher cost—in the production of the product acquired through the exchange.

Through what Jevons has aptly termed the "Mechanism of an Exchange," the division of labor is most equitably, conveniently and advantageously effected by and through an exchange of labor's products, the one for the other, on the only fair and equitable basis, viz., that of substantially exact equivalence in the gravities of the two hindrances it has been, or will be, necessary for labor to surmount in order to render the two products thus exchanged available for that purpose.

From the mutual benefits and advantages that, as *profit*, by right accrue to each party to an intelligent division of labor, by and through an equitable exchange of labor's products, has come the fact of *trade*. While from the fact of *trade* has developed the urgent need of a familiar and theoretically constant unit, or standard of surmountable hindrance, in terms of which the relative gravities of all known hindrances to human endeavor may be intelligibly expressed; thus affording data, in the convenient form of a common unit, for an intelligent determination of the relative gravities of widely different and apparently unrelated hindrances, upon equivalence in which, in the very nature of the case, the *equitable division of labor*, through an exchange of its products, necessarily depends. Hence *money*.

If, now, in any given exchange, the two hindrances it has been necessary for labor to surmount in order to render the products involved in the exchange available for that purpose are in fact, as they certainly are in theory, equivalents in gravity, then must it follow that the labor necessary to the task of producing one of them will be the quantitative equivalent, in *productiveness,* of that necessarily attendant upon the task of producing the other.

This being true,—and under normal conditions, involving free competition, any marked departure from this rule would be suggestive of inequity,—it must follow that each party to an equitable exchange does for the other as much as the other does for him. That is to say, each party to the exchange renders the other a service that, measured by the gravity of the obstacles encountered, the hindrances surmounted, is the quantitative equivalent in helpfulness of the service the other renders him. Then, too, must the service each renders the other prove fair and equitable *compensation* for the other's service in his behalf.

Under such conditions, and under no other, can we have an equitable division of labor by and through an exchange of Labor's products. Then, and only then, does each party to an equitable exchange get value received for his labor, in producing and supplying the other with the product parted with. In the usefulness of a service, whose sole function it is to relieve another of the specific cost impairment that otherwise must have attended his acquisition of a needful but not freely available product, do we find that form of utility known as value, which, it has been erroneously assumed, cannot be dissociated from the utility of the product itself, considered purely as a means of ministering to some specific need. That the utility of a service that supplies a needful product cannot exceed the utility of the product supplied is as apparent as the fact that a "stream cannot rise above its fountain."

For convenience in considering the economic phenomena involved in an equitable division of labor, by and through the only fair and equitable, if not the only practicable, method, namely, that of competitive equivalence in the gravities of the two hindrances it has been or will be necessary for labor to surmount in order to render the two products necessarily involved in every complete exchange, available for that purpose, let us introduce one X, who will stand for or be named to represent one who, as a consequence of both like experience and like aptitude in the two lines of endeavor represented by any two products whose equitable exchange is under consideration, is endowed with equal capacity to produce both; that is to say, one whose capacity to surmount one of any two *competitively equivalent* hindrances is on such perfect parity with his capacity to surmount the other that the labor cost attendant upon the production of one of the products involved is identical in gravity with that attendant upon his production of the other.

When we reflect that the ranks of labor in every important line of industry are being constantly replenished or depleted, as the case may be, by accessions from or desertions to other, and not infrequently quite dissimilar lines, the introduction of one who, like X, is endowed with equal capacity to produce any two products whose equitable exchange is under consideration, will not strike one as abnormal, or for that matter, unusual even. Nor will it be a matter of any consequence whether X's dual capacities are high or low. So long as they are the same for both, and the labor cost attendant upon surmounting one is the equivalent in gravity of that attendant upon surmounting the other, they must be accounted equivalents in gravity, each of the other; and regardless of their relative utilities, equitably exchangeable, the one for the other, on that basis.

Equally apparent should it be that two hindrances, however different in character, are, to all intents and purposes, equivalents in gravity, whenever and wherever the products secured only by surmounting them are freely exchangeable, the one for the other, or are freely bought and sold in the open market for the same money, or hindrance unit.

This admitted, "It must follow as the night the day," that under normal conditions involving equal opportunity in the production and distribution of Labor's products in the open market, the *relative utilities* of such products afford no data whatever for an intelligent determination of the equitable exchange relations between them.

But for marked variations in the relative capacities of individuals and groups of individuals—whether natural or acquired, it matters not,—there could be no rational incentive to the abandonment of the *direct* and seemingly most advantageous method of acquiring them, namely, by a direct application of productive energy—labor—for the indirect and roundabout method of exchange.

Thus, in its last analysis, the incentive to resort to an equitable division of labor, by and through an exchange of labor's products, is found only in the saving of labor cost that by right accrues to one who, taking advantage of his opportunities, as one rightfully may, exchanges in the open market the products of his toil in the industry in which his labors are most effective, for the products that, owing to his relatively inferior capacity, it would have cost him more to acquire by the direct method of producing them.

Let us bear in mind the fact that we are here considering, not the simple matter of distributing a limited store of things needful, that, manna-like, has fallen from Heaven over night for the benefit of a chosen people, but, quite to the contrary, an equitable division of labor's products, that through toil, fatigue and self-denial, have been brought out, or forward, and thus rendered available for man's employment, as a means of ministering to his needs. Furthermore, we are here considering an equitable division of labor by and through an exchange of its products, on a basis from which every consideration of the relative utilities of the products involved is eliminated, as not only without legitimate bearing upon the equities of the case, but as tending to promote inequity, through the introduction of irrelevant data, that, if heeded, must make, not for equity, but for inequity.

Thus equitable profit arises, *not* from the exchange of a product having less utility for one having greater utility, but simply and solely from the *saving in cost* that by right accrues to each party to an exchange of this character, as a consequence of his relatively superior capacity to surmount one of the two hindrances that, howsoever different in character, have, through free and open competition, demonstrated their right to be regarded as competitive equivalents in gravity.

This being true, it becomes apparent that there is no necessary quantitative relation between the profit—or saving in cost—that by right accrues to one, when compared with that which by equal right accrues to the other. Though one may by right freely sacrifice a portion of the profit that, on the prevailing basis of competitive equivalence, rightfully belongs to him, there is no equitable reason for his doing so, even though his capacity to produce or reproduce the product parted with is so abnormally high as to afford him a profit a hundred-fold greater than that falling to the party with whom he exchanges. Nor will the party whose profit is relatively low be justified in demanding a concession of this sort, which, as we shall see, may be partially or wholly due to marked variations from the normal in his own capacity to produce one or both of the two products necessarily involved in the exchange under consideration.

By way of illustration, let us consider an equitable division of labor between S, the shoemaker, and T, the tailor, by and through an exchange of the products of their labors, on what we have clearly shown to be an equitable basis. As the son of a tailor, S had early in life become familiar with the implements and methods of his father's trade; so familiar, in fact, that, being of a frugal turn, it had for years been his practice to fashion and with his own hand make up the garments for his everyday wear. T, the tailor, on his part, had in his boyhood served a short apprenticeship on the shoemaker's bench before taking up his life's work as a tailor. He, too, had made it a practice to take advantage of his spare moments to make up and thus provide himself and sometimes other members of his family with their necessary footwear. As a consequence, he was somewhat more proficient at shoemaking than was S at tailoring. By chance these parties, who had been boyhood friends, met one evening on a down-town street. After the usual friendly greetings, S, calling attention to a package he was carrying under his arm, remarked:

"You will be surprised to learn what I have in this bundle;" and without waiting for a reply, continued: "It is the cloth and trimmings for a pair of every-day trousers, which I shall make up for my own wear after my day's work in the shop has ended."

Then, somewhat apologetically, he continued: "You see I have a pretty good job at the shoe factory with Smith, at three dollars per day, and as this is the busy season I don't like to ask him for a day off.

While S was talking, a broad smile had gathered on his listener's face, and as he finished, T directed attention to the package he was carrying, and remarked:

"We both seem to be in the same boat. I have here the leather and findings for a pair of shoes that I intend to finish up after hours for my own wear. I, too, have a good job that I cannot afford to lose, and what is more, I should gain nothing by taking a day off to make them, as I am far more proficient as a tailor than as a shoemaker. My only gain from engaging in that task comes from the fact that I can make them up after hours." Continuing, he said: "While I had no opportunity to familiarize myself with the shoemaker's craft in my early childhood, as did you in your father's shop, I did serve a short apprenticeship at that trade before taking up my lifework as a tailor."

Then, after a moment's reflection, he continued:

"It strikes me, here is an excellent opportunity for mutual advantage, or profit, for both of us. While as a result of my short apprenticeship I can do a fairly good job at shoemaking, I am free to admit that my lack of practice, if nothing else, makes me a comparatively slow workman, and as a consequence of this handicap it costs me more, both in time and fatigue, than it would if I were as proficient in producing the products of your trade as I am in producing the products of my own. I presume this must be in line with your experience, is it not?"

S nodded his assent, and after some further discussion they repaired to the office of a mutual friend nearby, where each took the measurements necessary for the work he had undertaken; and after agreeing to meet one week later for the delivery of their work and a fair and, so far as possible, accurate report of the saving in cost or profit, if any, effected by this round-about method involving an exchange of work or services, each departed for his home.

Promptly at the appointed time they met, each with the completed work in hand. Unwrapping his package, S presented T with a pair of shoes showing workmanship of a high order. In the meantime T had opened his package and was prepared to deliver a pair of trousers equally well made and finished.

Then came their reports. As each had furnished the material for the products secured, their reports covered only the saving in cost, that by right would accrue to each as a consequence of his relatively superior capacity in the production of the product parted with, when compared with his capacity to produce the product acquired through the exchange of services.

A surprise was in store for both. For while S, much to his satisfaction, had produced the shoes that compensated T for his services in producing his trousers in two-thirds of the time, and consequently at substantially two-thirds of the cost, that would have attended his labors had he undertaken the task of producing the trousers, thus affording him a net profit of 50%, he found also that he had secured a much better fitting and workmanlike product than he could have turned out.

T's experience, though affording him less profit than had fallen to S, seemed equally satisfactory. Not only had he, too, secured a better fitting and more workmanlike product, but he had produced the trousers that compensated S for his labors in his behalf, in three-fourths of the time it would have taken him to produce the shoes secured through the exchange, thus affording him a net profit of 33⅓%.

No sooner had S learned that T's profit was but 33⅓%, whereas his had been 50%, than he generously offered to make up the difference, so that they might share alike in the profits.

T refused to consider this offer, saying:

"Your excessive profit is undoubtedly due either to your extremely high capacity to produce shoes or to your extremely low capacity to produce trousers. In either case your profit is legitimate."

For T could clearly see that this profit represented only the saving in cost that would rightfully accrue to any one who exchanges an article for which his productive capacity is high and its labor cost relatively low, for an article for which his productive capacity is low and its labor cost relatively high. In this profit alone do we find the only rational incentive to a division of labor by and through an exchange of its products on the only equitable basis, viz., that of competitive equivalence in the gravities of the two hindrances necessarily involved in the production of the articles to be exchanged.

Now, in a highly organized economic group of which S and T are normal members, how would it fare with X, our man of many-sided efficiency? Isolated from his fellows, he would be marvelously well equipped to carry on his struggle for existence. But in a highly organized group, would his mere versatility give him any advantage over men like S and T. Plainly not. For under such conditions *any* member of society, directing his energies solely to the production of articles for which his capacity is highest, and converting them into money (the medium through which exchanges like those between S and T are ordinarily effected, instead of by direct exchange of product for product, thereby obviating the necessity for bringing parties like S and T together), would be prepared to secure everything needful on the basis of that in the production of which his capacity is highest.

Thus it is, that, in the absence of monopolistic conditions that alone afford Greed its opportunity to prey upon Need, an equitable division of labor is most effectively secured by and through an exchange of its products, on the basis of competitive equivalence in the gravities of the two hindrances it has been necessary to surmount in order to render the products involved in the transaction available for this purpose.

Thus, broadly speaking, *profit* is the saving in cost that by right and in equity accrues to one as a consequence of his relatively higher capacity to produce, replace, or otherwise acquire, the product or thing parted with, when compared with his relatively lower capacity to produce, replace, or otherwise acquire the product or thing secured through the exchange. This being true, it must follow, that even though the importance of the thing exchanged for, considered as a means of ministering to our anticipated needs, is a thousandfold greater than that of the thing parted with, yet loss, and not profit, must result from the transaction, if the product secured through the exchange could have been produced by us at less of cost impairment than has attended the production of the product parted with.

Greenville, Mich.

AN INTERPRETATION OF THE WORKING RULES OF THE CARPENTERS' UNIONS OF CHICAGO.

BY EDWARD M. ARNOS.

Introduction.

Trade unions have been the cause of much alarm as well as loss to employers and consumers ever since the shoemakers of Wisbch (1538) walked out of the town and conditioned their return upon an advance of wages. Employers' associations have given an enormous amount of attention and funds to stamp out this mystic thing, trade unionism. The dramatic scenes surrounding the great battles of labor for control have left sanguinary impressions of trade unions upon our minds. The Homestead strike of 1892 and more recently the Lawrence strike in 1912, and the strikes of the Western Federation of Miners in 1914 show that force has been used by some unions, a fact which the press and employers have used to create the impression that such are the universal methods of unions. Perhaps unions have used violence to an unwarranted degree, but to conclude that such methods are universal does injustice to those peace-loving unionists, who recognize the importance of their control over the trades and desire to obtain this control only through peaceful and business like methods.

The twelve thousand words of evidence which I have taken from the carpenters of Chicago in personal friendly interviews, show in no uncertain terms the reasonableness of the carpenters' rules, the peace-loving disposition of the journeyman, the wisdom of the leaders, and the carpenters' business-like methods.

However, this is an attempt at a scientific treatment of the subject and therefore the reader must expect to find some evidence bearing upon trade disputes, craft selfishness and indifference to public welfare.

I collected the data from about fifteen different carpenters, in somewhat more than three dozen interviews, and from the files of their journal, "The Carpenter." I inquired into the causes leading to the adoption of the rules, the demands, methods, policies, and, so far as possible, their underlying theories.

The working rules of the carpenters' unions of Chicago are embodied in an agreement between the Carpenter Contractors' Association and the Carpenters' Executive Council of Cook County. The membership of these unions exceeds twenty thousand and leaves practically no carpenters outside the union.

The rules fall into four main divisions, as follows: a general statement of the rules taken from the joint agreement; their theoretical analysis; an interpretation from the workmen's point of view; and a summary of some of the significant points of trade unionism brought out.

Chapter II.

The rules adopted by the carpenters' unions have a two-fold purpose; to give solidarity to the group, and to control the trade. They fall into two main divisions: first, definitions of principles; and second, provisions for their enforcement. The first division may be subdivided into rules on demands, methods, policies and theories; the latter into penalties, provisions to procure prosecution of the employer, to expedite procedure, to facilitate conviction, to induce compliance and overcome evasion, and administrative enforcement through the Arbitration Board, the District Council, the Business Agent, and the Stewards.

The working rules are a joint agreement between the contractors and carpenters. It is a tri-ennial agreement. The present agreement of seventy-five rules went into effect on April 15, 1912 and runs for three years. The agreements date back to the third quarter of the nineteenth century but the effective ones appeared in the early eighties during the carpenters' struggle for the eight-hour day.

The provisions which prove effective are incorporated in the new agreements from time to time and those which prove to be faulty are altered or dropped out of subsequent agreements. For example, it has been the custom of the carpenters to allow the contractors to work on the job with their tools without carrying a union card. In time it became customary to allow one man to work on each job without a card on the ground that he represented the contractors. Under this ruling if the contractor did not care to work himself he could employ a non-union man to work in his place. This was a violation of the spirit, if not the letter, of the rule. The union became dissatisfied with such introduction of non-union men and dropped the rule from the last agreement. Therefore the questions which arise over the drafting of new agreements have to do with efforts to adjust the rules adequately to the prevailing conditions of the trade.

Of the rules on the definition of principles those expressing the unions' demands are most comprehensive. The most fundamental of this group of rules are those demanding the recognition of the union shop. The very joint agreement presupposes the recognition of the union, but article nine has removed all possible doubt about either. It provides that "No member or parties to this agreement will work on any building or job where laborers of any other trade are permitted to do carpenter work of any kind."

The recognition of the union is prerequisite to all other union action and therefore of prime importance. Such relationship of union and employer enables the union officials to treat with the employer in framing the joint agreement and also gives the union a high standing with the journeymen and the community. A union which is not recognized by the employers can not offer its members the work of any definite group of employers. This is a great disadvantage. The employees of the United States Steel Company are not recognized as a union and for that reason the Amalgamated Tin, Iron and Steel Workers' Union is of little importance to its members. No one is proud of his membership in that union and few will admit that they are members. On the contrary, it is a distinct honor to be a member of the Brotherhood of Locomotive Engineers of America or of the United Brotherhood of Carpenters and Joiners of America. It is an honor because these unions are recognized, and hold the respect of the journeymen and the community.

Another very important group of rules are those demanding a standard scale of wages, extra pay for holidays, for overtime, for extra shifts, for idle time on duty, and a definite time and place for payment in currency.

The standard scale of wages, which is a minimum of 65 cents per hour, is the result of a gradual increase, incorporated in the agreements of the last twenty years. The minimum wage of 1906-9 was 57½ cents per hour. This was advanced to 60 cents per hour in 1909 and 62½ cents and 65 cents in 1910 and 1911 respectively. The rate of 65 cents was retained in the 1912-15 agreement but there is already a great deal of agitation for 67½ cents per hour for 1916.

The demands for extra pay for holidays, over-time, extra shifts, and idle time on duty are a part of the union's effort to discourage such employment and determine what shall constitute a fair day's pay, as the union hopes to determine what constitutes a fair day's work, through the demands of the following type.

The eight hour day determines the length of a fair day's work, as the quite well defined tasks, the time system of payment, and the elimination of speeders and rushers determines the amount of work to be done during each of the eight hours of the day. Thus only a certain number of square feet of flooring may be laid in an hour and not more than twenty doors may be hung in a day. The many tasks in carpentry are well recognized and the time for the performance of each well understood. If the journeymen do more than customary they are branded as speeders or rushers and if they do less the employers discharge them. To strike a happy medium between these two extremes is often difficult. A journeyman complained at being discharged who had been working on concrete forms, on the ground that he was inefficient. The trouble was found to be due to a conflict in his orders from the foreman and the blue prints. Whatever the cause he lost his job because he would not work faster after he found the mistake in order to counteract the time lost.

The second sub-division of the definition of principles is methods. Unions are variously characterized as revolutionary, predatory, uplift, and business types, as their methods are radical, vicious, altruistic, or selfish. The selfish end of the business types are gained through the development of contracts, hence those types are called business unions. That the carpenters' union is a business union is evidenced by their conservative methods of collective bargaining, arbitration, and the union shop. The administration of these methods are carefully provided for in the joint agreement with the employers. Thus when controversies arise between employee and employer they can be settled or adjusted through discussion and interpretation of the agreement, which in the language of business is a contract.

The first of the methods which characterize unions as business unions is that of collective bargaining. It is through collective bargaining that the highly organized associations of the employers meet and treat with the equally highly organized unions of the employees. Each side employ able men to represent them in the negotiations. Under such conditions the joint agreement is drawn up and decided upon. Each organization is managed by experts just as a business is managed by men specially trained to fill the respective positions. Essentially, therefore, collective bargaining is bargaining by a few officials who represent the masses. These officials are "hired-men" and hold their jobs by getting good bargains with the employers. The net result obtained by this method in the building trades is the elimination of general bargaining and the establishment of a perpetual armed truce. The carpenters feel that they have a splendid agreement at present and the employers are well satisfied but each realize that at the end of the joint agreement each side will try to out bargain the other in drafting a new agreement. The contractors leave the impression with the journeymen that they can use the lockout if unreasonable things are demanded and the carpenters make the same use of the strike.

Arbitration, as the second of the methods of the carpenters' union is used as an adjunct of collective bargaining. A board of arbitrators, representing the contractors association and the union, sit bimonthly and pass upon violations of the joint-agreement and impose penalties upon offenders. The decisions of this board are final but either side represented may refuse to agree to a decision and therefore may disrupt the work of the Board. Such disagreement in the Arbitration Board suspends the operation of the joint agreement. It is therefore a misnomer to call such a method arbitration. It is only an agency for peaceful settlement of disputes with advisory powers. I do not wish to depreciate the importance of this method with the carpenters. It is an exceedingly useful agency. I only mean that it is a misnomer to call it arbitration.

The third of the carpenters' methods is that of the union shop. This is also one of their demands and has been discussed under the recognition of the union. The functions of this method are there made clear.

The third sub-division of principles is general policies. They are the expression of certain fundamental conceptions of the nature and functions of the union. Specific examples of these policies are the rules to control the working personnel; to limit the labor supply in the craft; the use of tools, and the output; and to share work with each other.

The control of the working personnel of a union is of prime importance for the successful administration of the functions of a union. The Prussian army is a powerful war machine because every man is under complete control of the leaders. There is no questioning of authority. The Carpenters' Union is powerful to the extent that the leaders have the unfailing support and obedience of the men. As the generals, colonels, captains, and lieutenants have the management and authority in the Prussian army, so the Arbitration Board, the District Council, the Business agents, and the Stewards, have control for the Carpenters' Union. It is through the control thus maintained that the Carpenters' Union can make and enforce joint agreements with the contractors. An instance of the exercise of this authority and control over the personnel was brought out in the evidence of an interview with one of the stewards when he said that the men objected to work upon a certain building on the West Side of Chicago because apprentices were doing rough work. The officers investigated the case and decided against the men. They were ordered back on the job and obeyed. This sort of incident happens frequently, I am told, and the men always obey. For this reason, the Carpenters' Union is effective, and for the same reason that the Prussian army is effective.

The second of the general policies is the attempt to limit the labor supply in the craft. The union controls the supply of labor in the craft by limiting the number of apprentices and by examining new members. Contractors are not allowed to indenture more than two apprentices for every ten journeymen employed. By this means of limitation there are only about four hundred apprentices in Chicago to twenty thousand journeymen. Only about eighty of the four hundred apprentices finish their training annually. The number of journeymen retiring annually must be about five hundred. (This figure is obtained by taking two and one-half per cent of the total number of journeymen, which assumes that no journeyman stays in the trade more than forty years.) The limitations on apprenticeship have been so severe that it is generally understood that only sons of journeymen carpenters get into the system.

The supply of labor in the craft is further limited by the examining board of each local union. In dull seasons these boards put up fake examinations or do not give the applicant fair returns on his examination.

The third general policy of the Carpenters' Union is the attempt to limit the use of tools and output. The nature of the trade and custom gives the journeyman control over his tools. Each carpenter owns his tools and therefore would naturally expect to control them and determine what types he should use. By limiting the use of certain types of tools they keep carpentering a hand trade. For this reason the carpenters may not take the sledge hammer, spike maul, or patent mitre box on any job.

The fourth general policy is the attempt to control the output. This control is secured by the force of custom and tradition rather than by rules. The men allow certain time for certain tasks. A carpenter will not hang more than twenty doors in a day, nor lay more than a certain number of square feet of flooring in an hour, etc. Besides these traditions the rules on the eight hour day and holidays limit the output. Through this limitation of output they accomplish their aim to share work among the members, they maintain a high state of physical health and strength and have more time for leisure.

And finally, the fifth general policy is work sharing. It is partly the result of their successful limitation of the output. Every union is popular with the men to the extent that its members are kept employed regularly. To this end the carpenters' attempt to limit those who are inclined to be too energetic and take the work away from their fellows. Thus the carpenters reduce the number of unemployed. One of the most obvious rules for work sharing is the one preventing the carpenter from installing non-union stairs. The stair cases could be made by semi-skilled workmen at lower wages than is paid the carpenters. But by installing only union made stair cases over six thousand union carpenters are kept employed at union wages.

It still remains to discuss the last of the four sub-divisions of the definition of principles, namely union theories.

The carpenters suggest some theories in the joint agreement which are misleading. Article Three says, "All workmen are at liberty to work for whomsoever they see fit." The same article gives the employers an equal liberty in employing. According to another section of the same article, "There shall be no limitation as to the amount of work a man shall perform during his working day," and "There shall be no restrictions of the use of any manufactured material, except prison made." These statements would indicate that they are in harmony with the elastic demand theory, and do not attempt to share work, nor believe with other labor unions in the fixed group demand theory. The preceding section shows the contrary. Their own interpretation of these theories, found in Chapter III, shows that the foregoing statements are misleading, and must have been included in the agreement from preceding agreements, or consciously included to deceive the employer and public.

There are on the contrary a number of quite well recognized theories which underlie the carpenters' rules. They do not appear in any declarations or rule but are a fundamental part of their working rules. Some of these fundamental theories are called the theories of standardization; undercutting; fixed group demand; and the standard of living. It is through the influence of their theory of standardization that units of measurements, as the eight hour day, are so vigorously fought for and maintained. The theory of undercutting makes clear the necessity of using standards thus established to prevent men from underbidding each other. The fixed group demand theory assumes that the demand for any commodity remains fixed, "inelastic." regardless of changes in the price. And the standard of living theory assumes that there is a certain fixed living cost below which the members of the union must not fall. According to their estimation of costs, the sixty-five cents per hour is sufficient to maintain their standard of living.

The foregoing theories will be discussed in Chapter III. Before continuing that discussion the second main division of the working rules, the enforcement of provisions should be treated.

The enforcement provisions of the rules are by far more numerous than those on general principles. As with all legislation, comprehensive enforcement provisions are imperative. These provisions fall into five main divisions: first, penalties; secondly, provisions to secure prosecution of the employer; thirdly, to expedite procedure; fourthly, to facilitate conviction; and, fifthly, to secure administrative enforcement through the Arbitration Board, the District Council, the Business Agent and the Stewards.

First. Penalties for violation are generally used. They serve as an auxiliary to the other types of enforcement. In some few cases, a liability in the form of suspension is used, but a fine of from five to twenty-five dollars is the usual method of forcing observance of the rules.

Second. The District Council prosecutes cases for the workmen, particularly cases of injured men. In case of accident, the steward is directed to "gather such evidence as may be useful to the injured member and notify the District Council at once." Such information is used by the District Council as its officers deem to the best interest of the injured workmen who are not able to collect the evidence on the cases at the time, and the entire personnel of the workmen may be changed before they become able. This rule gives the injured workmen the service of the union in prosecuting the employer for claims under the workmen's compensation act.

Third. The great injustice in much of the ordinary legislation arises from the numerous impediments in its enforcement. The carpenters have attempted to expedite the procedure so as to assure speedy administration of justice. The apprentices are given the benefit of the service of the Arbitration Board in determining whether proper instruction is being given them. Thus an apprentice has a speedy adjustment should he not be getting proper instruction. Responsibilities are definitely lodged in certain offices and are well limited and defined. Injustices to journeymen are administered with the same celerity. This makes possible a speedy administration of justice.

Fourth. Every member of the union is charged with the obligation to assist in the conviction of offenders. One rule provides that "any member refusing to give the actual conditions of a building or job when so requested by the business agent shall be reported and fined." The certainty of responsibility and directness of appeal facilitate conviction. The Arbitration Board's bi-monthly meetings and the efficiency of the business agents of the employers and employees in collecting evidence conduce to the speedy and regular conviction of offenders.

Fifth. The last group of provisions for enforcement are those for the administrative offices. The arbitration board sits as a court of final jurisdiction. All questions which cannot be adjusted between the business agents or the president of the district council and the president of the contractor's association are brought before this board for final adjustment. A refusal to comply with the decision of this board suspends the joint agreement.

The officers of the district council, a president, secretary, the business agents and stewards enforce the rules. The business agents make frequent visits to the jobs and make inquiries into the observance of the rules and the satisfaction of the men. If any have been abused or "fired" without cause, the steward communicates this to the offices of the business agent. The steward interprets the rules in the absence of the business agent and determines violations of the rules. He is a journeyman, usually popular with the men and well acquainted with the trade and union rules. Through this line of offices, any violation of the rules is speedily detected. Their efficiency commands the respect of the members and a well administered organization is the result.

Chapter III.

Theory and trade unionism are almost contradictory terms. The trial and error method of testing rules, the everchanging conditions of the trade, the large number of men concerned in the agreement, the different nationalities represented in the union personnel, and the tri-ennial agreements have left the carpenters' rules marked as if they are in a process. The constant changes in the agreements evince the carpenters' struggle to get control of the trade, first by one method or rule and then by another. (*125.) This trial and error method has removed at least the trace of theory as a controlling force in the construction of the joint agreement. Journeymen are seldom conscious of any underlying theory of the rules in explaining their demands, methods, policies, and aims. Although the development of the rules has been free from the control of theorists, development has been in harmony with certain theories of business and human relationship. The theory of standardization, the theory of undercutting, the fixed group demand or lump labor theory, and the standard of living theory, are vital to the carpenters' rules. Journeymen may not realize the presence of any theories, nevertheless the officers interpret the rules in the light of these theories.

To illustrate, one business agent said the rule prohibiting journeymen from taking their tools on the job before they were employed was to prevent men from gathering around the places of employment prepared to work, because the employers used their presence to intimidate the journeymen on the job; i. e., according to his theory of life, men who were out of employment would place themselves where they could underbid their fellows who were employed. To illustrate the underlying force of their fixed group demand theory, one of the officials said that they were in favor of a raise of wages to 70 cents per hour because there was a certain amount of work to be done and the carpenters could get 70 cents per hour as well as 65 cents. Thus consciously or unconsciously, the carpenters supported all of their rules by some of their theories of life. Let us consider these theories and their significance after careful analysis.

First, the theory of standardization. By means of the standard day, minimum wage. rushing, prohibiting tools on the job before procuring work, contract, piece and lump work, definite pay day, and union shop, the carpenters establish standards and uniform units of measurements. Why these standards and uniform units of measurements? There is one answer given by the men. By these standards all of the men can be judged on a uniform basis in order to detect undercutting which they think will exist as long as men compete. (*159.) They express the hypothesis, in explaining these demands if not the theory, that there is a strong or even inherent tendency for men to underbid each other. Some have expressed this underbidding in the following manner: If A, B, C, D, ... N should be the supply of workmen and the demand for labor were for A, B, C, D, ... N — X, the assumption is that the one unemployed man (X) would offer his services for less than (A) was receiving. Thereupon (X) would be employed and (A) would be discharged. (A) would then do as (X) had done before him, and A. B. C. D. ... N would do the same in their turn. (X) would shortly find himself underbid on the wage at which he originally underbid (A), and would now be obliged to underbid again at a still lower point. They assume a constant over-supply of labor, which the theory presupposes will be temporarily removed by the process of underbidding.

Second, the theory of undercutting. In speaking of the minimum wage, one official said, "the men are all willing to underbid the others on the slightest appearance of emergency." (*23.) This theory also appears in the once prevalent practice of giving the foreman a present on all big jobs. In this connection, several journeymen said that the "men continually slip things over to the boss," and thereby underbid the others. (*60.) Although the foremen no longer get presents, it is known that journeymen give the boss a certain sum of money at the beginning of work. This sum is gradually returned in the pay envelope. Thus the amount in the pay envelope is in accordance with the minimum wage rule, but a part of it is a return of money advanced by the journeyman. This is a subtile method of underbidding. One official said, "the Jews have a contract system of returning wages that is hard to beat." They give the contractor $50.00 for a guarantee of work for a certain length of time when another $50.00 is paid. Or they borrow from the boss, and this is increased above the actual figure in the pay envelope on pay day. Detectives get jobs on the foregoing basis at the suggestion of the boss. (*62.) This official and several journeymen thought this practice quite generally used by the Jews and Swedes. (*61.)

The presence of an unemployed group and their theory of undercutting necessitates standards and uniform units of measurement. Thus the first of the hypothetical theories is accounted for. This assumption of the constant over-supply of labor also presupposes that there is a fixed group demand for labor, thus their theory of a fixed group demand or "lump of labor" theory.

The third theory to be considered is that of the fixed group demand. This fixed group demand is usually approached through the desire to share work among their members, which they accomplish by limiting the supply of labor. Their rules on apprenticeship so limit the number of apprentices that it is said that only the sons of the most prominent journeymen are indentured. The number of apprentices range from one to two per cent of the number of journeymen. Rushing and excessive work have the same effect upon the supply of labor, through the limitation of the amount of work to be done in a certain time. The eight hour day and holidays limit the number of working hours and thus limit the labor supply. The fixed group demand theory is supported by their experience of unemployment. The leaders contend that the unemployed are as numerous under low wages as they are under high wages. The hypothesis is that there is a certain amount of carpentering to be done in Chicago. This is fixed by the number of persons who live there. To quote an official, "a man wouldn't live in a tent if wages were high nor in two houses if they were low." Of course this opinion would not bear strict interpretation nor do they claim that for it. The constant increase in the scale of wages and the accompanying decrease in unemployment in the trade are often cited as proof of their hypothesis. Their wage slogans, "high wages breed high wages," "no wage reductions," "cheap wages make cheap men," and "get more now," have their origin in this group of facts.

Their fixed group demand theory explains the union's defense for limiting the output. The public press has frequently denounced trade unions for limiting the output. Employers have made most bitter attacks upon the union for those rules and practices which result in limiting the output. The opponents of trade unions on this point usually argue that prices to the consumer are thus raised, and charge the union with a breach of good faith with society. The business man, the entrepreneur, and the classical economist would usually undertake to solve the problem of unemployment by reducing wages with the hope that the demand for labor would be increased by reason of the decrease in wages. Not so with the trade unionist. He has a different theory of business. The former groups think that prices and demand vary inversely, the latter group thinks that "there is a certain amount of work to be done and a certain number of men to do it. Each should be given a chance to do some of it." (*157.) In a few words, their theory is that there is a fixed demand for commodities regardless of price, within a reasonable limit. According to this latter theory, a man does not buy a straw hat because it is cheap, but because it is the custom of certain classes to wear a certain kind of hat on certain occasions. The increase in wages for the makers of high hats would probably not decrease the demand for that particular kind of hat. On the other hand the author of the foregoing reasoning admitted that he would buy an automobile if the price dropped to one hundred dollars and unwillingly admitted that his demand in the automobile market would increase the demand for mechanics. Neither of the above theories are valid if applied to the extreme, and are contradictory when so applied. The carpenters observe from experience that a change in wages is not followed by a corresponding change in demand for labor. They try to take advantage of this slowness of "demanders" to adjust themselves to a changed condition of supply. The union theory operates in these cases where the demand for an article does not fall when the price is raised, or in technical language, where the demand is inelastic, and the opponents' theory operates in those cases where the demand for an article falls off rapidly as the price is increased, or in technical language, where the demand is elastic. The demand for salt and carpenter work is almost fixed or "inelastic," and the demand for automobiles is quite elastic. Therefore the carpenters' and the employers' theories are both valid as you limit their applications and neither theory has universal applications.

Fourth, the standard of living theory. This theory is prominent in the defense of the minimum wage. The standard is indefinite. Some standards include a few and others many items. With each new agreement the carpenters demand more wages, because they include more items in their standard of living. It is a matter of individual interpretation, which differs as the purchasing power of their wages is greater or smaller than that of the wages in the other trades. The theory means that their wages must make them independent of the employer. If they must ask favors of the employer or are unable to withstand a strike, their bargaining power becomes nil. The rate of wage which will give them the necessary independence and keep them in the same class with their associates or other trades is 65 cents per hour at present.

There is still another group of ideas underlying the carpenters' rules which might be termed a theory of harmony of interest and sacredness of contract. There is a general expression of a certain harmony of interest between the employers and employees, which takes the form of mutual interest, as "when the employer does well we get better wages." This seems to be a watery type of harmony, and grafted on the situation, for most of the journeymen feel that they must take all they get and that the employer's profit is the product of their labor, which custom and laws have given him, and can be regained only by the group effort as expressed in the union. Such expressions as "there is no common basis for judgment on disputes, between employee and employer," "the interest of the employer is always opposed to ours," and the general expression of the struggle, is the basis for doubt as to their sincerity in their formal expressions of an existing harmony of interest. The harmony of interest theory is generally approached through their conception of a contract, which plays such an important role in their activities, and constitutes the instrument with which they aim to force the employer to give them favorable wages and conditions. When it fails to accomplish this end, its sacredness rapidly declines, as is shown by the evidence that the carpenters would break their contract with the employers if it involved the establishment of an unfavorable precedent. One of the officials high in the district council once said to me that should the employers attempt to hire non-union men in the building trades and attempt to establish the precedent of employing non-union men we would break our contract at once. It must not be inferred, however, that the carpenters regard their contract obligations lightly. They regard them as an efficient means to an end, namely, high wages, and good conditions, and for that reason their contracts are respected as a matter of security to future contracts. But they also regard the end as more important than the means. Violation of a contractual obligation results therefore when the contract fails to cover what they consider absolutely essential conditions. While they probably would not frequently break their contract with the employer of non-union men, in the other trades, yet they probably would if the non-union men were employed without reason, or if such employment would tend to establish the open shop in the building trades. (*69.)

Chapter IV.

It is the purpose of this chapter to present the workmen's interpretation of their rules. The order of treatment given in chapter two will be followed, namely; their interpretations of demands, methods, and policies.

The demand for recognition of the union is first in importance and is based upon the desire for control. The carpenters always assumed the necessity for the recognition of the union before any effective union action was taken. They are certain that none of the rules can be enforced without such recognition. Approximately 86 per cent of union strikes are for recognition of the union. As one journeyman expressed it, "the union men could never accomplish anything without recognition." (*67.) Or expressed in another way, "the union can be successful only as it controls the situation and is represented and recognized on the job." (*67.)

The demand for the union shop is closely allied with the recognition of the union. It is maintained as a result of that recognition. The union shop gives the journeyman the advantage of craft association. Knowledge of the trade is given new members and there are many social advantages for the families which could not otherwise be had. The journeymen look upon the work in the trade as their work. As the secretary of one of the unions expressed it, "certain rough work .... could and would be done by unskilled workmen at half the price if allowed by the union. This is a part of the carpenter's work which should be done by them. If it were not just that many more carpenters would be out of work." (*642.)

The social and trade distinction of union men and the maintenance of trade secrets and knowledge are additional defences of the demand for the union shop. The carpenter's journal, "The Carpenter," (Vol. 33, No. 3, p. 7,) expresses this defence. To quote from that journal, "no one who prides himself as possessing able knowledge and experience, desires to work alongside of an untrained, irresponsible, and disagreeable co-worker, nor to communicate to him the valuable information and knowledge he has acquired from sources, which he knows have long been skilled and by industrious workingmen worth their hire by the principles and precepts and under the guidance of organized labor." (*677.)

The eight hour day determines the number of hours in the "fair days' work" and the time system of payment in the absence of rushers and speeders determines the amount of labor to be performed in those eight hours. The eight hour day is also necessary because of the great distances between the journeymen's homes and their places of work. This trade condition served as a great leverage in favor of the carpenters during their struggle in the eighties for the eight hour day. Occasionally journeymen find it necessary to cross the entire city for work. It frequently takes an hour each way to get to and from work. This is becoming more and more true as the process of specialization becomes more intense. In the words of the journeymen, "distances are so great in Chicago that if one had to work 10 hours, much of the time he would have to leave home at 5:30 A. M. and not get back until 7 or 7:30 P. M. This means that many of the journeymen would leave before daylight and before the children are up and would not return until dark after the children are in bed. Thus the family life would be broken up.

The third argument in behalf of the eight hour day is that "the men can do more in eight hours than they can in ten hours." As proof of this statement they say the Chicago carpenters do more work in eight hours than the country carpenters do in ten. (*2.)

Fourth, eight hours is all that most men can stand. They work constantly and usually do very little "loafing" and talking during working hours. They are quite certain that eight hours under such conditions are a sufficient number for a fair day's work. (*5.)

Fifth, their desire to share work should be considered in this connection. Even though the journeymen are always quite active on the job and the work is irksome under long and continuous application, there is a difference of opinion upon the weight of this argument in assisting the carpenters in attaining the eight hour day. There is no general belief that the desire to share work influenced the rank and file persistently to demand the eight hour day, but their confidence of the desirability of the eight hour day was more finally established because the eight hour day would bring about a greater distribution of work among the journeymen. (*1-4.)

Last, the eight hour day being in the air, and popular, the carpenters were able to force their demand for it through the joint-agreement. (*1-3.) Some of the officials defended the eight hour day entirely on this basis.

Just as the eight hour day determines the length of a fair day's work the minimum wage and the time system of payment determine what constitutes a fair day's pay. The time system of payment is universal in its application in Chicago with the carpenters. This means that the journeymen work by the hour and are paid 65 cents for the work done during that time. Under this system, the practice of taking work by the job, i. e., lump or contract, and by the piece is positively prohibited. They claim that lump work, contract work, or piece work results in undercutting and that it is impossible to maintain any standard of work or pay under this system of payment. (*38.) As they express their feeling upon their experience, "piece work would kill any trade." (*38.) Their generalization upon this subject is probably too broad but it expresses their attitude and experience.

With such a definition of what constitutes a fair day's work and long established custom with respect to the amount of work a man should do in an hour, it can be assumed that the carpenters effectively control the standards of work and pay.

I have already shown that they demand a standard unit of measurement. The justice of this demand is apparent to the contractors, so that it has been inserted in the agreement for some years without any dispute, for without this standard the flood-gate of underbidding would be opened. Some journeymen and officers think that the "minimum" wage of 65 cents applies to the least efficient and the more efficient get more. Others think the minimum of 65 cents is probably almost universal and represents what the union can successfully get from the employers. Again others think the minimum wage is 65 cents because it "costs that much to live." (*20, 21.), and still others take the opposite view, namely, that the cost of living is what it is because the minimum wage is 65 cents, and that this minimum "is no more nor less than an expression of what we can get." (*19.) Another officer expressed this when he said, "we never did nor never could argue for a higher wage on the basis of getting a living wage. First we don't believe a living wage is enough and secondly we want more. Are we just to get a living out of life? Are we not entitled to get more than that?" (*19.) "How can a man with a job at 65 cents argue that he is not getting a living wage without being ridiculed even though he only gets that eight or nine months in the year? The living wage argument assumes that there is a limit at which workmen are satisfied, which is not true." (*19, 20.)

Extra pay is demanded for over-time and extra shifts because the union desires to discourage continuous work for more than eight hours. Work for a longer period is harmful to the journeymen's health, and the dangers accompanying work in the dark should be avoided. In addition to these two reasons, such extra pay and the change of men on every shift shares work. The journeymen generally attribute this rule to the first two arguments but recognize the influence of the latter. (*34, 12-15, 17.) The journeymen's attitude is characterized by one as follows: "the heavy charge on overtime is made to discourage employers from working men more than eight hours. The extra pay represents the additional energy necessary for the hours beyond eight." Or as another expressed it, "this is to prevent contractors from working men for many... hours... and impairing the employee's health." (*36.)

The importance of the established time, place, and kind of payment is very important and significant. Why should Tuesday rather than Saturday be the pay day, and why should payment be made at a definite place and in a definite kind of money?

In the first place, Saturday has proved unsatisfactory because the men spend unwarranted sums in the saloons on Saturday afternoons and nights under such a system. Mid-week pay-day eliminates much of this practice. One journeyman says that the purpose of Tuesday pay-day is wholly to keep men from spending their week's pay for drink as would be the case if paid on Saturday." (*48.) There is, however, another very good and definite reason for the Tuesday pay-day. It would be impossible for the contractors to make up the roll and get the money around to the various jobs on Saturday forenoon during banking hours. (*46.)

If Saturday were made the pay-day, it would be necessary to pay by check. This the union will not allow, "because the men would go to the saloon and have the check cashed." This increases their incentives to go to the saloon, drink and perhaps treat others, out of courtesy to the saloonkeeper, who has cashed their checks. The practice of cashing the checks at the saloon and the consequent evils of drinking led to the requirement for payment in currency.

Why should the union insist upon a definite place of payment? The great number of carpenters at work make it impossible for the unions to supervise the pay envelopes unless all the men are paid on the job. If payment could be made elsewhere the journeyman could accept less than the union scale of wages, and the union officials would know nothing of it. (*47.) In the second place, if carpenters were paid at the office of the contractor or other than at the place of work, he would lose time and carfare collecting his pay. He might also be obliged to wait in the office or go more than once for his pay. Under such circumstances he would lose much time and several car fares, hence the need for a definite place for payment, as well as a definite pay day and payment in currency.

The second general division of the principles of legislation brought out in the rules are their methods. The methods of enforcing specific rules will be treated under the head of enforcement provisions. Methods, in the sense here interpreted, cover those actions of the union which provide for the general direction or general policy for enforcing specific provisions. Arbitration, collective bargaining, strike, union shop, and mutual aid are the union methods in this general sense. As the Arbitration Board, District Council, penalties for violation, direction to agents, etc., are the specific enforcement methods, the former might be considered methods in the abstract sense and the latter in the concrete sense.

At a recent meeting of the Commission on Industrial Relations (1914) in Chicago, the representative of the Building Trades Council said that in his opinion the interests of labor and capital could best be conserved under a system of "complete control of the union and employers' associations in their respective spheres." This absolute control of the two organizations make it possible for the representatives to bargain collectively. Such absolute control virtually exists now with the carpenters and their employers. The officers are able to enter into contracts and the union and the employers' associations exercise sufficient control over their membership to enforce most of such contracts. Their conservative attitudes prompt them to enter into this business-like relation, and their efforts to increase their wages continually are advanced by it.

Arbitration is one of the carpenters' methods in this general sense. Arbitration is a part of their scheme for collective bargaining. Even the journeymen regard their type of arbitration unreal and a misnomer. One person expressed this interpretation in most emphatic language. "We don't have arbitration. It is conciliation, a part of collective bargaining." (*154.) Another expressed the same idea by saying, "arbitration involves complying with the decision of an arbitration board selected by the State or some agency other than the union. Our arbitration is not that type." (*154.) The carpenters do not have even a voluntary type of arbitration. They do not agree to arbitrate anything, except, that the arbitors be selected chiefly from the unions and do not agree to accept the decision arrived at by such a board. Their objection to arbitration is that no unprejudiced judge can be found. (*154.) The second method is collective bargaining.

Collective bargaining is strongly supported by the entire union. It removes the necessity of individual "higgling," which would occur so frequently without the collective bargaining. To them it is a panacea for almost all trade ills. In fact collective bargaining between two such strong organizations as the carpenter's union and the carpenters contractor's association results in little or no bargaining. Each side recognizes the strength of the other. Only questions of broad significance are brought up and then but once in three years. Even these questions are considered by only a few men. Thus in this trade, collective bargaining not only does away with individual bargaining but destroys all bargaining.

The third method is the union shop. The purpose of the union shop, unlike that of collective bargaining, is negative. The union shop is an adjunct to collective bargaining. Through it the personnel of the trade is controlled, and only union men can be employed on any job. Without this control the union could not enforce any of its contracts and therefore could not be able to get employers to enter into contracts with them. The union shop is therefore not only profitable for the union members, but establishes stable relations with the employers. To maintain this control, the members must carry union cards. "This is the only way the rules maintaining a closed shop can be enforced. Were it not for this, non-union men could work on the job." (*104, 106.) The need for the union shop and the union control is also evident in case of picketing. If the union strikes, it must be able to keep the men off the job or the right to strike is useless. (*74, 144.) The power to strike and the power to keep all men off the jobs, which is necessary for a successful strike, has made it unnecessary to strike in the carpenters' trade of Chicago. Thus preparation for industrial war maintains industrial peace. It is this control over the men through the union shop that makes organized labor a conservative and steadying force in the building industry. It is through this control that the union is able to command the respect of the employers, the men and the public.

The fourth method is the strike. When all other methods fail, the strike is used. The carpenters have had very few general strikes in Chicago. The "Carpenter," Vol. 32, No. 5, p. 4, says, "to the labor hater and the unthinkable ... public strikes come under but one category. They are all bad." (*632.) Again in (Vol. 31, No. 3, p. 16,) "strikes are the manifestations of brute force against a still greater brute force that denies men the right to live." (*66Z.) It is unquestionably true that the carpenters dislike the use of the strike and fully recognize its undesirable effects.

The sympathetic strike is even more unpopular. The uncontrolled selfishness of the craft unionists has full sway on this type of labor action. Several men explained this when they said, "the carpenters don't care much about the other trades as most of the troubles arise from jurisdictional disputes, which leave much bitter feeling, and they don't care anyhow." (*68.) Many journeymen also feel that the sympathetic strike is a means by which one craft forces another craft to fight the former's fights. (*73.) This they said the carpenters "got tired of." (*70.) Thus the sympathetic strike is undesirable from even a trade point of view.

The coöperation ordinarily secured through the sympathetic strike is obtained by custom in the building trades. Although the carpenters expressly agree "not to leave their work because other than union men in any other line of work are employed on the building or job .. etc." (Art. 12), the men are well informed that it is against their interest to work under such conditions. In spite of the above mentioned agreement, union men will not work with non-union men of other trades. "No employer would attempt to employ non-union men .. for .. he .. would be heavily fined by the employers' association .. and so many inconveniences would be put in his way by the union that he couldn't do it. (*68.) Through this intertrade cooperation the building trades are able to assist each other without the use of the sympathetic strike.

The last of their methods to be mentioned is that of mutual aid. Sick and death benefits are provided for through the national organization. There may be some who defend this method as a means of preventing underbidding, on the ground that unemployed men and men in great need will underbid under the necessity of poverty and not otherwise. The primary motive, however, is probably a desire to help the injured and sick as well as provide for some of the needs of widows and orphans.

The third general division of the principles of legislation in the carpenters' rules is union policies. A well organized and efficient union has definite policies just as a well organized and efficient business must have definite policies. Occasionally the policies of a business become characterized by some slogan such as "always believe the customer." It is the present policy of the United States Steel Co. to sell steel rails cheaper abroad than at home (large scale production and the tariff make this profitable). It is also known that it was the policy of the Carnegie Steel Co. not to employ union labor. These are instances of business policies. The union policies differ in nature because the nature of the union's business is different from the above mentioned business policies. A union or a business without policies might be compared to a man without a purpose in life. Just as some of the business policies may be bad and contemptible, so the union policies may be bad and contemptible and vice versa. Let us now examine the carpenters' policies from this point of view. These policies are the control of the labor supply; of machinery, tools, and materials; of the output; and of work sharing.

The first of these, the control of the labor supply, is accomplished through the apprenticeship rules and the examination for entrance into the union. The presence in the city of more journeymen than can be employed is a menace to the union. It is also uneconomical for society to train men for the carpentry and then have no work for them. To this end "apprentices are limited in number to limit the supply of journeymen to the demand and thus prevent a large number of men from learning the trade who can not get work." (*118b.) In the words of another journeyman, "Why do we want to train men to be carpenters and have them walk the streets?" (118a.)

The labor supply is also limited through examinations. The "Carpenter" advises journeymen when work is "dull" in any place. Should journeymen go to Chicago disregarding such advice they are compelled to submit to an examination before they can enter the union. Fake examinations are put up when more men are not wanted in the union. "If they pass the examination, we vote them down in the union." (*118c.)

It would be inferred from this interpretation that the carpenters could and did limit the supply of labor to the demand. That this is not the case is evidenced by the fact that the carpenters are unemployed from twenty to thirty per cent of the time in Chicago. Several business agents told the writer the carpenters were unemployed one-half of the time. (*18.) It is therefore doubtful if they have the power to control the labor supply, and they certainly do not exercise that power if they have it.

The case of control of the working personnel is otherwise. In this instance the control seems almost absolute. The journeymen obey the business agents and officers of the union as a matter of custom if not of judgment. One journeyman said, "we obey the business agent in order to enable the union to maintain the rules and force the employer to comply with our demands." (*98.) Another said, "all must obey or it would be open shop. It would tend to break the ranks if we didn't act in unison." (*97.) This control of the working personnel not only enables them to hold the men together for their own sakes but also to carry out the various agreements with the employers. This control of the personnel is desirable from the contractor's point of view also. The union guarantees to supply all of the men needed in the trade so that the contractors know that they will always have a supply of able and well controlled workmen. This is also of great value to society. Under the regime of a strong union, construction work, when begun, is not delayed.

The control exercised over the tools and machinery is very little. The carpenters attempt to limit the journeymen to the use of only such tools as will keep the trade a hand trade. The patent mitre box is not owned by the journeyman, because it makes their tools too heavy to carry. (*120-122.) The sledge hammer and spike maul are seldom used and are supplied by the contractor.

The same control over the materials used by the journeymen is explained differently. Only staircases, made by the mill workers of Chicago, may be placed by the Chicago carpenters. They either regard this as carpenter's work (*123-124,) or undertake to keep the millworkers employed. (*124-125.) One official hinted at the reason the carpenters did not demand all union made materials when he said, "the carpenters attempt to compel the contractors to agree to install only union made trim, doors, etc., but failed principally because that would have given the manufacturer a monopoly of the trade, who would "rob and extort" the consumer to the detriment of the union and the public. (*125.) This opinion is not generally shared by the journeymen, especially not in the case of union made tools, machinery, etc. Probably the carpenters more generally agree with their official organ, the "Carpenter," (Vol. 33, No. 2, p. 15), when it says, "Unionism also teaches him that the wages he earns should be expended in the purchase of goods bearing the union label, that he may thus reward those employers who deal fairly with their help and at the same time punish those employers who do not." The Chicago carpenters would therefore probably prefer the further limitation of the use of materials but have not been in position to get greater limitations included in their agreement.

Third, limitations of output. Many rules indirectly limit the output. Even the eight hour day limits the output, because men may work only eight hours. Barring the argument that men can do as much in eight hours as they can in ten, this rule alone limits the output approximately twenty per cent. Holidays have the same effect upon the limitation of output. This type of limitation of output is however little objected to in any trade. There is a less praiseworthy type,—that of limiting the amount of work any journeyman may perform in a unit of time. The carpenters have no rules thus limiting the output, but the custom of ostracizing men who hang more than twenty doors in a day, or lay more than the customary amount of flooring, or put on more than the customary amount of "trim" in a day, limits the output more effectively than any number of rules could. The limitation of output is closely allied with the carpenters' policy of work sharing, which is the last of their four policies brought out in this investigation.

The eight hour day, holidays and prohibition of rushers limit the output and to the journeymen this is a defense for these rules as several journeymen said "another reason for the eight hour day and half holidays is to share work with others." (*4.) That is, they meant that the effect of the eight hour day and the half holiday was to limit the daily output of the men, which limitation of output gave others more to do. Another explained the rule discouraging overtime employment as a means of "dividing up work." (*35.) The desire for approbation has its influence with the carpenters as with the rest of humanity. The men like to be popular with their fellows if for no other reason than for the offices which await the leaders. There is nothing that would bring greater disapproval or disapprobation than rushing or scabbing. This force is sufficient to limit the output because the men will not undertake to compete with the idea of outdoing their fellows. To the extent that the journeymen are so guided, the output is limited and work is shared.

Chapter V.

An attempt will be made to give in this chapter such evidence as the investigation offers upon the extent to which the rules are the outgrowth of conditions of the trade; the extent to which they are the expression of the men and of the leaders; the extent to which they are forced upon the union; the extent to which they are enforced; and the extent to which the rank and file understand the rules, and upon the spirit of the men; and the claimed advantages of the union.

Some of the rules are the outgrowth of trade conditions. The eight hour day falls in this category. The place of employment in carpentering, unlike most other trades, is distributed over the entire city. For this reason men can not live close to their work. At one time a journeyman may be working on a building opposite his own home, but when that job is completed he may be obliged to go many miles from home to the next job. The minute subdivisions of the jobs within the craft hasten changes of jobs and necessitates more travel over long distances. The work within the trade is so subdivided that certain journeymen lay all of the flooring, others place all of the "trim," and still others hang all of the doors. Floor layers pass from job to job to do that particular work, and "trimmers" do likewise. Thus the nature of the trade and the size of the city have made the eight hour day a necessity in Chicago. Whether or not other forces operated to its accomplishment, these made it inevitable.

The established place and time of payment is also made necessary by the nature of the trade. In other trades men can pass from the work shop to the payoffices, but in carpentering men are at work in all parts of the city. The directions of the stewards, examination of the pay envelopes and the daily walks of the business agent all result from the conditions of the trade.

In speaking of the influence of trade conditions over the rules, one trade unionist said, "Trade union rules come from and change with the conditions of the trade. They develop from misunderstandings, strikes, failures, trade disputes etc." (*165. *166.) This impression is so universal with the men that the whole tone and vocabulary of the trade rules are expressed in terms of the conditions.

Second, to what extent are the rules forced upon the unions? It is difficult to point to any number of rules which have been forced upon the union. The carpenters have of course failed to get all the advantages they desire or have desired because of the opposition of the employers. So perhaps privileges which they have been denied constitute a better criterion for judging what rules have been forced upon them. It is conceded, however, that the rules preventing small contractors from working on the job and the use of open shop "trim," were forced upon the union by the large contractors. By preventing small contractors from working on the job, journeymen are prohibited from building cottages with the intent of selling them. Carpenters built quite a number of cottages in the suburbs of Chicago for profit before the 1912 agreement inhibited them from so doing. The large contractors argued that they were maintaining an office and an administrative force to do this work and should not be obliged to compete with men who did not have such expenses. They won the case. The journeymen can no longer build cottages. In the case of the open shop "trim," the large contractors successfully argued that such a rule would give the manufacturs of union-made trim a monopoly of the business. They carried their point again.

Third, to what extent are the rules the expression of the men and of the leaders? It is impossible to measure the influence of the journeymen in framing the rules or in interpreting them. It is true that they exercise the right of referendum on all rules and this power probably has some influence on the nature of the rules. On the other hand, the men generally do not know the rules nor understand them. (*162-9.) Probably the only interpretations the men get of the rules are made in the meetings of the union. Seldom do the men hear the discussions of the rules on the job. If a dispute arises it will be settled between the officers of the two organizations and not in the presence of the men. Furthermore, the men regard the rules as legislation which should be obeyed. The journeymen usually do as they are told and seldom exercise the power of the referendum. The rules are drawn up by the executive council, and interpreted by the Arbitration Board and Business Agents. When the Stewards are obliged to interpret them "they always attempt to do so in accordance with the established precedent of the business agent." (*169.) These methods of legislation and administration are the results of experience and custom. The product is a practical set of working rules.

Two factors operate strongly in determining the rules for the union; namely, the contractors and custom. Such rules as prohibit contractors from using tools on the job, and oblige the men to work with non-union men of other trades, are admittedly forced upon them by the contractors, as the established pay day on Tuesday is largely for the contractors' convenience. (*38-39; 43-48; 67-73; 76-78.) "The contractors demanded this or that," is a common form of expression with the men. One leader said, with respect to the rule obliging them to work with non-union men of other trades, that "the employers demanded this rule." (*68.) Another leader, speaking of the same rule, said, "This was put in the agreement in 1901 after the year's lockout in the building trades upon the request of the contractors. The union don't like it, but can not get it out." (*69.) Relatively few rules are, however, so distinctly forced upon the union.

The influence of custom is not so easily detected. The bearing of the standard of living upon wages and that of wage scales of other unions, have their foundation in the influence of custom. The carpenters seem to have an idea of this factor but consider it inevitable One journeyman said, " The men do not object to miniature saw mills on the job . . because it has always been the custom." (*156.) A prominent leader said, "Whenever a boss tries to employ non-union men of other trades to set up a precedent, the carpenters are called off the job. The other trades do the same." (*69.) Satisfaction with the conditions established by the force of custom makes it necessary not only to overcome the opposition of those injured by a change, but to educate the members of the union to the point of desiring more and better things which custom denies them.

Encroachments are by-products of custom. Encroachments upon the agreements and the trade by other trades and the employers form a most serious problem for the carpenters. This problem arises in the wake of custom and the development of industry. Who shall hang a door which is covered with sheet metal? The carpenters have always hung the doors. That is custom. The sheet-metal workers have always done all of the sheet metal work. That is custom. The development of the art has brought the sheet-metal door. Custom would justify either the carpenters or the sheet metal workers in doing the work. Both claim the exclusive right to do it and a bitter struggle has ensued.

From present indications in this direction there will be no carpentering in the buildings in the business sections of our great cities in less than twenty-five years. Indeed, many carpenters fear this change will take place in fifteen years. The general introduction of steel and the disappearance of timber will hasten this transformation. (*170.)

The encroachments by the employers are less important but perplexing. The bosses constantly curtail the work during the period of the joint agreement. According to the union the character of the work in certain lines are changed or eliminated and new kinds are introduced, which are not covered in the agreement.

The influence of the conditions and needs of the trade from year to year are, however, the dominant force in determining the nature of the carpenters' rules and must ever remain so if the union is to remain realistic. Some of the rules are, and probably will continue to be forced upon the union from without, but the conditions of the trade, the necessity of control over the men, and the rising costs of living are the chief factors.

If the leaders, the condition of the trade, the contractors, and custom are the dominant factors in developing the carpenters' working rules, to what extent do the journeymen, (the rank and file) understand them and their underlying principles? Journeymen who were interviewed always admitted lack of knowledge on some rules and some actually knew little or nothing of the rules in the light of other explanations. One leader speaking of this, said "Not 25 per cent of them know anything about the rules." (*162.) Another leader said, "They know nothing about the rules." (*181.) Even when the journeymen know an immediate explanation for particular rules, they do not often connect the rule with the underlying principle, aim or theory. For example, one journeyman thought the eight hour day was for work sharing without connecting work-sharing or the eight hour day with their relatively fixed demand theory, which stands out so prominently in the evidence of the leaders. Journeymen are disinclined to probe into the aims or purposes of rules or theorize about them. One journeyman speaking of the source of the rules, said, "There is no theory about trade unionism or trade unionists. It is all and only realistic. A theorist is never listened to by the unionists." (*165.) Thus the hypothesis that trade unionists do not comprehend, to a very great degree, their rules and much less the underlying principles and theories as given by the leaders is strongly supported.

Whatever the dominant force in union legislation may be, it is now our purpose to inquire into the extent to which such legislation or rules are enforced. The carpenters' joint agreement contains few obsolete rules. A small number of unenforced rules are likely to be found in every body of rules or laws. It should also be expected that some rules are enforced under one circumstance and not under another. In speaking of the rule compelling union carpenters to work with non-union men of other trades, one leader said, "This rule must be applied with judgment. There is a lot of give and take in it." (*69.) If the rules are the result of conditions as explained by the unionists, it could hardly be supposed that they would be repealed as soon as they become obsolete. There is generally no incentive to repeal a dead-letter law, by a legislative body. Such rules as the investigation of the pay envelope, and the report of the exact location of the job, are admittedly obsolete. (*63-66; *113-114.) In the first instance, the evil of undercutting is accomplished in a much more subtle manner than the rule comprehends, and in the second instance, the information collected was not used. This led the stewards to discontinue sending many facts and perhaps the district council did not encourage their collection because they were unable to handle the material. The information about the jobs was desired to enable the officers of the district council to direct more intelligently those seeking work. Some think the ideas contained in these rules excellent and that they should have been continued. The district council could thus help men get work and at the same time collect data on the building trades and unemployment.

There are some rules that cannot be enforced; for example, rules prohibiting rushing, and underbidding in some of its more subtle forms. (*136-141; *59-62.) In spite of the careful supervision over rushing, there are rushers on every job in Chicago, according to the best information I could get. The carpenters admit that rushing cannot be prohibited because of the selfishness of the men and the "weakness" of human nature. (*136.) Undercutting in the form of wage returns are generally admitted as prevalent. (*61, 60, 62.)

It is unsafe to generalize too broadly on the spirit of the men from such a small amount of evidence as I have collected, yet one can hazard a guess upon the subject without being ridiculed. Although I had personal interviews with less than two dozen men, I saw several thousand men at work on my tours and from time to time met a considerable number of journeymen who were unemployed. I was impressed with their energy and industry while at work. They seemed conscientious and anxious to make their services profitable to their employer. I was also impressed with the absence of conversations between the men yet there exists a sympathetic attitude between them.

The hypothesis that the journeymen distrust the leader is strengthened by the opinion of several journeymen and leaders as well. (*177-179.) In one interview with several men, they said that the "officers give or sell our rights and privileges outright to the bosses." (*179.) Or, in the words of another journeyman, "The officers lose their heads and the spirit of the trade when in office and away from the tools too long. The employers either are able to buy them when need be, or get their consent when the labor officials are drunk." (*178.) One conscientious leader said, with regard to this distrust that "Their distrust is usually unfounded, but the journeymen think that, because the officials can't always get just what the journeymen want, they (the officials) sell out." (*177.) There seems, however, to be little doubt but that the rank and file of the carpenters distrust the officers, whether the distrust is well founded or not.

Finally, what advantages do the men think they get from the union and why do they want and need a union? It seems impossible to get a comprehensive understanding of the nature of a trade union, from the carpenters. They have quite definite ideas of what the union is for and its "business" but not of what it is. They recognize an element of group action in a union. One journeyman, after considerable explanation, said, "a trade union is group action for collective bargaining." (*176.) One leader laughed at me when asked what a trade union is. They are not so much concerned about what a union is as what it does. The general tone of the interviews shows that the men want a union to get more now. This is strongly supported by direct evidence. The "Carpenter," speaking of this, says, "The organized labor movement has so far proved the only practicable means of giving the working people as a whole a chance to obtain what the Great Maker surely intended every man and woman to have; namely, a decent living." (*174.) Or again, "We shall look out for ourselves, . . God helps those who help themselves, and we practice what we preach." (*175.) And according to one journeyman, "Our union rules are for the advantage of the union members, and we want a union to get us good wages, good conditions, and short days." (*164.)

They also think that they need a union in order to treat with the employer in a group, in order to get something which they could not get by bargaining individually, because of the apparent advantage the employer would have over them. Their theory of relatively fixed demand and the ever present over-supply of labor coupled with the antagonistic interest of the employer probably force this conclusion. Another journeyman said, "If we did not have a union some one would come in and take the benefit of our efforts and labor would be left with longer hours and less pay. (*175. *168.)

Thus the carpenters want the union because they cannot succeed in individual bargaining, and because of the immediate benefits which the union can get for its members. They are not anxious to do anyone injustice, nor are they devoted to the cause of establishing justice in their trade between employer, employee and the public. They are anxious to have the expedient thing of the hour done and reap their benefits immediately.

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*Starred numbers refer to the sheet of evidence.

ZOOLOGY.

PECULIAR NESTING BEHAVIOR OF A ROBIN.

BY BERTRAM G. SMITH.

Early in May, 1914, Miss Mary Goddard called my attention to the peculiar behavior of a robin which was nesting on the fire escape just outside the window of her office on the second floor of the Science Building.* The robin had begun the construction of a series of five nests, located on five successive steps of the stairway. The first nest, located on the first step above the platform, was represented by only a few bits of nest-building material; the second nest was nearly finished; the third, fourth and fifth were in successively earlier stages of construction, the last one being only slightly more advanced than the first. During the next few days the second and third nests were completed, but only slight additions were made to the other two. Nest-building was then discontinued. An egg was laid in the second nest and another in the third; an additional egg was then laid in the second nest. (See Pl. IV.) The robin then commenced the task of incubating the eggs, dividing her time between the two nests containing eggs. After about five days she abandoned the nests; possibly she was frightened away.

It seems quite certain that the nests were the work of a single robin, or at most a single pair of robins. Robins do not ordinarily nest in communities; only one robin at a time was ever seen near the nests. It is certain that none of the nests were left over from the preceding year.

This strange nesting behavior naturally aroused much interest among the students and teachers. The comments brought forth indicated that most of the observers thought the bird was crazy—"that fool robin" was the way one person expressed it. My own interpretation is that the bird was perfectly normal, but that the circumstances served to test the limitations of the robin mind. The locality-memory of the bird was confused by the similarity of the successive steps. In other words, we may regard the whole affair as an experiment whose results show that the robin cannot count. It is significant that the nests were built simultaneously, not successively. If we were to plot a curve showing the amounts (by weight) of the material on successive steps, the curve would indicate that the material was distributed in the main according to the

*Zoological Laboratory, Michigan State Normal College, Ypsilanti.

laws of chance, assuming that the start was made on the second or the third step. The "skewness" of the curve (i. e., the fact that the mode is not exactly at the center of the series) may be due to the fact that the platform furnished a landmark at one end of the series.

I am indebted to Professor Goddard for aid in making the observations upon which this account is based, and to Mr. C. C. Edwards for photographing the nests.

NOTES ON THE LATE HISTORY OF THE GERMINAL VESICLE IN CRYPTOBRANCHUS ALLEGHENIENSIS.

BY BERTRAM G. SMITH.

The observations here recorded are supplementary to the account of the history of the ovarian egg contained in Part I of "The Embryology of Cryptobranchus"* (Smith, 1912).

THE GERMINAL VESICLE AT THE SURFACE OF THE EGG.

The question of the nature of the opaque globules. At the time when the egg is ready to leave the ovary, the germinal vesicle is a conspicuous object at the surface of the egg at the animal pole (Pl. V A). In the living egg, the contents of the germinal vesicle consist for the most part of clear liquid; but floating at the surface are usually to be found some opaque white globules readily visible to the naked eye. These were successfully photographed, but lost much in distinctness in the half-tone reproduction. In the paper above cited I suggested that they might be nucleoli. To be sure, they are much larger and fewer in number than the numerous small nucleoli usually found at the center of the germinal vesicle of eggs that have been stained and sectioned; but it occurred to me that this difference might be due to the action of reagents used in fixing and preserving. The point seemed worthy of investigation.

The action of reagents on the nucleoli. The study of the effects of some reagents on the nucleoli was undertaken primarily in order to determine whether the opaque objects seen from the surface were the real nucleoli unaffected by reagents. It was conceived that the nucleoli might be broken up and in part dissolved by the acetic acid used in the fixing reagents, or by the acids present as impurities in the formalin used for fixation and preservation. Hence eggs were fixed by two methods not involving the use of an acid; Neutralized formalin followed by Müller's solution, and bichromate-formalin in which the formalin was neutralized. In both cases the nucleoli appearing in sections seemed precisely the same as if acetic acid or ordinary formalin had been used in the fixing solutions. The results afford evidence that the nucleoli are not identical with the opaque globules seen from the surface, and, what is perhaps of

*The Embryology of Cryptobranchus allegheniensis, Pt. I, Jour. Morphology, vol. 23, No. 1. March.

greater importance, they serve to strengthen our faith that the reagents ordinarily used in fixing solutions do not destroy the objects they are intended to reveal.

Yolk islands. Some material obtained in the fall of 1913 gave preparations which seem to afford direct evidence that the problematical bodies seen in living material are not nucleoli and are not even included within the nuclear membrane; they are composed of small masses of yolk that become imprisoned between the vitelline membrane and the germinal vesicle when the latter approaches the surface. For convenience they may be called "yolk islands" (Pl. V B). My earlier preparations comprised only a few slides showing the germinal vesicle at the surface, and these happened not to have the yolk islands. These objects thus prove to be lacking in theoretical importance, but from a practical point of view it is worth while to have determined their nature in order to eliminate them from further consideration in connection with studies of the germinal vesicle.

THE RECESSION AND DISSOLUTION OF THE GERMINAL VESICLE.

The migration of the germinal vesicle from the center of the egg to the surface at the animal pole has been previously described (Smith, 1912); but formerly I was unable to secure the exact stages showing the dissolution of the germinal vesicle. One lot of material preserved during the fall of 1913 gave the stages desired.

The dissolution of the germinal vesicle does not take place at the very surface of the egg, but the vesicle recedes a not inconsiderable distance before dissolution occurs. During recession a trail of cytoplasm is left between the germinal vesicle and the animal pole. In some eggs the germinal vesicle appears to be in a state of disintegration without ever having reached the animal pole, as shown by the absence of this trail of cytoplasm.

The dissolution of the germinal vesicle takes place by a gradual disintegration and convergence of its membrane, rather than by a localized rupture such as would be expected to occur if it burst through pressure from within. During the process the disintegrating wall becomes thicker and more spongy in nature, and stains more deeply than before.

In my preparations I have found but a single egg showing the germinal vesicle just before the process of dissolution is complete. This egg was stained in toto with paracarmine. The vesicle contains, besides some nucleoli, numerous deeply stained spherical or lobed bodies, resembling nucleoli but much larger and not so regular in form. They may be artifacts, but my impression is that they represent aggregations of some substance precipitated from the nuclear sap during the contraction of the nuclear membrane. Since they have never been found in sections of earlier stages, it is not likely that they are the opaque globules seen from the surface in the living egg.

The germinal vesicle usually collapses before the egg escapes from the ovary, but in some females a few eggs with the germinal vesicle still at the surface were found in the body cavity.

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NOTE ON THE PROPORTIONS OF THE SEXES IN THE WHITEFISH.

BY RAYMOND PEARL.[1]

In the summer of 1901, while engaged in a study of variation in certain fish, in connection with the Biological Survey of the Great Lakes directed by Professor Jacob Reighard, I collected some statistics regarding the proportions of the sexes in the common Whitefish of Lake Erie, *Coregonus albus* Jordan and Everman. In more recent years interest in problems connected with the determination of sex has impressed me with the great dearth of definite statistics regarding the normal sex-ratios of even the commonest animals. For that reason it seems now desirable, merely as a matter of definite record in the literature, to publish the data for *Coregonus*.

The fish were taken in deep water gill-nets in Lake Erie off Dunkirk, N. Y. The data were obtained by standing beside the benches where the fish were dressed and recording the sex of each as it was opened. There was no selection whatever in the recording. The results represent the sex distribution of that sample of the Whitefish population in the early summer which was caught in a gill-net.

The statistics follow:

Date	Male	Female
July 1, 1901	14	15
" 2	112	120
" 3	98	129
" 5	43	52
" 6	119	139
Total	386	455

This gives a sex ratio of 848 males : 1,000 females.

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1. The writer is indebted to Mr. W. C. Kendall of the Bureau of Fisheries, for a discussion, *in lit.*, of the terminology of the whitefish of the Great Lakes.

THE PREPARATION OF SERIAL SECTIONS OF FROG EMBRYOS.

BY BERTRAM G. SMITH.

The developmental history of the frog is one of the best with which to illustrate the fundamentals of vertebrate embryology. Particularly is this true of the early stages, since cleavage and gastrulation proceed in a manner which is presumably more primitive, and certainly more easily observed, than the same phases of development of the chick. But the difficulty of preparing serial sections of these early stages of the frog embryo has discouraged many from using this material for class work.

In attempting to prepare serial sections of frog embryos in early stages, fixed in Tellyesnicky's solution,[1] the writer had trouble in cutting paraffin in sections on account of the crumbling of the yolk. Experience with other amphibian eggs led to the hope that a remedy might be found in proper fixation of the eggs and careful attention to some other details of paraffin technique, rather than in resorting to the tedious method of celloidin technique.

FIXING.

It is well known that formalin is a good fixing and preserving solution for embryos of the frog intended for surface study only, and some have reported fairly satisfactory histological results from embryos, in late stages, fixed in rather strong formalin. I sectioned some embryos, in blastula and gastrula stages, fixed in formalin (10% to 20%) only. When imbedded in paraffin, they cut like wax, in fairly thin sections, at ordinary room temperature. The form of the embryo is preserved perfectly. On the other hand, the cytological details were not good; numerous small fissures extended in all directions irrespective of cell walls and it was difficult to determine the outlines of individual cells; the germ layers were not well differentiated.

The results suggested that a combination of formalin with the bichromate-acetic solution might prove successful. I therefore used the bichromate-acetic-formalin solution that had already proved well

1. The solution is made up as follows:

Potassium bichromate............	2g.
Glacial acetic acid................	5cc.
Water	95cc.

adapted to the more heavily yolk-laden egg of Cryptobranchus. The formula is as follows:

Potassium bichromate	1 gram
Glacial acetic acid	2.5 cc.
Formalin, Schering's	5 cc
Water	97.5 cc.

Eggs fixed in this solution cut better than those fixed in Tellyesnicky's solution, but the yolk was still slightly brittle. By cutting thick sections (20 microns) at a high room temperature crumbling of the yolk could usually be avoided. The cell structure was well preserved.

The results with these three fixing solutions pointed to the use of formalin, in combination with a small proportion of potassium bichromate and acetic acid, as a satisfactory fixing solution for the frog's egg. The following formula was tested and proved entirely satisfactory:

Potassium bichromate	0.5 gram
Glacial acetic acid	2.5 cc.
Formalin, Schering's	10 cc.
Water	87.5 cc.

The sections should be cut 15 to 20 microns thick, in a warm room.

The envelopes are most easily removed before fixation, but care must be taken not to disturb the egg by rough handling, since this may result in a rearrangement of internal structures. In the gastrula stage the thin septum between blastocoele and gastrocoele is easily broken down. For this reason, and because one may find it inconvenient to spend time in removing the envelopes when preserving eggs, it is desirable to choose a fixing solution that will permit of the eggs being killed with envelopes intact.

With fresh material, with material preserved in formalin only, or material preserved in a bichromate-formalin-acetic solution containing not more than 0.5% bichromate, the envelopes may be easily removed by holding the eggs in the palm of the hand, or on moist filter paper, and cutting the envelopes with a sharp scalpel. If the material has been fixed in a solution containing more than 0.5% bichromate, it is necessary to remove the envelopes with sharp needles, and this is a difficult and tedious process.

Eggs fixed in a bichromate-acetic solution should be rinsed in water, and washed in frequent changes of weak formalin (5%) for several days, until the formalin is no longer discolored. If the envelopes are left intact, it is important to preserve the eggs in formalin rather than in alcohol, since the latter causes the envelope to shrink and become tough, and usually renders the egg worthless.

Although formalin is such a valuable reagent for fixing and preserving frogs' eggs, it does not follow that it is good for all amphibian eggs. On the eggs of Amblystoma, formalin has a very pernicious effect.

For fixing frogs' eggs after the closure of the neural folds, I have used Lavdowsky's mixture with very satisfactory results. The envelopes must first be removed, but this may be done rapidly in these stages. I have not tried the solution for early stages. The formula is as follows:

Formalin, Schering's	10 parts
Alcohol, 95%	50 parts
Glacial acetic acid	2 parts
Water	40 parts

The material should remain in this solution for a day or two, then it should be preserved in 70% alcohol.

EMBEDDING.

It is helpful to leave the embryos for a day or two in a mixture of 52° paraffin and xylol, at a temperature of about 40° C., before putting them in pure melted paraffin at the higher temperature. Infiltrate in 52° paraffin at a temperature not to exceed 55°, for several hours, changing the paraffin once or twice.

In the early gastrula stages, the embryos are difficult to orient in melted paraffin, because of the faintness of the landmarks. This difficulty may be reduced to a minimum by attention to the following details: Use bright daylight or a strong Tungsten light. Imbed in a shallow paper box resting on a black plate. The work is best done in a warm room or over a warming oven. Use a hot needle to keep the paraffin melted. Orient under a lens. Several eggs may be oriented in one box; they should be placed close together in a row, to save time in cutting.

STAINING.

The embryos may be stained in bulk in Grenacher's borax carmine, which should be allowed to act for a day or two in a warm room. Destain in 70% alcohol containing 0.25% hydrochloric acid.

Counterstain on the slide with Lyons blue to which sufficient piric acid has been added to turn it green.

In early stages the borax carmine may not stain the nuclei with sufficient intensity. These stages may be stained in bulk in para-carmine, which should be washed out with 1% acetic acid; or the embryos may be stained on the slide with Delafield's haemotoxylin and counterstained with Orange G.

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THE PORIFERA, OLIGOCHAETA, AND CERTAIN OTHER GROUPS OF INVERTEBRATES IN THE VICINITY OF DOUGLAS LAKE, MICHIGAN.*

BY FRANK SMITH AND BESSIE R. GREEN.

Little has been published concerning the Michigan representatives of certain groups of aquatic invertebrates. It therefore seems advisable to make known the results of our observations on some of these groups as represented in the vicinity of Douglas Lake in Cheboygan County of that state. The observations were made by the senior author during the four summers of 1911-1914 while on the staff of the University of Michigan Summer Session at the Biological Station and by the junior author during the summers of 1911 and 1913, during the latter of which she held a research fellowship.

The groups chiefly studied were the earthworms and the fresh water-sponges, but a few additions were made to the lists of forms known in the vicinity, in certain other groups.

FRESH-WATER SPONGES.

Nine species of sponges were found in the Douglas Lake vicinity although none were collected in the lake itself. The wave action is too violent in the shallower parts of the lake to permit such development and we made but little search for sponges in the deeper parts. Seven species were found in the streams connected with the lake and in the beach pools along its shores. Along with three of these species, two additional ones were found in a small pond in what is known at the Station as Smith's Bog, about two miles to the southeast. The list of species and localities follows.

Spongilla fragilis Leidy. Abundant in Bessey Creek, beach pools, and Smith's Bog. Also collected in Burt Lake and Indian River.

Spongilla lacustris (L.). Common in Maple River.

Ephydatia mülleri (Lieberkühn). Common in Maple River. Also collected in Burt Lake, Crooked River, and Indian River.

?*Ephydatia fluviatilis* (L.). Bessey Creek. We have tentatively referred to this species a number of specimens which differ somewhat from the typical form but about whose exact status there is

*Contribution from the University of Michigan Biological Station No. 32.

some doubt. In addition to the ordinary birotulate spicules of the gemmules, there is a variable number of bicapitate spicules with heavier shafts, which tend to lie near the inner ends of the birotulates and to approximate a tangential relation to the gemmule wall. It is intended to give them more extended treatment in a later paper.

Heteromyenia repens (Potts). Common in beach pools and Smith's Bog. Also collected in Burt Lake.

Heteromyygenia ryderi Potts. Common in Bessey Creek and Smith's Bog.

Heteromyenia argyrosperma (Potts). Common in Smith's Bog.

Carterius tubisperma (Mills). Abundant in Bessey Creek and beach pools.

Tubella pennsylvanica Potts. One specimen in Smith's Bog.

Some species have a much more general distribution than others and it was noticed that in some of the situations studied, there was a marked difference in the relative numbers of certain species in different years. This was especially noticeable in Bessey Creek where the most abundant species in 1911-1912 was the form listed as *Ephydatia fluviatilis?* and *Heteromyenia ryderi* was not collected. In 1913, the last named species was decidedly more abundant than the former.

BRYOZOA.

Plumatella punctata Hancock. This is by far the most abundant species and is widely distributed in the region. It is common on the submerged surfaces of various water plants and many non-living objects.

Fredericella sultana Blumenbach. Occurs sparingly near Grapevine Point in Douglas Lake and also in Burt Lake.

Cristatella mucedo Cuvier. Numerous colonies were found in Maple River near Douglas Lake in July, 1913 and 1914. Ciliated embryos were liberated in considerable numbers during the next few days after collection. Statoblasts were not present and hence it was not determined whether the typical form or a variety was represented. Statoblasts from the typical form were found in Munroe Lake, a few miles distant.

OLIGOCHAETA.

The earthworm fauna of the region corresponds in general with what one would be led to expect from a study of the few papers already published, which deal with the earthworm fauna of the northern tier of states and of Canada. With the exception of the widely distributed *Sparganophilus eiseni*, the species represented are all *Lumbricidae*.

Sparganophilus eiseni Smith. Abundant in the mud of the bottom and margins of beach pools and the less exposed shores of the lake.

Helodrilus tetraedrus (Savigny). A few specimens of the typical form of this species were found at the margin of a pool near the north shore of Burt Lake.

Helodrilus foetidus (Savigny.) In rotten logs near the west shore of Douglas Lake.

Helodrilus caliginosus trapezoides (Dugès). Fairly common in the soil of the hardwood forest area on the west side of Lancaster Lake and in the "Gorge."

Helodrilus tenuis (Eisen). Common under the bark of rotting logs near the shores of Douglas Lake. Numerous specimens were found in an old heap of decaying horse manure mingled with sawdust, near an old lumber mill site at the north end of Burt Lake. Various conditions in the development of spermathecae were found in the sectioned specimens. In other respects the specimens were similar to those of *H. tenuis*. The relations of these worms are obscure and their discussion is left for a later paper.

Helodrilus parvus (Eisen). Under logs on the shore at the west end of Douglas Lake.

Helodrilus beddardi (Michaelsen). In moss on shore of brook in the "Gorge."

Helodrilus zeteki Smith and Gittins. Fairly common in decaying logs of the hardwood forest areas near Douglas Lake.

Lumbricus rubellus Hoffmeister. Under debris along the shore of Douglas Lake near Ingleside and Bryant's.

The *Enchytraeidae* of the region are receiving attention from Dr. Welch who has already described two species: *Fredericia douglasensis* Welch and *Henlea tubulifera* Welch.

The only species of the *Lumbriculidae* that is represented in our collections is *Lumbriculus inconstans* (Smith) which is abundant in the detritus of the bottom and margins of beach pools and the less exposed shores of the lake.

Very few *Tubificidae* were collected and as they are mostly immature, no complete identifications have been made. *Tubifex* and *Limnodrilus* are both represented.

No special study was made of the *Naididae* but the following species were noticed.

Chaetogaster diaphanus Gruithuisen. Common in masses of algae.

Chaetogaster limnaei von Baer. Abundant on *Lymnaea stagnalis appressa* (Say).

Nais communis Piguet. Abundant in algae and on surfaces of submerged vegetation.

Stylaria lacustris L. Abundant in algae and on surfaces of submerged vegetation.

Pristina longiseta leidyi Smith. Common in the vegetation of beach pools.

Aeolosoma tenebrarum Vejdovsky. Common in beach pools.

The *Discodrilidae* are receiving attention from Dr. M. M. Ellis.

CRUSTACEA.

Cambarus diogenes Girard. This species is not included in the list of Pearse (1910), as occurring in Cheboygan County, but is abundant in a large beach pool at the east end of Douglas Lake and was also found near the north end of Lancaster Lake. The late summer ecdysis occurs about the middle of August and the males then acquire the first form of abdominal appendages.

MOLLUSCA.

The only addition to the list of mollusks known to occur in the region is *Lymnaea megasoma* (Say). Specimens were found in abundance by the senior author and Dr. W. W. Cort in a pool at the village of Indian River near the south end of Burt Lake in July, 1914.

University of Illinois.

BOTANY.

CUCUMBER SCAB CAUSED BY CLADOSPORIUM CUCUMERINUM.[1]

BY S. P. DOOLITTLE.

IMPORTANCE OF THE DISEASE.

The scab or "black spot" of cucumbers caused by *Cladosporium cucumerinum* Ell. & Arth., was first noted in the United States about 1887 and since that time has been reported as generally prevalent in both this country and Europe. It has appeared at various times in nearly all parts of the United States where large quantities of cucumbers are grown and is also quite common in England and Germany.

The disease is found both in the field and in the greenhouse but is more especially connected with the growing of cucumbers for pickling, since the young fruits used for this purpose are most susceptible.

During the past two seasons it has been very severe in the states of Michigan, Indiana, and Wisconsin. This territory is the center of the pickle growing industry and the crop reaches a high valuation each year.

The fact that the nature of the fungus causes it to spread from field to field with great rapidity and that the young fruits are the most subject to attack makes the loss severe.

This is not all due to the actual fungus injury however, but to the fact that the scab lesions give a point of entrance to various soft rots. When the cucumbers are mixed together after picking, the rotted ones affect the sound fruits as well and they become useless for pickling.

The difficulty and expense of sorting out all damaged fruit, a thing which the average grower will not do thoroughly, has led many salting stations to refuse all the fruit from fields which are seriously infested with the fungus. This greatly increases the loss to the grower since he has no other means of disposal of the crop.

The disease was particularly severe last season at Big Rapids, Michigan, and in the northern part of the State in general. In this locality the yield was greatly reduced although there are no

1. Part of thesis presented for degree M. S. at the Michigan Agricultural College, 1915, under the H. J. Heinz Industrial Fellowship.

figures available. The growers are beginning to realize that it is uncertain whether they can much longer grow pickles at a profit and are slow to contract for more acreage. This falling off is watched with anxiety by the companies having stations in the district since if it continues they will be obliged to change their locations and the expense of such a step would be a large loss to them and to the growers.

HISTORY.

The disease was first found in this country at the Geneva Experiment Station, in 1887[2], when it was noted by J. C. Arthur, who described it as probably being a Cladosporium.

It was first studied by him also, at the Indiana Experiment Station in cooperation with J. B. Ellis of New Jersey, in 1889[3]. The disease was very severe in that year and investigation proved it to be due to a new species of Cladosporium, which they named *Cladosporium cucumerinum.*

Arthur describes the disease as appearing first as a sunken spot with a velvety surface, from which there may be a gummy exudation, giving the appearance of an insect injury. As the disease progresses a small cavity is formed beneath the fungus-covered surface. He states that this is due to the action of the mycelium which dissolves the cell walls, thus causing the exudate of gum on which the fungus subsists.

No other work was done except the description of the main symptoms and characters, control measures not being discussed.

Frank found the disease in a garden near Berlin in 1892[4], and his description is practically identical with that of the fungus found by Arthur. Not having heard of Arthur's work he called it *Cladosporium cucumeris.*

He stated that it was quite prevalent in Germany at that time and noted that the growers were using Bordeaux mixture to combat it, with very little result. This fact led him to experiment with the effect of Bordeaux mixture on the spores of the fungus.

A portion of the infected material was taken and immersed in a 2% Bordeaux for two hours, taking care that the spores were actually in contact with the fungicide. After this period they were washed thoroughly and their power of germination tested. He found that the copper apparently was not fungicidal in its action toward the spores as they germinated readily. However, no work was done beyond this one experiment.

2. 6th. N. Y. Agri. Exp. Sta. Report. 1888, p. 316.
3. Bull. 19. Indiana Agr. Exp. Sta. 1889. p. 8.
4. Frank, A. B. Zeitshr f. Pflanzenkr. III p. 30, 1893.

Humphrey[5] noted the disease in Massachusetts as affecting the leaves in the season of 1892, no other part of the plant being attacked. The leaves are described as showing translucent, watery spots, the fungus growing within the tissue and sending out through the stomata, hyphal branches on which the conidia were produced.

He describes the spore production as follows:—"A highly complicated mass of spore threads, consisting of the successive acropetal production of sprout buds from the originally terminal joints so that there are formed chains of successively smaller and smaller cells."

He simply described the organism without recommending any control beyond the suggestion of spraying.

In 1896[6], Aderhold noted the fungus near Breslau in Germany and identified it as *Cladosporium cucumerinum* Ell. and Arth. He inferred its parasitism from inoculation experiments with field material and found it prevalent both in the gardens and under the glass.

He endeavored to connect it with *Sporidesmium mucosum* found on other cucurbits but did not find sufficient ground to warrant such a belief.

Since that time the literature shows little work on the disease, the few references being confined to mere mention of its occurrence. There is no record of special experiments for its control except the work of Frank mentioned above. I have it verbally from Mr. W. A. Orton, however, that the Department of Agriculture conducted spraying experiments along this line in Michigan about 1905 with little success.

SYMPTOMS ON THE HOST.

On the fruit the disease appears as a very slightly sunken, water-soaked spot, usually accompanied by a small drop of gummy exudation. As the fungus progresses this spot becomes more sunken and is covered with a smooth, velvety, olive-black coating of spores and conidiophores. These spots are seldom more than 2-5 mm. in diameter, although several will often coalesce to form larger patches.

If cut through in cross section the fruit shows a shallow depression of about .5-3 mm. in depth. This depression is underlaid by a slight cavity in the flesh but the lesion never extends deeply into the fruit. Where the fruit is allowed to mature however, these

5. Humphrey, J. E. 10th Rept. Mass. Exp. Sta. 1892, p. 227.
6. Aderhold, R. Zeitschrf. f. Pflanzenkr. VI, 1896, p. 72.

spots may cause a cracking of the flesh or the cucumbers may be gnarled and deformed.

On the young fruit the infection seems to occur principally at the blossom end, there often being a number of spots at this point. This fact may be due to the blossom holding drops of moisture at this end of the fruit and thus allowing more chance of infection.

In the field the fungus will produce typical lesions in from two to three days under favorable weather conditions, i. e. heat and moisture. It was found by experiment that many of the spots which were unnoticeable at the time of picking would develop after the fruit had been in the crate for 24 hours, since the mass of pickles generates a certain amount of heat and moisture, thus furthering the growth of any fungus present. This fact explains some of the difficulty experienced in trying to cull out all infected fruits from diseased fields.

On the stem the lesions appear first as a slight crack at the surface, accompanied by a gradual splitting if growth is rapid. These lesions often attain a length of from .5-1 cm. but are usually only from 4-6 mm. long. They occasionally extend rather deeply into the stem and may cause it to break off but ordinarily the injury is superficial. The surface of the spot is not densely covered with spores as it is in the fruit but has more of a brownish, roughened appearance. Spores are present together with the conidiophores but do not produce a dense felt as on the fruit.

The character of the disease on the petioles is exactly similar to that on the stem. In both cases the lesions are slower to develop than on the fruit, a period of 5 to 7 days being required before typical lesions occur under ordinary conditions.

On the leaves the fungus is not so conspicuous as on the other parts of the plant. It appears as a brown translucent spot which tears out very easily.

DESCRIPTION OF THE FUNGUS.

The causal organism, *Cladosporium cucumerinum*, was isolated from diseased fruits sent to the writer from Big Rapids. Inoculations into healthy cucumbers produced typical lesions in about five days, and from these the fungus was reisolated, thus proving its pathogenicity.

It consists of a much branched, closely septate, granular mycelium, which is occasionally enlarged and swollen so that the segments appear nearly globular. This last character is much more common on certain culture media than on the plant.

The conidia are borne at the apex of the fruiting hyphae, being formed by a simple cutting-off process. These hyphae are more slender than the vegetative mycelium and not so much septate. The conidia occur in chains and are occasionally two-celled though this is not common, most of the spores being single celled. They vary in size from 3-4 microns in diameter and 7.5-12 microns in length. They are ordinarily rather a broad oval, sharply pointed at one end but in the case of the two-celled forms we find them more cylindrical in shape. The chains are very easily broken and the spores detached so that it requires careful handling to observe them.

Spore germination takes place in from 20 to 26 hours, depending somewhat on the medium used. On germinating the spore sends out a rather large germ tube which may come from either end of the conidium or from both. This becomes septate soon after its appearance, being many septate under normal conditions. The branching is very profuse, the branches originating directly back of the septa and in some cases occurring from nearly every cell. The mycelial strands occasionally show a fusion but this is uncommon and the writer has observed it only in two cases.

Spore production takes place very soon, usually in two days upon ordinary media. The fruiting hyphae begin to cut off into conidia, at the apex of each tip if the hyphae be branched, and continue to bud off into more conidia. There soon is produced a very complicated chain of conidia, the whole cluster forming a complex branched mass.

As said before, these are very easily broken and in some of the older works we see the fruiting hyphae shown as having only the remnants of the spore chains still adhering to the conidiophore.

TABLE I.

REACTION OF ORGANISM TO VARIOUS MEDIA: UNSEALED CULTURES GROWN IN LIGHT.

Medium.	Spore Production.	Discoloration of medium.	Color of growth.	Rate of growth.	Size of spores.	Character of mycelium.
Cucumber agar	After 2 days. Many.	None	Yellow to dark olive	Rapid	3 x 7 m Mostly 1-celled.	Much branched many septate.
Nutrient agar	After 2 days. Many.	None	Light olive with light buff border	Medium	4 x 7.5 m mostly 1-celled.	Much branched segments swollen.
Hard potato agar	After 2 days. Few.	None	Olive green	Slow	3 x 7 m mostly 1-celled.	Slender, not much branched, short conidiophores.
Cornmeal agar	After 2 days. Many.	None	Slate olive	Medium	3.5x7-8 m mostly 1-celled.	Not closely septate.
Oat agar	After 2 days. Many.	None	Dark slate olive, light border.	Rapid	2.5-3x7 m mostly 1-celled.	Many septate not much branched.
Cucumber agar	After 5 days. Many.	Blackened	Whitish gray	Slow	3 x 7 m 1-celled.	Many septate conidiophores very long.
Carrot plugs	After 2 days. Numerous.	Darkened	Dark green olive.	Very Rapid	3.5-4 x 7-12 m Many 2-celled.	Not much septate. slender.
Potato plugs	After 5 days Many	Slightly darkened	Deep olive with light border.	Slow	4 x 6 m Mostly 1-celled.	Similar to that on carrot.
Celery stems	After 2 days. Few	Slightly darkened	Buff olive	Rapid	3.5x8 m 1-celled.	Large diameter many septate conidiophore short.
Boiled rice	After 2 days.	Reddish tint.	Dark slate gray	Medium	3 x 7 m	Much swollen in segments.
Cornmeal meal	After 2 days. Many.	None	Deep grayish olive	Rapid	3 x 7 m	Many septate much branched.
Parsnip	After 2 days. Many	Blackened	Olive green	Very rapid	3.5-4 x 7-10 m	Slender, not much septate.

UNSEALED CULTURES GROWN IN DARK.

Cultures grown in the dark showed very slight differences over those in the light. The rate of growth was slightly faster in the majority of cases and the colors varied a little in shade but no other differences were noted. The spores appeared about the same time and were similar in size and shape.

SEALED CULTURES.

The growth of the hermetically sealed cultures indicated that the organism does not thrive under anaerobic conditions, as the growth was very slow, ceasing after the ninth day in most cases.

From the examination of the above data it can be seen that the fungus behaves very nearly the same on all kinds of culture media. The most important fact brought out in the experiment was the rapidity with which spores are produced. The usual time was two days and it can be seen that a fungus which fruits so rapidly must of necessity be hard to control.

The best culture media of those tried were cucumber agar, parsnip and carrot plugs, particularly the latter. These furnished an excellent media for all kinds of work since great numbers of spores were produced within the space of two or three days.

The slight variations in color noted are not sufficient to warrant any particular notice since they were but shades of olive green.

The rate of growth was the most variable factor together with the fact that the fungus evidently does not thrive anaerobically, judging from the checking of growth in all the sealed tubes. The spore form does not seem to vary appreciably on different media nor does the character of the mycelium undergo any radical alteration.

DESSICATION EXPERIMENTS WITH SPORES.

A number of sterile cover glasses were used in this experiment, each one being smeared with a solution of spores of *Cladosporium cucumerinum* in distilled water. These were allowed to dry in the light at room temperature and were then broken up into small pieces, the fragments being planted in tubes of cucumber agar at intervals of 24 hours.

Five tubes were inoculated each day and the experiment was continued until the spores no longer showed the power of germination.

This was begun on December 24, and continued up to January 19.

After the 18th day the spores no longer germinated, and although 7 additional tests were allowed no further germination took place.

A second experiment was run at a later date and approximately the same result obtained, the spores retaining their vitality for 19 days.

While the resistance to dessication on glass seems to be only about 18 days, the conditions on the plant might be much different. The various materials found on the surface of seeds or on the plant or fruits might enable the fungus to survive a much longer period of drying in its natural environment than it would on clean, sterile glass such as was used in the experiment. This has proven true in the case of other organisms and the above data cannot be accepted as absolutely fixing the limit of resistance to dessication.

MAXIMUM, MINIMUM AND OPTIMUM TEMPERATURES.

The apparatus for this experiment consisted of a metal box having a compartment in one end filled with ice and one at the other end filled with water, kept heated by an incandescent lamp. The space between the two was divided into compartments, thus getting varying degrees of temperature as follows.

8° C.
11° C.
24° C.
29° C.
34° C.
43° C.
51° C.

These temperatures were maintained within one degree. Test tubes of cucumber agar inoculated with the fungus were placed in each of these compartments and the amount of growth, if any, observed.

TABLE II.

Tube.	Temperature.	Amount and Character of Growth.
1	8° C.	None.
2	11° C.	Very slight growth.
3	19° C.	Fairly heavy growth.
4	24° C.	Heavy growth.
5	29° C.	Very slight growth.
6	34° C.	Bare trace of mycelium.
7	43° C.	None.
8	51° C.	None.

From this date the maximum temperature seems to be about 33-35° C., the optimum about 23-25° C. and the minimum around 11° C.

THERMAL DEATH POINT.

The apparatus for this experiment consisted of an iron vessel filled with water and agitated by a small motor-driven paddle. A thermostat regulator attached to the gas burner beneath kept the water at the desired temperature and the tubes were suspended in a wire basket.

The temperature reading was made with a thermometer placed in a test tube of the same size and thickness and containing the same amount medium as those in which the spores were placed. These tubes were 18 mm. in diameter and about .5 mm. in thickness.

The temperature of the bath was held at the point desired from 3 to 5 minutes before placing the culture in the water. When the temperature was as desired the tube of melted agar was placed in the bath for 3 minutes to bring it to the required temperature and was then removed, quickly inoculated and placed again in the bath for exactly 10 minutes, when it was taken out and plated; three sets of test tubes were made with temperature ranging from 41°C. to 58°C. at intervals of 1°C. No growth appeared in plates from tubes heated above 50°C. and the thermal death point appears to be about 50°C. for 10 minutes.

RELATION OF THE ORGANISM TO TEMPERATURE AND HUMIDITY.

These data were obtained through the kindness of Mr. H. J. Buell, who conducted spraying experiments for the H. J. Heinz Co., at Big Rapids, Mich., in 1914.

The data on time of general infection was obtained from his notes and the meteorological data from the United States Weather Bureau reports.

TABLE III.

Plot.	Infection.	Date of last Rain previous.	Amount of rain.	Average Temperature following.
1	Aug. 29	Aug. 18-20	1.78	82°
2	Aug. 7	Aug. 1	.55	81°
3	Aug. 17	Aug. 9-10	.36	78°
4	Aug. 17	Aug. 9-10	.36	78°
5	Aug. 26	Aug. 18-20	1.78	82°
6	Aug. 16	Aug. 9-10	.36	78°
7	Aug. 29	Aug. 18-20	1.78	82°
8	Aug. 19	Aug. 16	.05	83°
9	Aug. 22	Aug. 18-20	1.78	82°
10	Aug. 25	Aug. 18-20	1.78	82°

These data show that general infection took place in about 4-7 days after heavy rains followed by hot weather in mid-August. From reports received from other localities, this seems to have been the critical period throughout Michigan, Indiana, and Wisconsin.

The fungus can endure a temperature of about 34°C. so that it is not checked by warm weather and is peculiarly severe during hot moist weather. Heavy dews also increase the severity of attack as the vines lie close to the ground and dry out slowly.

The fact that it grows under such conditions makes its attack most severe where the crop would be the largest, since the host plant is one requiring large quantities of moisture to produce large crops of pickles, the young fruits being 90% water. This fact necessitates a rainy season to make the largest crop.

Hence where vines are on rather low lands and the humidity is high, we find the fungus damage most serious. One field was noted in 1914 where vines grown on low land made so heavy a growth that the leaves completely covered the surface of the ground and the crop was a large one. Scab appeared in this field following a heavy rain and hot weather, and a count made a week later, showed 95% of the fruit badly infected with the fungus. In this case the hot, moist weather was unusually favorable for the parasite, but it shows how severe it may become, when conditions are favorable for attack.

INOCULATION EXPERIMENTS.

These experiments were carried on in the greenhouse with plants which had reached a fair size and were not infected with any fungus so far as known.

Inoculations were made in two ways as follows:

1. Spores were sprayed on the plants with a sterile atomizer, spores being in solution in sterile distilled water. The plants were all kept under bell jars with a good supply of moisture.

2. Plants were punctured with a sterile needle after the surface of the plant had been washed with $HgCl_2$ solution. Spores were introduced into the puncture with another sterile needle and the wound covered with a tiny piece of moist cotton.

Stem Inoculations:

Stem infection took place in practically all inoculations where punctures were made. The stem first showed a water-soaked spot at the point of inoculation after 3 or 4 days. In 6 days to a week it became a buff brown, and a slight splitting occurred. However, the plant was not growing fast enough to cause the large split seen under field conditions. The infection did not seem to extend deep into the stem nor far from the spot of puncture and it is likely that many of the lesions seen in the field are not entirely due to the fungus but also to the tendency of the stem to crack open when injured during rapid growth.

Leaf Inoculations:

Leaf infection was secured only where the plant was actually punctured and then in only a few cases. The infected spot became lighter in color and then gradually developed a translucent, brown appearance. This spot took up about one-half the leaf and soon became shriveled and water-soaked. The spores were borne sparsely on the surface but could be seen only microscopically.

The water-soaked, blackened appearance sometimes found in the field, is possibly due to outside infection with soft rots of some sort. The tissues are softened and the cell walls more or less dissolved so that the leaf would form a very susceptible medium for such infection. The writer has never seen this condition produced in plants inoculated with Cladosporium cucumerinum, nor does it appear to be a constant character in the field.

Inoculation of the Fruit:

With the fruit the same factor of mechanical injury was noted. Where the spores were sprayed on the fruit the successful inoculations were relatively few, while when injured they were almost universally successful.

The first sign of infection is a water-soaked spot accompanied by a gummy exudate, due to the dissolving action of the mycelium on the cells of its host. This appears about 48 hours to 72 hours after inoculation and becomes gradually more sunken until the fungus growth covers the surface and the entire epidermis is destroyed, being replaced by the mass of fruiting hyphae which give the olive black color to the infected spot.

The myeclium of the fungus as seen in stained sections does not penetrate the cells but exerts a dissolving action upon them. A cavity is formed beneath the epidermis and the mycelium is found pressed closely against the walls of the gradually disintegrating cells. This mycelium grows in a medium composed of the products of this cellular decomposition and in section we see the strands of mycelium massed around the edge of the cavity and intermixed with the gum and fragments of the broken cell walls. After the fungus begins to fruit on the surface and becomes mature the action of the parasite seems to be checked and the host begins to form a thin layer of cork cells about the lesion.

This seems to be resistant to the fungus action as the lesions are never more than 2-3 mm. deep. This corky layer is more apparent after the fruit is withered and dry, when the epidermis may be peeled off and the bare cavity will be found underlaid with a tough layer of corky cells.

When seen in vertical sections the fungus growth appears to be on the surface with a shallow cavity beneath, but this is not really the case as the epidermal tissue is entirely destroyed and the fungus penetrates as far as the bottom of the cavity. The formation is due to the fact that the web of mycelium hardens and dries on the surface by the evaporation of the gummy material's volatile portion and a sort of crust forms covering cavity beneath.

The threads of the mycelium do not seem to penetrate the cells but are found closely pressed along them. The cells, three or four layers back, in young lesions show traces of gradual disintegration by their broken walls, but the fungus apparently cannot actually penetrate the cell wall.

AGENTS OF DISTRIBUTION.

The methods of transmission of the disease may be many as the spores are produced in great numbers on the fruit and to some extent on the leaves and petioles.

The conidia are very easily detached and may be blow about by the wind to some distance so that this seems likely to be the most common means of dissemination.

The human agency is also a factor as the pickers may carry large numbers of spores on their clothes, shoes, and hands. Insects may also play a small part in the spread of the disease, and the splashing of water during heavy rains would account for further infection.

The fungus probably winters over in the trash of the year previous, since the stems, leaves, and pickles plowed under would carry a large amount of infectious material to reproduce disease during the following season.

The question of transmission by seed is an open one but there is a possibility that during the process of removing the fleshy portion of the fruit many spores might become attached to the seed coats.

RESISTANCE OF THE ORGANISM TO FUNGICIDES.

As no work had been done on the disease except that by Frank, it was decided to attempt to discover whether the copper sprays were as ineffective as had been supposed by most writers. Other fungicides were also tested in the hope of finding something which would prove effective. Frank's work was also duplicated in an attempt to see if the immersion of spores in the spray really was as harmless as had been claimed.

A culture of *Cladosporium cucumerinum* on carrot was taken and a small portion of the substratum heavily covered with mycelium and spores were immersed in a 2% Bordeaux mixture for two hours, taking care to agitate the spore bearing material in the spray and bring it actually in contact with the solution.

After two hours the fungus was removed, washed thoroughly in distilled water after a preliminary washing in a Gooch crucible submerged partially in a gently flowing current of water for some time, and then spores from the material were placed in hanging drops in Van Tieghem cells.

On examination of the spores after 26 hours it was found that 90% of them had germinated, indicating that Frank's work was correct. Immersion in a spray is not to be compared with conditions in the field, however, since in that case the fungicide has dried on the host in the presence of the various chemical agents in the atmosphere, and many chemical changes have occurred which alter the value of the spray to quite an extent. This has been pointed out by Wallace in his work on lime sulphur. He points to the fact that the only method which approximates natural conditions is where the fungicide is allowed to dry before it is brought in contact with the spores.

The method developed by Wallace and Reddick[7] is the best means of making tests of fungicides in the laboratory and comes very close to conditions in nature. This was the method on which the following tests were based with slight alterations in the methods.

Wallace's method consists of spraying one-half of a glass slide with the spray to be tested, leaving the other half blank to serve as a check. The slides are allowed to dry under atmospheric conditions for some time and are then ready for the tests. In making these a suspension of the spores is made and a drop placed on each end of the slide. These are kept moist and when sufficient time has elapsed the drops are examined and the percentage of germination on each and determined by count under the microscope. The comparsion of germination on the check and on the sprayed end will give a fair idea of the value of the fungicide.

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7. Wallace, E. and Blodgett, F. M. Cornell Bulletin 290, pp. 167-179, 1911.

The method followed in this work was the original Burrill[8] method. The experiments were set up as follows:

Seven cover glasses were sprayed with each dilution of fungicide used, these were allowed to dry at room temperature. These cover glasses were then used as tops to Van Teighem cells, a drop of the spore suspension being placed on each one.

A separate check was not run for each dilution but a sufficient number were made to be sure of an accurate determination of the average germination.

The spraying was done with an atomizer, taking care not to have too large drops and to cover the slide thoroughly. The spores were from a fresh culture on carrot.

The use of Van Tieghem cells instead of slides was to insure against drying out and to enable the spores to be counted with a 4mm. objective, which is necessary in the case of small spores.

The fungicides were used while fresh and mixed in large enough quantities to insure that they were like those used in the field.

In counting, six fields of the microscope were used on each drop, all spores being counted in each field, thus getting a fair average of the whole.

The formula for each spray is given with the results of the tests in the following pages.

TESTS WITH BORDEAUX MIXTURE.

The Bordeaux used in these tests was made up from two stock solutions, one of Chemically pure (Kahlbaum) CaO and the other of $CuSO_4$. These were both made up on a basis of 1 gm. to 50 cc. of water, which is approximately the equivalent of a mixture containing 8 lbs. to 50 gallons of water.

The two stock solutions were diluted separately and then poured together, being shaken for two or three minutes to insure proper mixing of the chemicals.

The spray was not allowed to stand or settle but was placed in a clean atomizer and sprayed on dry cover slips at once. These had been soaked in cleaning fluid and washed thoroughly in distilled water before use.

After they had been sprayed they were allowed to dry for at least six hours at room temperature to allow for any chemical changes due to atmospheric action, such as might occur when the spray was used in the field.

Two separate tests were made with Bordeaux mixture at an interval of some time, a new set of stock solutions being used and

8. Burrill, T. J. Ill. Sta. Bul. 118, p. 569, 1907.

fresh cultures of the fungus. This was done to insure against error in the previous work and give a larger number of counts on which to base the average amount of control secured by the use of different strengths of spray.

BORDEAUX MIXTURE.

4-4-50.

Stock solution of $Ca(OH)_2$ .... 20 cc.
Stock solution of $CuSO_4$................................ 20 cc.

This gives a mixture equivalent to a solution containing 4 lbs. of lime, 4 lbs. of copper sulphate and 50 gallons of water.

TABLE IV.—FUNGICIDAL VALUE OF 4-4-50 BORDEAUX MIXTURE.

Slide.	No. of Spores Counted.	No. Germinated.	Per cent Germination.
1	56	0	0
2	62	0	0
3	72	0	0
4	51	0	0
5	56	0	0
6	63	0	0
7	67	0	0
SECOND SET OF TESTS.			
1	46	0	0
2	52	0	0
3	58	0	0
4	61	0	0
5	47	0	0
6	63	0	0
7	59	0	0

BORDEAUX MIXTURE.

4-3-50.

Stock solution of Ca $(OH)_2$ .... 30 cc. & 10 cc. water.
Stock solution of $CuSO_4$................ 40 cc.

This gives a mixture equivalent to one containing 4 lbs. of copper sulphate, 3 lbs of lime and 50 gallons of water.

TABLE V.—FUNGICIDAL VALUE OF 4-3-50 BORDEAUX MIXTURE.

Slide.	No. of Spores Counted.	No. Germinated.	Per cent Germination.
1	71	0	0
2	65	0	0
3	73	0	0
4	57	0	0
5	73	0	0
6	51	0	0
7	64	0	0
SECOND SET OF TESTS.			
1	64	0	0
2	67	0	0
3	83	0	0
4	74	0	0
5	62	0	0
6	70	0	0
7	65	0	0

BORDEAUX MIXTURE.

4-2-50.

Stock solution of $Ca(OH)_2$ .... 10 cc. & 10 cc. water
Stock solution of $CuSO_4$.................. 20 cc.

This gives a mixture equivalent to one containing 2 lbs. of lime, 4 lbs. of copper sulphate and 50 gallons of water.

TABLE VI.—FUNGICIDAL VALUE OF 4-2-50 BORDEAUX MIXTURE.

Slide.	No. of Spores Counted.	No. Germinated.	Per cent Germinated.
1	61	0	0
2	56	0	0
3	70	0	0
4	59	0	0
5	67	0	0
6	71	0	0
7	64	0	0
SECOND SET OF TESTS.			
1	58	0	0
2	64	0	0
3	57	0	0
4	69	0	0
5	72	0	0
6	49	0	0
7	81	0	0

BORDEAUX MIXTURE.

3-3-50.

Stock solution of $Ca(OH)_2$.................. 30 cc. & 10 cc. water
Stock solution of $CuSO_4$.................. 30 cc. & 10 cc. water

This gives a mixture equivalent to one containing 3 lbs. of copper sulphate, 3 lbs. of lime and 50 gallons of water.

TABLE VII.—FUNGICIDAL VALUE OF 3-3-50 BORDEAUX MIXTURE.

Slide.	No. of Spores Counted.	No. Germinated.	Per cent Germinated.
1	50	0	0
2	67	0	0
3	78	0	0
4	69	0	0
5	57	0	0
6	82	0	0
7	72	0	0
SECOND SET OF TESTS.			
1	59	0	0
2	64	0	0
3	51	0	0
4	68	0	0
5	73	0	0
6	55	0	0
7	54	0	0

BORDEAUX MIXTURE.

3-2-50.

Stock solution of $Ca(OH)_2$.................. 20 cc. & 20 cc. water
Stock solution of $CuSO_4$.....................30 cc. & 10 cc. water

This gives a mixture equivalent to one having 3 lbs. of copper sulphate, 2 lbs. of lime and 50 gallons of water.

TABLE VIII.—FUNGICIDAL VALUE OF 3-2-50 BORDEAUX MIXTURE.

Slide.	No. of Spores Counted.	No. Germinated.	Per cent Germination.
1	69	0	0
2	81	0	0
3	74	0	0
4	59	0	0
5	87	0	0
6	89	0	0
7	72	0	0
SECOND SET OF TESTS.			
1	70	0	0
2	68	0	0
3	74	0	0
4	86	0	0
5	50	0	0
6	71	0	0
7	63	0	0

BORDEAUX MIXTURE.

2-2-50.

Stock solution of $Ca(OH)_2$.................... 20 cc. & 20 cc. water
Stock solution of $CuSO_4$.................... 20 cc. & 20 cc. water

This gives a mixture equivalent to one having 2 lbs. copper sulphate, 2 lbs. lime and 50 gallons of water.

TABLE IX.—FUNGICIDAL VALUE OF 2-2-50 BORDEAUX MIXTURE.

Slide.	No. of Spores Counted.	No. Germinated.	Per cent Germinated.
1	50	0	0
2	48	0	0
3	56	0	0
4	69	0	0
5	46	0	0
6	71	0	0
7	63	0	0
SECOND SET OF TESTS.			
1	72	0	0
2	81	0	0
3	74	0	0
4	68	0	0
5	73	0	0
6	87	0	0
7	73	0	0

The results given in the above tables show that Bordeaux mixture has a very positive fungicidal action when tested under conditions similar to those found in the field. Even the weakest mixtures seem as effective as the more concentrated, germination being effectively prevented in every case.

BARIUM POLYSULFIDE SOLUTION.[9]

This is a proprietary compound, recently patented and not yet put on the market. Some was sent for experimental purposes and was tested on the fungus although it was unknown whether it would be possible to use it on the plant without injury.

The mixture was made up in three strengths as shown below. The solution was made readily by simply allowing the required quantity to dissolve in cold water.

Tests with 1-50 solution:

9. Thomsen Chemical Co.

TABLE X.—FUNGICIDAL VALUE OF 1-50 BARIUM POLYSULFIDE.

Slide.	No. of Spores Counted.	No. Germinated.	Per cent Germination.
1	47	44	94
2	50	50	85
3	46	40	87
4	78	70	89
5	64	60	94
6	72	68	94
7	49	43	86

Average germination for tests with this strength of spray was found by the above to be 89%.

Since the checks run with these experiments show a germination of only 92%, it is apparent that the dilution used would not be likely to prove effective.

BARIUM POLYSULFIDE TESTS.

1-40 dilution.

This dilution was made by taking 1 gm. of the material and allowing it to dissolve in cold water.

TABLE XI.—FUNGICIDAL VALUE OF 1-40 BARIUM POLYSULFIDE.

Slide.	No. of Spores Counted.	No. Germinated.	Per cent Germinated.
1	80	75	93
2	64	58	91
3	73	64	87
4	87	76	86
5	57	50	87
6	59	53	89
7	63	57	91

Average germination for the tests with a 1-40 dilution of this spray 89%, which indicates very little fungicidal property for this dilution, in the case of *Cladosporium cucumerinum,* since the checks show a germination of only 92%.

One effect of this chemical was very noticeable, however, that being the delaying of germination. All the spores were examined at the end of 36 hours and at this time most of those which germinated at all had developed a good sized germ tube. In the case of the spores placed on the cover glasses sprayed with this solution however, the germination was noted well begun before 40 hours although it proceeded at a normal rate after that time.

BARIUM POLYSULFIDE TESTS.

1-30 dilution.

This dilution was made by taking 1 gm. of the material and allowing it to dissolve in 30 cc. of cold water.

TABLE XII.—FUNGICIDAL VALUE OF 1-30 BARIUM POLYSULFIDE.

Slide.	No. of Spores Counted.	No. Germinated.	Per cent Germinated.
1	71	55	77
2	62	42	67
3	51	33	64
4	63	51	81
5	72	54	75
6	64	52	81
7	58	42	73

Average germination of spores in this test was 77%, which is somewhat higher than that which would represent a valuable fungicidal action. Judging by the action of other sulfur fungicides on cucumbers it is unlikely that this could be used successfully on such tender plants in this dilution.

However, even were it possible to use the compound, none of the dilutions used gave any indications that it would be of value in controlling the fungus attack. To be effective against so severe an organism as this has been proven to be, it would be necessary to have some fungicide which practically prohibits germination, as Bordeaux mixture seems to do.

TEST WITH POTASSIUM SULFIDE.

This was used in a dilution corresponding to a common formula which is as follows:—

3 ounces of K_2S.
10 gallons of water.

This is equivalent to a mixture made with 1 gm. of K_2S and 427 cc. of water and the dilution was prepared by this formula from chemically pure K_2S.

TABLE XIII.—FUNGICIDAL VALUE OF POTASSIUM SULFID.

Slide.	No. of Spores Counted.	No. Germinated.	Per cent Germination.
1	65	60	92
2	79	74	93
3	59	53	89
4	62	55	88
5	77	69	88
6	83	78	94
7	65	61	94

The average germination for the entire series was 91%, which shows that this spray would be useless as a control for scab, there being practically no control if any, since the checks showed 92% germination.

TESTS WITH AMMONIACAL COPPER CARBONATE.

This is a fungicide that is much used where a non-staining compound is sought, but has not so strong fungicidal properties as Bordeaux mixture.

The common formula used is as follows:

5 ounces Copper Carbonate
3 pints Ammonia
50 gallons of water.

This is approximately equivalent to the mixture used in these tests, which was made up in these proportions:

1 gm. $CuCO_3$
8 cc. Ammonia
1600 cc. water. Dissolve the copper carbonate in ammonia and add water.

TABLE XIV.—FUNGICIDAL VALUE OF AMMONIACAL COPPER CARBONATE.

Slide.	No. of Spores Counted.	No. Germinated.	Per cent Germinated.
1	58	48	85
2	72	63	88
3	81	76	94
4	64	56	82
5	67	55	82
6	78	62	79
7	51	46	90

The average germination for this set was 85%.

SECOND SERIES.

1	74	60	81
2	58	41	71
3	69	54	78
4	63	59	93
5	79	68	81
6	55	42	79
7	67	51	71

The average germination in this case was 79%, while the average for both series was 82%. This would not seem to indicate that it was valuable as a fungicide as was noted before but in the case of the two sets it was found that soon after germination the germ tube of the fungus became much distorted, the cells being swollen in some cases so as to be almost unrecognizable. This seemed to be followed by a complete cessation of growth, so that it is possib'e that while the spore might germinate it would not be able to resist the action of the fungicide on the germ tube.

This is one of the reasons that Burrill's method is so superior to mere temporary immersion of spores in the fungicide, and may be the explanation of the apparently contradictory results of Frank's experiments as contrasted with those here reported.

TESTS WITH "DRY BORDEAU."[9]

This is a commercial chemical compound and was used according to directions. A dilution of 10 lbs. to 50 gallons of water is recommended and it was made up by dissolving 2 gm. of the dry material in 78 cc. of water, this giving the equivalent of the dilution recommended.

TABLE XV.—FUNGICIDAL VALUE OF DRY BORDEAUX.

Slide.	No. of Spores Counted.	No. Germinated.	Per cent Germinated.
1	47	0	0
2	53	0	0
3	80	0	0
4	69	0	0
5	74	0	0
6	56	0	0
7	54	0	0
SECOND SERIES.			
1	60	0	0
2	54	0	0
3	73	0	0
4	69	0	0
5	66	0	0
6	78	0	0
7	52	0	0

The "Dry Bordeaux" mixture seemed perfectly effective in its fungicidal action, as no germination was noted in the set.

TESTS WITH ATOMIC SULFUR.[10]

This is another proprietary compound and is recommended for use in a dilution of 5 lbs. to 50 gallons of water. The mixture as used in the tests was made as follows; and is equivalent to the dilution recommended:—

1 gm. Atomic sulfur
80 cc. water.

9. Sherwin-Williams Co.
10. Thomsen Chemical Co.

TABLE XVI.—FUNGICIDAL VALUE OF ATOMIC SULFUR.

Slide.	No. of Spores Counted.	No. Germinated.	Per cent Germinated.
1	67	1	1
2	75	2	3
3	54	0	0
4	69	0	0
5	76	2	3
6	54	0	0
7	58	1	1

The average germination in the case of this spray was about 1%, showing that if it is possible to use it on the foliage without injury, it might prove effective.

However, the writer cannot say as to the danger of its use on cucumbers.

TESTS WITH POTASSIUM DICROMATE.

This chemical was used merely as an experiment, without any idea as to whether it would be effective or whether it could be used on the plant. This was due to the fact that the work was all done on the presumption that Bordeaux mixture was ineffective and every possible fungicidal preparation was tried in an effort to secure something which would kill the spores of the fungus.

The first set of cover slips used with this chemical were sprayed with a .5% solution of it in water.

TABLE XVII.—TESTS WITH .5% POTASSIUM DICHROMATE.

Slide.	No. of Spores Counted.	No. Germinated.	Per cent Germinated.
1	74	3	4
2	64	1	1
3	68	1	1
4	57	2	3
5	82	5	6
6	77	3	4
7	61	4	6

The average germination in this case was about 4%, which would mean that it might prove an effective agent of control if the vines could stand an application of the chemical.

TESTS WITH POTASSIUM DICHROMATE.

In this set the dilution was made stronger, being 1% instead of .5% as before.

TABLE XVII (b).

SECOND SET.

Slide.	No. of Spores Counted.	No. Germinated.	Per cent Germinated.
1	85	0	0
2	76	2	2
3	69	0	0
4	71	3	4
5	82	1	1
6	68	0	0
7	75	2	2

The average germination in this case was slightly over 1%, showing that this would effectually kill the spores of the fungus if it did not injure the plant too severely at the same time.

There was little difference in amount of germination between the two dilutions and if one were used, the .5% would be as valuable as the other.

This spray is so soluble in water however, that some other ingredient would have to be added to give it more adhesiveness, since otherwise it would wash off in the first light rain or in heavy dews.

CHECKS.

A set of seven check slides were used for each series of spray tests conducted. The spores were germinated in distilled water on clean cover glasses and a careful count made to determine the actual average germination.

TABLE XVIII.

CHECK.

Slide.	No. of Spores Counted.	No. Germinated.	Per cent Germination.
1	57	54	94
2	64	58	90
3	56	52	85
4	62	56	90
5	56	52	96
6	68	65	96
7	72	69	96

Average germination of check—92%.

SECOND SET OF TESTS.

1	49	42	81
2	63	54	85
3	57	50	75
4	69	53	76
5	58	50	86
6	75	63	84
7	52	48	92

Average germination of check—85%.

OTHER PARASITIC DISEASES CAUSED BY CLADOSPORIUM SP.

Peach Scab, caused by the fungus *Cladosporium carpophilum*[11] is found on the surface of the fruit, but does not penetrate beyond the first layer of epidermal cells to any extent, absorbing food from its host but not working into the flesh. The cells directly beneath the fungus threads usually form a cork like layer and this hardening of the surface is what causes the cracking of the fruit.

The fungus usually is controlled by self-boiled lime and sulfur but Bordeaux mixture is an effective remedy except for the fact that it is likely to injure the fruit.

Tomato Scab, caused by *Cladosporium fulvum*, is a disease of the leaf of the tomato, the fungus penetrating the host tissues and causing a yellowing of the upper surfaces of the leaves, the conidia being borne on the lower surface; giving it a mildewed appearance.

Bordeaux mixture is a perfect control for this disease if used early enough in the season, but control when it has progressed far is difficult.[12]

Scaley Bark of Citrus Fruits, caused by the fungus *Cladosporium herbarum*, var. *citricola*[13], affects the shoots of citrous trees and causes a flaking out of the bark in the infected portion. The fungus penetrates the cambium layer and causes the bark to become brittle and hard. A false cambium often forms beneath, and the infected portion is left between two rings of wood. A gummy substance is usually formed by the destruction of the host cells.

It affects the rind of the fruit, often causing portions to drop out. The conidia are borne on the surface of both fruit and twigs as in all Cladosporia noted. Bordeaux mixture is recommended as a control.

Cladosporium citri, or citrus scab causes a superficial injury to the surfaces of the fruit, twigs, and leaves of citrus fruits. It produces small wart-like swellings and penetrates slightly into the tissues, the spores being borne on the surface[14].

Moist weather is very essential for its growth and Bordeaux mixture is recommended for its control.

From the comparison of the above diseases with Cladosporium cucumerinum, it will be seen that they are all similar in nature, the spores being borne on the surface of the host and the injury merely a superficial one.

The formation of a gummy product seems to indicate that they

11. Chester. Del. Agr. Exp. Sta. Rpt. 8. 1895, p. 60.
12. Massee. Diseases of Cult. Plants & Trees. 1913.
13. Bul. 106. Fla. Agr. Exp. Sta. 1911.
14. Bul. 8, Div. Veg. Path. & Phys. 1896.

are alike in their effect on the cells of the host and we find a corky layer being formed in most cases to protect the host.

The diseases all being caused by fungi of the same type and the injuries being similar in their main characters, we must suppose that a fungicide which controls all but one of them should be at least partly effective against that one. It is hardly likely that Bordeaux mixture should be useless as a fungicide in the case of Cucumber Scab, when it is advised as a control for most of the diseases caused by Cladosporium. There is no reason to believe that Cladosporium cucumerinum is as resistant as would appear from Frank's work, and the tests made by fungicides in the laboratory have shown that this resistant quality, so long ascribed to it, is in reality lacking.

FIELD EXPERIMENTS BY H. J. BUELL ON CONTROL OF SCAB.

The work here referred to was done in the season of 1914 at Big Rapids by Mr. H. J. Buell for the H. J. Heinz Co. The different fields were sprayed on one-half and the other half left as a check.

The mixture used was a 3-6-50 Bordeaux mixture, applied at the rate of 200 gallons per acre. The fields were sprayed in regular order, the first being sprayed again as soon as the last was finished. Approximately a week was required for the round. All spraying was done with a barrel sprayer, holding 50 gallons, mounted on a cart and fitted with a 12 foot hose and an eight foot bamboo spray rod, carrying two Vermorel type nozzles.

The Big Rapids district was the center of the most severe attack of scab noted in 1914 and as none of the fields outside of those in the experiment were sprayed, there were unusual difficulties in the way of successful control.

As some of the fields sprayed seemed to show partial control by the spray and others did not, Mr. Buell's records were examined to see if they could throw any light on the matter. This examination showed a seeming correlation between the amount of disease and the time of spraying with reference to rain periods.

The data on rainfall was obtained from the records of the United States Weather Bureau and is given under Temperature and Humidity relations.

In these sprayings, we have both extremes, the spray applied just before a rain and just afterwards. The difference in effect of the two methods was very marked in its results as is shown below.

Plot 2.

Sprayed some time after the rains in July and 5 days before the heavy rain of August 18, when most of the infection took place.

August 8	Scab appeared.
August 15	15% on sprayed side.
	40% on unsprayed side.
August 19	25% on sprayed side.
	40% on unsprayed side.

The entire lot was abandoned the next week from scab.

Plot 3.

This plot was sprayed from one to three days after every rain and in no case were vines freshly covered with spray previous to heavy storms.

August 17.	Scab appeared.
August 27	50% on sprayed side.
	70% on unsprayed side.

An infection of 50% does not represent control as this is equivalent to almost total loss of the crop.

Plot 4.

Sprayed one to two days previous to all rains in August, never more than two days previous to any rain.

August 7	Scab appeared.
August 27	10% on sprayed side.
	70% on unsprayed side.
September 3	No change on sprayed side.

This plot shows very fair results in control of the fungus.

Plot 5.

Sprayed no more than three days previous to all rains in August and only a few hours before that of August 18th.

August 19	Scab appeared.
August 26	5% on the sprayed side.
	15% on the unsprayed side.
August 30	100% on the sprayed side.
	40% on the unsprayed side.

This shows partial control of the disease, although the unsprayed side is rather badly infected.

Plot 6.

Sprayed well until just preceding mid August when the spraying was abandoned.

September 1. 40% on the field everywhere, spray showing no effect.

Plot 7.

This field was sprayed within at least three days of all rains during the season.

August 15	Scab appeared.	
August 24	65%	on unsprayed side.
	15%	on sprayed side.

This, like the preceding, shows fair control of the fungus.

Plot 8.

This was sprayed just a few hours before the wet weather of August 18 and just before all rains in August.

August 19	Scab appeared.	
September 5	15%	on the sprayed side.
	75%	on the unsprayed side.
September 8	No change in percentages.	

This is another example of fair control from proper timing of the spray.

Plot 11.

This was sprayed four or five days before all the important rains of mid August and the rest of the season as well.

August 24	Scab appeared.	
September 3	50%	on the unsprayed side.
	50%	on the sprayed side.

These results show that when the spraying occurred so that the vines had little chance to make new growth before a period of humid weather, they were fairly well protected. On the other hand, where the spray was applied some time before the rains, the vines were seriously affected on both sprayed and unsprayed portions.

This was in particular true in August when the epidemic commenced as during the month of July there was so little rain that fungous injury was almost negligible.

The fact that only one-half of the field was sprayed and the remainder usually became seriously affected added greatly to the difficulty of securing the greatest amount of success in the work. The percentages are based on actual count and they should be fairly correct as to the amount of disease present.

To be effective the fungicide must so cover the cucumber fruits that spores germinating in a drop of water will come in contact with the spray. The spray must be on the plant before the rainy period in order to give complete protection. The cucumber plant grows very rapidly and will produce fruits continually. Hence, to give complete protection, it would be necessary to spray at least, at intervals of two days, a thing which is not practical in commercial growing.

The next best thing is to make each spraying as efficient as possible. Hence it is not necessary to spray so often during periods of dry weather, in fact it is better not to spray at such times, since the pollination may be injured to some extent at every spraying. But if the grower can keep in touch with weather predictions and study local conditions, he may be able to get a fair idea of the conditions which may prevail for the next few days and endeavor to forestall the danger periods by applying the spray as shortly before the rain as possible to permit drying.

This is theoretically the proper way to apply fungicides but it will require some effort and foresight on the part of the grower to follow out these principles successfully.

RECOMMENDATIONS FOR CONTROL.

The problem of controlling *Cladosporium cucumerinum* does not lie in developing an efficient fungicide as the laboratory tests made show that Bordeaux is effective against the spores of this fungus. The difficulty in control lies rather in the rapidity of growth of the cucumber plant and fruit, coupled with the rapid development and spread of the fungus which prevent complete protection of the plant.

The following recommendations, however, can be made:

1. The general necessity of spraying must be recognized.
2. All trash and vines should be burned each year and rotation of crops practiced.
3. Vines may be turned over to allow them to dry after heavy dews or showers. This is a common practice with some growers and should prove valuable in times of epidemic.

4. While it is generally recognized that the old hill system where the vines are left to spread is not effective, yet the growers should be advised against allowing the vines to mat and form dense clusters not more than 2 or 3 feet wide. While adhering to the drill system it is necessary that the rows be ample in width and when the scab begins to appear the new growth should be allowed to run slightly out into the row and not turned back into the dense mass.

5. Probably no other factor so demonstrates the superiority of drained soil over undrained for pickles.

6. The only specific, effective weapon, aside from those above, is the increase in the number of sprayings. These sprayings should be effectively coordinated with the weather conditions.

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AN UNDESCRIBED BARK CANKER OF APPLE AND THE ASSOCIATED ORGANISM.

BY G. H. COONS.

In March, 1911, specimens of badly cankered apple limbs were sent to the Botanical laboratory of the Michigan Agricultural College from an orchard near Boyne City, Charlevoix County, Michigan. Examination of the specimens and field studies during the same month indicated that the canker was different from the described cankers of apple. Accordingly abundant collections were made and from this material an organism was isolated. Pure cultures from a single spore were used successfully in inoculation experiments in 1911 and again in succeeding years. The rules of proof of parasitism have been fully complied with. The organism has been used in physiological studies, especial attention being given to the factors which affect growth and reproduction. The work dealing with pathogenesis as well as the physiological relations of this organism are reserved for future publication. It is the purpose of this preliminary paper to describe briefly the canker as found upon the apple and the morphology of the causal fungus.

THE CANKER.

The typical limb canker (Pl. VI) associated with this organism is caused by the killing of the cortex in long strips which extend along or wind about the affected limbs. The killed tissue shrivels and becomes separated from the healthy bark. The strong fibres in the shrivelled portion prevent the flaking off of the dead portions for a year or two but eventually the wood becomes bare. The disease is progressive and year after year the canker encroaches upon the healthy, younger tissue. This encroachment is, for the most part, along the limb rather than around it. Accordingly we may find a large limb with as much as one-fourth of its circumference bare. This bare condition extends along the limb toward the tip and there we find twigs, one, two, or three years old with canker in its first stages. In the early stages of the canker the diseased bark is still in place, but it is separated from the healthy portions by a definite cleft. The bark at the edges of the diseased strip cracks into definite square or rectangular areas of varying sizes, averaging about an eighth to a quarter of an inch across. The cracking is due no doubt to the rapid drying and shrinking which takes place after the bark is killed. As the healthy portions of the limb increase in girth, the rift between the diseased strip and the sound bark becomes more pronounced. Very soon a definite lesion is formed and the healthy portions are walled off by a wound callus. No doubt the inability of the fungus to penetrate this wound callus brings about the restriction of its advance around the limb.

The woolly aphis, *Schizoneura lanigera,* attacks this wound callus very severely, often lining the entire margin of the canker with a white cottony layer. As a result of the stimulation of the punctures of this insect, the wound callus grows three or four times the normal thickness and swellings and knobs occur all along it. The net result of the aphis attack is to aggravate greatly the cankered condition. The aphis is a secondary factor increasing the severity of the disease. It may be noted that the woolly aphis is commonly found upon the tender growing parts of the apple, and wound callus about any wound is subject to attack. The canker of apple caused by *Nectria galligena* is similarly aggravated by this same insect.

The fruiting bodies of the causal organism, are to be found on all stages of the cankers. Where the dead bark still clings to the wood the fruiting bodies, seen as small globose or flattened masses about ¼ of a millimeter across, are present in small numbers embedded or half submerged in the rotted bark. They are most common, however, in series or clumps upon the decorticated wood.

This canker differs from the common *Sphaeropsis* canker in many ways. The rather rapid decortication of the wood, the tendency to kill the bark in long strips along the limbs and the rectangular checking of the dead bark are distinguishing characteristics. Girdling by the fungus has never been found upon older limbs although it may take place on young ones. Girdling accompanied by a swelling of the diseased tissue is a common characteristic of the *Sphaeropsis* canker.

MORPHOLOGY OF THE CAUSAL ORGANISM.

The fruiting bodies of the fungus consist of single-celled pycnidia. These pycnidia are typically globose, becoming flattened or depressed when old. Although they usually stand distinct from each other, two may grow together, but in this case the wall of each is distinct, hence the association can not be considered as an evidence of stroma formation. Sometimes pycnidia are found which are greater in their horizontal than in their vertical dimension. The sizes of the pycnidia vary from 1/10 to ⅓ of a millimeter. Thus same variation in size is found in pycnidia produced in media and seems to be related to nutrition.

The relation of the pycnidia to the wood and bark is very important since it determines the classification of the organism. The pycnidia which occur on the dead bark, either submerged or partly submerged, may by weathering of the bark become wholly exposed. When the pycnidia are borne on the wood the base is formed on and in the outer wood fibres by a loose felting together of the hyphae and this part of the wall eventually becomes carbonaceous pseudoparenchyma. When a pycnidium is broken from the wood a definite ring is left. There is no definite pushing up of the pycnidium, as in *Sphaeropsis malorum*, accompanied by rifting of the bark. The pycnidia vary greatly with regard to the ostiole. A few pycnidia have a marked beak, especially in culture. In other cases, the pycnidia are pear shaped. In old dried material, the morphology in this regard is very hard to decipher.

The walls of the pycnidium are thick and composed of two distinct layers. The outer is brown or black and made up of small cells with thick walls. The inner layer is hyaline but with distinct large cells. The outer wall is covered with hyphae as the pycnidia grows in culture, but smooth and shining as the fungus is found in nature. Within, the walls of the pycnidium bristle with conidiophores which arise from the sides and base. The base is frequently much thickened and the beginnings of foldings and convolutions in this hymenium are evident.

The conidiophores are about two times the length of the spores. They are swollen at the base, and pointed at the apex. Frequently two cling together in material from young pycnidia. These conidiophores are hyaline and filled with a granular protoplasm. The spores are cylindrical with blunt, rounded ends. Occasionally a spore will show a slight curve. In mass the spores have a slight greenish or brown tinge. If the spores are viewed singly, the deviation from hyaline can hardly be detected. The spores have never been observed to push out in long tendrils, but in some moist cultures a little globule of spores will be protruded. This globule is yellowish when fresh but it becomes brownish with age.

The following table gives a summary of some measurements:

Pycnidia.		Spores.		Conidiophores.
Apple.	Cultures.	Apple.	Cultures.	Cultures.
218 × 218 346. × 346 336 × 346 201. × 346 268 × 470	420 × 420 420 × 336	3.9 × 1.3 4.5 × .8 5.2 × 1.3 4.5 × 1.3 5.2 × 1.3 3.9 × 1.3 5.2 × 1.3	5.2 × 1.3 3.9 × 1.9 5.4 × 1.3 5.2 × 1.3 4.5 × 1.9 3.9 × 1.3 5.2 × 1.3	7.8 × 2.6 9.1 × 2.6 13. × 2.6 7.8 × 2.6

Measurements in Microns.

CLASSIFICATION OF THE ORGANISM.

The naming of the organism has presented some difficulty. The shape and general character of the pycnidium correspond to the genus *Phoma* in its widest sense. But this genus of numerous and widely variant species has been subjected to more or less subdivision. Indeed Saccardo states that he himself would have radically subdivided the group if he had had more complete descriptions of the species to guide him.

The color of the spores has been considered carefully since this character is of such taxonomic importance. Saccardo in his first compilation of the species of the *Sphaeropsidales* transferred to *Coniothyrium* all species formerly referred to *Phoma*, in which the spores were colored. But the extremely dilute color of the spores of this species is strikingly different from the spore color of the ordinary *Coniothyrium*. Furthermore, the examination of well-authenticated species of the genus Phoma in the herbarium showed that in many species there occurred a similar tinge of color.

The convolutions of the hymenium and the occasional curved spores gave a suggestion of the genus *Cytospora*, but in *Cytospora* the locules are distinct. The multiplicity of characters of this fungus which enables it to partake of the "key" characters of several of the broad form-genera makes a decision somewhat difficult. One might bring considerable reproach against the system, if it were not so well known that the whole arrangement is temporary and highly artificial.

Saccardo had made a segregation from the old genus *Phoma* on the basis of the relation of the pycnidium to the substratum. This genus which he called *Aposphaeria* has the characters of *Phoma*, except that the pycnidia are submerged or partly so. In this genus, which the fungus in question also conforms with, there is a species described by Saccardo, originally under the name *Phoma*, which fits the fungus with which I worked remarkably well. After strict comparison of descriptions of all *Phoma*, *Cytospora*, and *Coniothyrium* species given in the Sylloge on the basis of spore size, character of the conidiophore, color of the spores and character of the pycnidium, I find this species agrees most nearly with the fungus in question. The following is Saccardo's description:

Aposphaeria fusco-maculans, Sacc. Mich. II p. 275 (Phoma).

Peritheciis late gregariis, ligno superfice infuscato, semi-v. fere totis immersis, 1/5 mill. diam., globulis v. subcompressis, nigris; ostiolo obsoleto; sporulis oblongis, uterinque rotundatis, 5=1—1¼ dilutissime olivaceis, basidiis fasciculatis deorsum incrassatis 8=2, hyaliuis suffultis.

Hab. in ligno decorticato Piri mali, in Italio bor.—affinis Aposp. fusciculae Sacc. a qua basidiis, matrice infuscata, etc., satis recedere videtur. (Sacc. 3: 174.)

In only one particular, the superficial discoloration of the host tissue, does important variation in the description of the two organisms occur. It would seem considering the discoloration which might occur on weathered decorticated apple limbs, that this portion of the description need not be adhered to strictly. Accordingly in view of the other points of accordance, which are so close on various points—host, spore size and color, basidium size and color, morphology of parts,—as to make coincidence almost out of the question, it seems safe to assume that the fungus found in Michigan is the species Saccardo described for Italy.

Diedicke* has recently been working over many of the species of the Sphaeropsidales and his work has attracted great attention. Diedicke's recommendations have found much favor with American workers and it can not be gainsaid that some of the segregations which he has emphasized are groups of marked coherence and form excellent working units. Diedicke has emphasized the character of the pycnidial wall as a basic character in this division of the Fungi Imperfecti. If the wall in the Phoma-like forms be thin and evidences of stroma are lacking, we have, according to Diedicke the true *Phomas*. If the wall be otherwise, Diedicke makes use of the two genera *Phomopsis* and *Plenodomus*. These genera are closely related and have been generally confused. In both we have a thick wall and a hymenium more or less irregularly folded. In *Phomopsis* the chamber is not equipped with a wall entirely complete, for the base in this genus is made up of the loose mat of fungus and host, and is not darkened. In *Plenodomus* the wall is distinct throughout. *Phomopsis* has a wall of four layers, in *Plenodomus* two layers.

*Diedicke H., Die Gattung Phomopsis. Ann. Myc. 9:137-141, 1 pl. 1911.

If we emphasize the pycnidial-wall character, a thing about which Saccardo is silent—then our fungus may be taken from the genus *Aposphaeria* and placed in the genus *Plenodomus.*

This transfer is warranted because of the demonstrated value of the character of the pycnidial wall in associating organisms of close relationships. The genus *Phomopsis* is an excellent example of the worth of this character. In the genus *Phomopsis* there are known nearly fifty species and the great majority of these show similar spore forms and more decisive, the great majority have some member of the genus *Diaporthe* as a sexual state. A glance at the genus *Aposphaeria* shows that the relationships are ill-assorted. There is in this group more than thirty with spores of small size and with other characters in variance from the rest of the genus. One of these *Aposphaeria salicinum* Sacc. has been transferred by Diedicke to the genus *Plenodomus* because of its distinct characters. I have compared the morphology of this species with the fungus from apple, using the same material which Diedicke used (Sydow, Mycotheca germanica 87) and find close morphological agreement in the generic characters. It is worthy of note that *Phoma brassicae* or *lingam* which has about the same spore size as the apple fungus is also placed by Diedicke in the genus *Plenodomus*. Judging by analogy, it may be that we can associate a number of closely related pathogenic forms which may be expected to have close correspondence in their sexual stage. It is therefore essential that the important character take precedence over the trivial.

For these reasons, I have proposed the name *Plenodomus fuscomaculans* (Sacc.) n. comb. and emended the description to include the characters of the pycnidial wall.—April, 1915, East Lansing, Mich.

Due to delay in publication of this report, the new combination was proposed in the Journal of Agricultural Research 5: 713—769, and a brief summary of these reasons was given.

THE MICHIGAN PLANT DISEASE SURVEY FOR 1914.

BY G. H. COONS.

For a number of years the Department of Botany at M. A. C. has been conducting a plant disease survey in cooperation with the U. S. Department of Agriculture. This work which is carried on throughout the United States, has for its object the collection of data as to distribution, severity, and control measures for various plant diseases. In Michigan the basis for a comprehensive survey is being laid. The collections of fungi at Ann Arbor have been listed in reports of this academy by Pollock and Kauffman, and this work has been carried on to the present time by Dr. Kauffman. The collections at M. A. C. exclusive of the Basisiomycetes have beeen listed by me in the 1912 Academy Report in a provisional host index, which includes the fungous collections at Ann Arbor as well. In this host index a literature list is given which includes the mycological and pathological work done in the state or with Michigan material. A comprehensive account of Michigan plant diseases is to be prepared in the near future to serve as a summary of the present status of our knowledge of Michigan pathogenes. This paper merely attempts to record a few of the plant diseases either new to the state or of particular importance which were met with last year.

POTATO DISEASES.

The Curly Dwarf Disease. In 1914 in a popular experiment station bulletin (66) on potato diseases, Dr. Bessey discussed dangerous potato diseases at that time rare or unknown for Michigan. Since then an extensive survey and especially the work of the group of scientists which under the auspices of the U. S. Department of Agriculture visited fields in the state, have given further information on Curly Dwarf and Leaf Roll which we did not have at the time of Dr. Bessey's summary.

In that bulletin, Curly Dwarf was described as reported from but one locality. A grower in Montcalm County had noted occasional dwarfed plants which yielded only small worthless tubers. He saved the tubers from some of these hills and found that when these were planted the progeny was of the same worthless nature.

He repeated this a second and a third year with similar results. Specimens from this man's field have been examined and were typical Curly Dwarf material. There is little doubt but the experiments performed were with Curly Dwarf.

Last year I visited the field of a farmer who had followed consistently the practice of using his small potatoes for seed-stock. In this field instead of an occasional Curly Dwarf plant, there were at least 10 per cent of the hills with plants which produced only a mat of stunted wiry growth, and whose yield was a dozen or more small worthless tubers. It is significant that many of these tubers were of a size such that they would be planted if the practice of planting small potatoes were followed. It is further significant that the disease was not found in fields where high grade seed had been introduced. With seed of ordinary size from a prolific stock, and especially if the stock be a pure line, this disease should be entirely unknown. So far the disease has been noted in Kent, Montcalm and Van Buren counties.

The Leaf Roll Disease. Leaf roll was found for the first time in Michigan in 1914 although it has doubtless been present for some time in some varieties. In July, 1914, a few rows of a trial lot of potatoes, Twentieth Century, obtained along with a whole assortment of varieties and strains of potatoes for testing on the College grounds, showed curled foliage in more than 90 per cent of the plants. These rows presented a marked contrast to the other rows whose leaves were normal. The juice of these plants gave a marked reaction with gum guaiac, turning it blue instantly. Other varieties gave but a faint reaction after an hour. In August, Dr. Otto Appel who was with the party of scientists, examined the plants and pronounced the disease typical Leaf Roll. Leaf Roll is now known from several counties, St. Clair, (in imported seed) Oakland, Ingham, and Allegan County.

Leaf Roll (Pl. VIIA) and Curly Dwarf are diseases of the type called "Physiological" for which no parasite is known. They cause the type of disorder significantly called "running out of seed." There is always danger from diseases of this type and especial effort has been made to examine fields of growers anxious to develop good, safe, seed-stock, and to certify these as free from a dangerous per cent of such diseases. For a full discussion of these diseases the comprehensive bulletin by Orton* may be cited.

*Orton, W. A., U. S. Dept. Agr. Bul. 64: 48pp. 16 pls. (1914).

CUCUMBER DISEASES.

Michigan is one of the most important cucumber-growing states. There are at least 250 salting stations in the lower peninsula. For a number of years the cucumber diseases have been doing much damage. In fact in 1912, I made the statement in a popular article that Cucumber Diseases were so serious that the crop was in precarious condition. Last year at the majority of stations the profitable picking season was on an average only one-half of the possible length. Three diseases were responsible for this shortening of the picking season, Downy Mildew, White Pickle, and Scab.

Downy Mildew. Downy Mildew is caused by the fungus *Pseudoperonospora cubensis* (B & C) and in 1905 was reported by Orton in the yearbook as causing an epidemic in Michigan. It has been found in various localities since that time. From observations for several years it seems safe to say that given hot, moist weather in August an outbreak of Downy Mildew is to be expected. Last year it occurred too late to do its usual amount of damage.

White Pickle. White Pickle (Pl. VII B) is a new disease which has never been reported in the literature of plant diseases. Attention was first called to the disease in 1912, when specimens were sent from Grand Rapids. The disease shows first as a distinct mosaic of the leaves, accompanied by shortening of the main shoots. The restriction of growth of the shoot and leaves gives the impression of leafiness to the diseased runners. In the last stages, the leaves are dwarfed. The most conspicuous effect is produced upon the fruits. These become excessively warty and roughened. These warts show ripening effects before the rest of the pickle, hence one commonly finds a small green cucumber with very conspicuous yellow warts upon it. Pickles borne upon plants in the last stages of the disease do not show the excessive wartiness, but remain small, pale, bitter fruit, hence the name, "White Pickle."

Observations made in 1913 and the testimony of the growers indicated that the disease was infectious, since the history of the disease in the fields always indicated a progressive attack. Although in many ways the appearance of the plants and fruits suggests a stigmonose, and although plant lice were common on the diseased plants, they were not in great abundance, nor were they more prevalent in the fields affected than in the unaffected fields.

When the disease started in a field the loss soon became total. The disease appeared in well-drained as well as in low situations, in sand and in clay, on loamy soil which had not grown cucumbers as well as in fields where the crop was repeated. It had been known in one locality for 7 years. The striking character of the disease and the familiarity of the growers with it, make this figure reliable. No parasite has been associated with the disease. The study of this disease is being continued.

The loss brought about by this disease is extremely heavy. It usually shows up in fields before the vines have reached the height of yield, and once appearing, there is but a short time of profitable growth. In the locality in Allegan county where the disease is worst, the annual yield has been decreased more than 50 per cent. As a loss throughout the state, its effect is smaller, because as yet its distribution is restricted to a few counties about Grand Rapids. Potentially it seems to be the most serious disease of the plant.

Cucumber Scab. Cucumber scab due to the fungus *Cladosporium cucumerinum* Ell & Arth. did great damage to the crop, chiefly in the counties north of Grand Rapids. This distribution corresponds very well with the area which had frequent rain in August and sub-normal temperature. A full discussion of this disease is given on another page of this report.

CELERY DISEASES.

Stunting Disease. A celery disease has been prevalent about Kalamazoo for at least 5 years which differs from the ordinary celery troubles. The disease may have been described before but the reports are very contradictory.

The disease manifests itself by a stunting (Pl. VIII) of the affected plants, beginning always in the seedling stage. The vascular system of the main root and of the heart is discolored, and the discolored fibres may be traced up the leaf stalks. Sometimes a lateral root is affected, and then the discoloration is found to be only upon one side. Microscopical examination of thin sections of the vascular tissues show the tubes to be plugged with rod shaped bacteria. Plants with a plugged vascular system, with the inception of active growth frequently split and the pithy heart dries out, becoming a rusty red. If the conditions be wet, the plants with cleft hearts rot with the ordinary secondary rots. Insects are found associated only at this stage. The stunted portion of the plants does not grow vigorously but lateral buds may start and grow vigorously after the development of a new root system. The disease does not progress noticeably in the older plants. A plant which starts to grow after the central portion is rotted seldom becomes marketable.

The diseased plants become especially noticeable because of the blanching of the leaves which accompanies the stunting. A number of such plants in a row makes a conspicuous spot in a field. These spots gradually enlarge year after year. Spots containing many hundred square feet have been found in some fields. In one or two cases dirt from such areas had been used for seed-bed purposes. As a result an area larger than an acre became completely infected and crops failed year after year.

The finding of the disease in certain fields following flooding and washing of soil from diseased area seems to indicate the transference of infectious material in this way. The common source of infection however is from diseased seedlings and the appearance of small diseased areas sprinkled all over a field has been traced to a seed bed where a small percentage of the plants showed the disease. The restriction of the disease to these types of transference seems required by the observation made so far. The failure to find evidence of spread of the disease by the ordinary methods of cultivation or by mere walking from the diseased areas to healthy ones is a marked peculiarity which is not as yet explainable.

The disease produces loss only in the early, self-blanching varieties. Although the disease is found in the winter or green varieties, a successful crop of these may be grown on land where other varieties are a failure.

The causal bacterial organism has been isolated and its pathogenicity tested. Control measures consisting of soil sterilization by steaming have been successfully tried. The details of this work are reserved for future publication.

The disease is a serious menace to the celery industry about Kalamazoo. Many areas of this extremely valuable land are now not fit for growing the high-priced product, although other crops may be safely planted. A survey of the region showed spots in the majority of fields in one large marsh.

For this disease which as yet lacks a common name, I propose the name, the Stunting Disease of Celery.

The Sclerotinia Disease. In the fall of 1914, specimens of winter celery were sent to the laboratory in a badly rotted condition. These plants had rotted in the trenches where they had been covered with dirt in the usual manner for keeping celery for the winter market. In many areas in the trenches all the celery was decayed. The decayed celery when first sent to the laboratory showed a white felt of hyphae. After about a week in the laboratory, characteristic black sclerotia appeared in great abundance upon the rotted plants.

While the apothecial stage has not been produced from these sclerotia it is very likely that this *Sclerotinia* is the common *Sclerotinia libertiana* Fckl. which Reddick* has found to attack celery, producing similar effects.

As the disease gradually advanced on the stalks a reddening became evident. It is likely that the trouble called "Red Rot" by the growers is this same disease.

The history of the disease indicated that it occurred to a slight extent in a portion of a field which had received manure which had contained refuse from a grocery store. In view of the common occurrence of this fungus on vegetables the introduction of the fungus into the marsh, in this manner is very probable. The marsh had been under cultivation only a very few years and had grown nothing but celery and onions. Since the first appearance of the disease the spread has become more extensive and now large areas show rotted bunches in the trenches.

LETTUCE DISEASES.

Lettuce grown in the field in Michigan is subject to but few serious diseases. Head lettuce frequently shows a high percentage of loss as it grows in the field due to the attack of *Bacillus carotovorus.*

Lettuce grown under glass is injured to a much greater extent by diseases. Two leaf diseases, Downy Mildew and Leaf Anthracnose (due to *Marssonia perforans* E. & E.) are common. Of these, *Bremia* is by far the more widespread. As a control measure for *Bremia* some growers are painting the steam pipes with commercial Lime Sulphur. The leaf anthracnose due to *Marssonia* is restricted in its spread, but with improper watering may greatly damage a crop. It has been found in Grand Rapids, Port Huron and Ann Arbor.

In a few green houses where the soil was kept excessively wet the gray mould *Sclerotinia fuckeliana* (De By.) Fckl. was common on the lower leaves. Lettuce drop caused by *Sclerotinia libertiana* Fckl. was found in one greenhouse upon from 2 to 7 per cent of the plants. This greenhouse had been erected but a year and the appearance of the disease to such an extent in the first year's crop is out of the ordinary. The greenhouse however was erected on an old garden spot and to this no doubt the great prevalence of the disease may be attributed.

A disease which corresponds very closely with the Black Rot of Lettuce described by Ramsey† in 1904 but for which no causal

*Reddick, D. Phytopathology 3: 176. 1914.
†Ramsey, H. J. Wis. Sta. Report. 1904: 279-288. 2 figs.

organism was found, occurred in great abundance in a greenhouse in which conditions were more moist than normal. This disease showed up by causing blackish or at times slightly reddish elongated lesions on the under side of the lower leaves, especially those resting on the ground. In the early stages the lesions were unevenly sunken and at this time the color was mottled. In the later stages a slightly pinkish or buff colored, film-like mold appeared on the diseased spot. This upon microscopic examination was found to be composed of the basidia of *Hypochnus* (*Corticium* in the sense of Burt.) The lesions themselves contained an abundance of the typical threads of Rhizoctonia, but the deep color was not evident.

Secondary rots frequently occurred and in some cases large masses of bacterial slime oozed out of the rotted stem. On the withered leaf blades, a gray mold was common. As a result of the combined action of these rot-producing forms, the entire petiole was rotted off and left only a blackened patch upon the main stalk.

Although work of a decisive nature has not been done with this disease, in view of the well-known effects of Rhizoctonia upon a wide range of hosts, it seems safe to attribute this disease to some species of Rhizoctonia.

Lettuce Rosette. Another disease of lettuce has been associated with Rhizoctonia by Selby.** This is the Lettuce Rosette. In this disease the lesions instead of occurring upon the leaf petioles occur upon the stems and roots as typical Rhizoctonia lesions, which eventually cause a girdling and the associated rosette appearance of the tops.

No such appearance of stems or roots has been found, but on the contrary, a rosette without any lesions and with complete absence of Rhizoctonia threads has been found. This disease which is found first in the seed bed, where naturally it can not be readily seen, becomes prominent after the last transplanting. Affected plants do not grow to any great extent after transplanting. The few center leaves which are put out remain small and stunted and present a marked contrast to the few outer leaves. In the last stages the inner leaves die and blacken.

This disease shows the vascular system in the roots markedly discolored. Sections show the water tubes to be plugged by bacteria. Cultures, however, have not yielded any one germ with regularity. The cause of this disease is as yet in doubt although it seems that this is a bacterial disease of the same type as the celery disease described earlier in this report.

**Selby, A. D. Ohio Sta. Bul. 145: 15-28. 1903. 4 figs.

The disease so far as a hasty survey of the literature is concerned has never been described, although a number of bacterial diseases of lettuce have been worked with. No doubt the similarity of the signs of this disease to the Rosette has caused this oversight. The disease is however distinct and for it I propose the name, The Stunting Disease of Lettuce. Further work is under way upon this disease.

The constancy of the appearance of diseased plants throughout an entire setting, indicates a seed-bed source for the disorder. Moreover the per cent of loss varies greatly, at one time being as high as 90 per cent while the next year the loss was from 5 to 10 per cent in the same bed. If we assume for this disease, an immunity in older plants as has been mentioned for celery, we have a plausible explanation for the conditions outlined. Where healthy seedlings are set out in spots where the Stunting Disease has killed the plant, these plants reach maturity.

As has been said the loss from year to year seems to vary with the comparative health of the seedlings. The health of the seedlings is associated with the newness of the soil in the seed beds, but even with fresh soil the disease has appeared. Considering the crudeness, so far as sanitary precautions with which this renewal takes place in the ordinary greenhouse, there is still plenty of opportunity for a quick reinfestation. This is especially augmented by the fact that the laborers who transplant the seedlings from the first seed-bed commonly work alternately in the growing beds and in the propagating houses. Sterilization of the soil has been tried, but here again the failure to make the clean-up absolute, has made conclusion impossible as to the efficacy of this measure. Where one seed bed has been sterilized, it frequently happens that the first transplanting will take place to an old bed which has previously borne diseased seedlings, and vice versa. From failure to realize the infectious nature of the trouble, and from the failure to prevent a quick reinfection, steam sterilization, which would probably be an effective control measure has fallen into disrepute.

So far, the disease has been found in Grand Rapids and Ann Arbor greenhouses. The outbreak in Ann Arbor was in soil that had never been used for greenhouse purposes, and the disease was first noticed in a bed planted with seedlings bought in New York. This points to a rather widespread distribution of the disease.

Its seriousness may be seen from the following counts made in squares of a hundred plants, lying adjacent in a bed, 6%, 3%, 3%, 4%, 3%, 6%, 3%, 6%, 3%, 3%, 7%, and 5%. The margin in lettuce growing between cost of production and selling price is sometimes very low, and the extent of damage from this disease is sometimes the deciding factor as to whether a bed is profitable or not.

TREE DISEASES.

Chestnut Bark Disease. The finding of the Chestnut Bark disease in Painesville, Ohio, and its occurrence in several western states made the question of whether the disease had advanced into Michigan of some interest. Chestnut as a forest tree is found only in a very restricted area in Michigan, in fact its occurrence is practically limited to two counties, Wayne and Monroe, in the southeastern part of the state.

In 1912, the report reached the department that many trees were dying about Wayne. Upon investigation at Wayne and Belleville no trace of the disease could be found in the large groves around those places. The death of tops and the general unthrifty condition was caused by the ravages of a cyclone. In 1914, in company with Mr. M. W. Gardner these localities were again visited and the groves carefully examined. In addition many large acreages of native chestnut about Monroe were inspected. No case of the disease was found.

The Chestnut plantations at the college have shown a marked mortality for the last few years, but on the dead trees no lesions of the Chestnut Bark disease have been found. Dr. Beal who planted nearly all of the trees and who has watched their growth for years attributes the death of the trees to severe winters.

Maple Leaf Diseases. Each year the college receives numerous specimens of hard maple leaves which show dead areas. Depending upon the time of year, or in other words, upon weather conditions, these specimens are either anthracnose resulting from the attack of a *Gloeosporium* or the well-known Leaf Scorch due to drought. The dead areas (Pl. IX) run along an affected vein in specimens which are sent in in spring and early summer, while those sent in in August show the dead areas between the veins. In the former case fruiting bodies are not readily found on the specimens, but they develop readily in moist chamber after a few days. The other specimens may mold, but no sign of anthracnose-like fungi are found.

These two diseases are of importance in Michigan where the hard maple is the principal shade tree in some cities, not so much because of the damage or even the unsightly appearance of the trees, but because of the number of trees that are cut down by the owners. The sudden withering and blighting of the tops is commonly construed to mean that the trees are dying.

The Phyllosticta Disease of Horse-chestnut. Of similar nature to the above diseases is the disease of horse-chestnut caused by *Phyllosticta paviae* Desm. (Pl. X.) No doubt the great vitality of the tree can stand the occasional defoliation, but the effect upon the householder is very much more severe! The accompanying cut shows the striking effect upon the leaves. In the usual attack upon the shade tree aside from the litter and the unsightly appearance little damage is done to the full-grown tree. The writer has observed complete defoliation and great stunting of growth of young horse-chestnut trees in a row in the nursery.

On the point of seriousness, these three diseases are very insignificant in comparison with the great loss of trees which occurs each year because of the gradual encroachment of heart rots upon the sound wood of the maples. It is very difficult to find trees which do not show more or less stag-head appearance. It seems safe to predict that at the present rate of deterioration the present mature trees which line the lawns will be rendered worthless for shade in from 15 to 25 years.

SUMMARY

In this preliminary article, the present extent of Curly Dwarf and Leaf Roll of potato has been outlined. The cucumber disease situation is seen to be a serious once. A new disease of unknown cause, is described for the first time and the name "white pickle" given by the growers is retained because of its descriptive value. A celery disease which has already done great damage is described. This disease has been found to be caused by a bacterial organism which produces its effects by plugging the vascular system. For this disease the name Stunting Disease of Celery is proposed. Attention is called to *Sclerotinia libertiana* Fckl. as a trench rot of celery and as a disease of greenhouse lettuce. Each of these cases were of interest because of the more or less definite history of the introduction of the parasite which could be traced. The Black Rot of Lettuce has been found associated with Rhizoctonia. An undescribed disease of lettuce which gives indication of being a bacterial disease of similar nature to the Stunting Disease of Celery is given a similar name, Stunting Disease of Lettuce. This disease although presenting the symptoms of Lettuce Rosette shows no connection with Rhizoctonia.

Several tree diseases are discussed briefly. Chestnut bark disease has not been found in the state. Maple anthracnose and leaf scorch are contrasted. The *Phyllosticta* disease of horse-chestnut has attracted much attention but it is not known to be serious. These foliage diseases by the suddenness of their attack and the striking effect upon the foliage have aroused much more interest than the heart rots which, in maple especially, may safely be predicted to be so serious, that in from 15 to 25 years, all the present mature trees will be dead or rendered worthless.

The diseases which are here described as new are at present under study at the laboratory and future publications are promised.

April, 1915, East Lansing.

LIGHT AND PYCNIDIA FORMATION IN THE SPHAEROPSIDALES.

BY EZRA LEVIN.

As a result of a hint* obtained elsewhere, experiments were initiated for the purpose of testing the effect of light upon various members of the Sphaeropsidales.

A representative number of forms were collected at Ann Arbor from as many genera as possible. A pure culture was obtained (always using the single spore method) transferred to a medium upon which pycnidia would be formed, and finally a set of cultures arranged so that all environmental conditions were equal except that one set was placed in the light and the other in the dark.

The material was brought into the laboratory and identified. The twigs or leaves were placed in moist chambers. After 24 hours, plates of corn-meal agar were poured in the usual manner. A pycnidium was cut out with a sharp scalpel and broken up in a tube (I) of agar. Three transfers were made with a platinum loop from tube I to tube II. Then three loops from tube II into tube III and finally poured into sterile petri dishes. The spores were immediately found under the low power of the microscope and marked. These were cut out and transferred to tubes of agar, usually five transfers being made.

Corn-meal agar was found to be the best medium for pycnidial production. In order to keep cultures in the dark and still allow for the maintenance of identical conditions of other environmental factors, the following method was used. The tubes were wrapped in black paper but not sealed. These were placed side by side with the tubes of the same species in the light. All trials for both light and dark were made in duplicate.

In this preliminary report just a few of the forms which have shown a decided difference in pycnidial formation when growth in light and dark will be reported.

(Considering 10 as arbitrarily representing the largest number of pycnidia formed in any the cultures, the data can be given briefly as follows.)

*That light is essential for pycnidia formation in some forms was first shown by Mr. G. H. Coons in this laboratory, working with *Aposphaeria fusco-maculans* Sacc. the results soon to be published.

	Light	Dark
Ascochyta	6	0
Phoma	3	0
Sphaeropsis	6	0
Fusicoccum	5	0
Coniothyrium	9	3
Phyllosticta	10	4
Cytospora	7	3

The cultures in the light and dark appeared similar in all respects, the mycelial growth was abundant and similar in amount as far as could be distinguished by the eye.

Agricultural College, East Lansing, Mich., 1915.

SOME FACTORS CONCERNED IN THE GERMINATION OF RUST SPORES.

BY E. B. MAINS.

Workers with the rusts have, for a long time, been troubled with the so-called "erratic" or "capricious" germination of the spores of these fungi. Such were the words usually used to explain the uncertain germination and infection by the uredo- and aecidiospores of the rusts.

Eriksson, while working upon the grain rusts,[1] found considerable difficulty in germinating the aecidiospores of *Puccinia graminis* Pers during the summer for, although spores of different maturity were sown in solutions of different kinds, no results were obtained. Finally in the late summer, he came to the conclusion that chilling the spores might have some effect. He found that by placing the spores on melting ice which finally came to the room temperature he obtained the best results. Upon having similar difficulty with the uredospores of *Puccinia glumarum* (Schw.) E et H., he tried the same method with like success. Marshall Ward in his work upon the brome rust[2] found that a number of factors contributed to this "capricious" behavior. He found that the uredospores of the brome rust *Puccinia dispersa* (Erikss.) germinated best at about 20° C. with a maximum limit of germination at 26-27.5° C. and a minimum at about 10-12° C. He remarks that it had been largely taken for granted that uredospores would germinate at almost any temperature during the summer. It was due to the failure to obtain infection under conditions which pointed to the temperature as a cause which led him to investigate the subject. Melhus, working on the Oomycetes, found that a low temperature was important for spore germination and infection in this group. He later applied his methods, as used in that group, to others.[3] Among the rusts, he obtained abundant infection with *Puccinia helianthia* (Schw.) at 14° C. and with *Puccinia coronata* Corda. at 16° C. and with *Puccinia sorghi* Schw. at 18° C. E. C. Johnson, working on the cereal rusts[4] found for *Puccinia graminis* Pers. and for *Puccinia rubigo-vera*

1. Zeits. für Pflanzenkrankheiten 4:66. 140. 197. 257.
2. Annals of Botany 16:233; Annales Mycologici 1:132.
3. Phytopathology 2:197.
4. Abstract in Phytopathology 2:47.

(Dc.) Wint. on wheat and rye that the minimum temperature for germination was 2° C. and the maximum 31° C. For *Puccinia coronata* Corda. on oats the minimum was 7° C. and the maximum was 30° C.

Other factors besides temperature enter in controlling germination but none are as general except moisture. Thus Marshall Ward has found that the spores of the brome rust germinate readily in light or in darkness, in red but not as well in blue light, in water containing green Algae, fibers of paper-pulp, and even germinating spores of other fungi, provided the temperature does not rise above the maximum and the spores are mature and fresh. W. Robinson has found[5] that the germ tubes of the sporidia of *Puccinia malvaccarum* Mont. grow away from the light. I also understand that F. D. Fromme has reported the same for the germ tubes of the urédospores of *Puccinia rhamni* (Pers.) Wettst. (*Pucc. coronata* Corda.) to the Botanical[6] Society of America in December, 1914.

In experiments with decoctions of the host, Marshall Ward was not able to find any effect produced by raw or cooked extracts of the host upon the germination of rust spores. Robinson, likewise, found that, when germinated in the dark, pieces of mallow leaf had no effect upon the sporidia of *Puccinia malvaccarum* Mont.

Moisture, of course, is a factor of prime importance. All workers with the rusts have recognized the fact that germination will take place only in the presence of moisture. Fromme finds[7] that, even with a humid atmosphere of 93 per cent infections take place only sparingly and, to obtain good infection, the saturated atmosphere of a belljar is required. Klebahn has worked with the teleutospores of *Puccinia graminis* Pers, *Pucc., phragmitis* (Schum.) Körn., and *Pucc. Magnusiana* Korn.[8] In all these, the teleutospore is supposed to germinate only after wintering. He found, however, that the condition for the germination of the teleutospore is principally an alternate wetting and drying. Cold is not necessary and in fact, acts as a hindrance.

The work upon which this paper is based was mostly done during the summer of 1914 and was initiated, as most of such work has been, by the difficulty of obtaining germination during the summer months. The rust which was under investigation at the time (*Puccinia coronata* Corda.) was first tested as to its germination at different temperatures. Other rusts were then investigated to see how far this temperature relation held. The tests were all made

5. Annals of Botany 28:330.
6. Amer. Jour of Bot. 2:82.
7. Torrey Bot. Club Bull. 40:501.
8. Zeits. für Pflanzenkrankheiten 24:1.

in hanging drops on the cover of a petri dish used as a moist-chamber. These cultures were run for twelve hours and then the per cent of germination was calculated. Most of the work was done upon uredospores but a few teleutospores and aecidiospores were tested.

Puccinia coronata Corda. (*Puccinia coronifera* Kleb.; *Puccinia rhamni* (Pers.) Wettst.) The results obtained with this rust agree with those obtained by other workers. The uredospores were used and gave 0% germination at 10° C. in two series of tests, 16 and 13% at 15° C., 81% germination at 18° C., and no germination was obtained at 30° C. Another series of tests was run, in which spores of different maturity and solutions of different sorts were used. It was found that, in case the spores were taken from pustules on leaves which had been dried for some time, the germination (35% at 18° C.) was much less than when the spores were taken from well opened pustules on green leaves (55% at 18° C.). Spores taken from unopened pustules on green leaves gave only slight germination at 18° C. There was found to be practically no difference between germination in conductivity water and in ordinary distilled water. In cases where pieces of the host were placed in the hanging drop there was no effect observed, either upon the germination or upon the direction taken by the germ tubes. It was found however that in cases where the cultures were illuminated from one side that the germ tubes turned away from the light. This negative heliotropism has been reported by Fromme[1] for this same rust (*Puce. rhamni*). The per cent of germination in this series accord with those in the other. A slight germination was obtained at 12° C., 15-20% at 13° C., 35-55% at 18° C., 26-46% at 25° C., and very slight germination at 30° C.

Puccinia taraxaci Plow. The uredospores of this rust gave rather varying results. In one series, no germination was obtained at any temperature. In another, 0% was obtained at 10° C., 1% at 18° C., 0% at 27° C., and 0% at 35° C. In a third series, 34% germination was obtained at 10° C., 30% at 14° C., 5% at 18° C., 0% at 27° C., and 0% at 35° C. The results obtained would indicate that a rather low temperature was necessary for this rust.

Puccinia sorghi Schw. The uredospores of this rust gave 0% at 10°C., 26% germination at 14°C., 50% at 18° C., 24% at 27° C., 18% at 35° C., and 0% at 45° C. This shows a higher range for the maximum than in most rusts. The most germination however takes place, as in most other rusts, at about 18° C.

Puccinia phlei-pratensis E. & H. Three series of tests were run

1. Amer. Jour. Bot. 2:82.

on the uredospores of this rust. The first two were not very conclusive as the material was not very good. A slight germination took place at all temperatures from 10-30° C. and no germination took place above this. The third series gave 21% at 10° C., 42% at 18° C., 20% at 24° C., and 0% at 30° C. This, as well as the previous two series, indicates a low limit for the minimum.

Puccinia polygoni Pers. The uredospores of this rust were tested three days after gathering. At this time, they did not give a very high per cent of germination. There was no germination at 15° C., a slight germination at 18° C., while only a few spores germinated at 28° C., and there was no germination at 36° C.

Uromyces trifolii (Hedw.) Lev. The uredospores of this rust gave 2% germination at 10° C., 27% at 16° C., 12% at 22° C., and no germination at 34-38° C.

Coleosporium solidaginis (Schw.) Thum. The uredospores of this rust gave rather variable results. At the best, they gave only a small per cent of germination and, in two out of six series of tests, no germination was obtained at any temperature. In the other four series, a slight germination took place between 14 and 20° C., the best being 13% at 16° C. At other temperatures above and below this, no germination was obtained. It may be that this is one of the rusts which needs the presence of the host in order to bring about abundant germination, as Freeman found in the case of some races of *Puccinia dispersa* Erikss. on some of the bromes.[9]

Melampsora Biglowii Thüm. In two series of tests with the uredospores of this rust, a slight germination took place between 10 and 27° C. Above this, there was no germination. In the third series, better germinating spores were used. This gave 14% at 10° C., 24% at 16° C., 15% at 22° C., and 0% at 34° C.

Melampsora Medusae Thüm. The uredospores of this rust gave 2% germination at 10° C., 6% at 16° C., 0% at 22° C., and 0% at 34° C.

Cronartium comptoniae Arth. The uredospores of this rust gave no germination. This was probably due to the fact that they were old, since they were collected late in the summer after a long dry spell and the teleutosporic columns had formed in large numbers. The aecidial stage of this rust, *Peridermium comptoniae* (Arth.) Orton & Adams, from Western Yellow Pine, gave no germination at 10° C., a slight germination at 18° C. and at 26° C., and no germination at 29° C.

The germination of the teleutospores of the three following rusts were studied:—*Cronartiun comptoniae*, *Cronartium commandrae*,

9. Annals of Botany 16:487.

and *Puccinia sorghi*. The teleutospores of the first two germinate immediately, while the last requires wintering.

Cronartium comptoniae Arth. As the teleutospores are formed in columns, it is difficult to express the germinations in per cent. Putting it relatively, there was no germination at 10° C., a slight germination at 18° C., a good germination at 25° C., and no germination at 35° C.

Cronartium Comandrae Peck. There was no germination at 10° C., a fair germination at 18° C., a good germination at 24° C., and no germination at 30° C.

Puccinia sorghi Schw. The method used in the germination of the teleutospores of this rust was the same as that used by Klebahn.[10] The experiment was carried on in the laboratory at a temperature of about 20° C. Leaves bearing teleutospores were alternately wet and dried by covering them with water for three days, the water being changed each day, and then drying them for three days. This process was repeated five times and then, after drying, the teleutospores were placed in a moist chamber, where fair germination was obtained with the formation of well developed basidia and sporidia. The material used was obtained from plants in the greenhouse during January and so had not been weathered at all. Similar material was also placed in bags out of doors, along with material which was collected from nearby fields in the fall. Neither of these gave any germination whatsoever, although both had been subjected to drying and wetting out of doors. From such results, Klebahn draws the conclusion that the winter cold is not a factor which promotes germination but rather that it hinders the germination of teleutospores.

Botanical Laboratory, University of Michigan, 1915.

10. Zeits. für Pflanzenkrankheiten 24 :1.

SOME CULTURAL CHARACTERISTICS OF PESTALOZZIA FUNERA DESM.

BY P. V. SIGGERS.

A comparative study* of vegetative growth was made on several kinds of agar and upon gelatin. Pine, carrot, corn meal, dextrose and synthetic agars were used. The cultures were made Jan. 16, 1915, and they represent the vegetative growth that appears in 14 days. Cultures were repeated so that representative cultures could be obtained.

Corn meal agar. Upon corn meal lateral growth (Pl. XI A) is comparatively slow. In the alloted time the distance covered was but two-thirds the distance from the center to the sides of the dish. There was little superficial growth and this type of growth consisted in nothing more than small, erect, simple branches from the surface of the agar.

Duggar's Synthetic agar and 1/20% peptone: Upon this agar the fungus spreads out in fan-shaped concentric areas (Pl. XI B). Three or four irregularly concentric circles are formed by a dense, superficial growth. The superficial mycelium remained unchanged in color and was dense enough to produce a decidedly bush effect.

Duggar's Synthetic agar and 1/2% peptone: Upon this agar there is a streaked appearance (Pl. XI C.) which is produced by the mycelium growing in thin fan-shaped areas.

Carrot agar: On carrot agar there is a density and a regularity of growth (Pl. XII A) which was not in evidence on the other media. An abundant superficial growth completely hides the surface of the agar. The erect aerial mycelium stood from 2 to 3 mm. above the surface of the agar.

Dextrose agar: Growth upon dextrose agar is characterized by rapid lateral (Pl. XII B) growth. The fungus spreads rapidly over the surface in irregular fan-shaped areas and scattered superficial masses appear upon the surface of the culture. This superficial growth has a tendency to form circular cell aggregations. In such regions many anastomosing filaments are found.

Beef gelatin: On gelatin, (Pl. II C) growth continues for a few days and stops. In that period hardly a third of the distance from the center to the edge of the dish is covered. Superficial growth is abundant and there are no concentric circles which indicate changes in rate of growth. There is no liquefaction.

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THE ORIGIN OF THE ANTHOPHYTA.

BY ERNST A. BESSEY.

This paper does not represent to any great degree the results of the writer's own investigations but aims to bring together the conclusions of the more recent investigations in this field, e. g. C. E. Bessey[1], Arber and Parkin, Wieland, Coulter and Chamberlain, Hallier, Lotsy, Sargent, Eames, Henslow, Bancroft, Sinnott and Bailey, etc.

As here used the name Anthophyta is applied to that immense group of seed-bearing plants which possess closed ovaries and true, although often much simplified, flowers; in other words, the group generally known by the name Angiospermae. At the time that it was thought that all seed-producing plants were monophyletic the name Spermatophyta was justified, with its subdivisions Gymnospermae and Angiospermae. The developments of recent years, however, have shown that the seed habit has appeared at a number of different points in groups but distantly related, e. g. Lycopods (almost, if not quite), Ferns, etc., and further, the cleavage between the Angiospermae and the several divergent groups of the Gymnosperms was so early and fundamental that it seems better to place the flowering plants in a separate phylum, distinct from the several other phyla of seed-plants.[2]

In spite of the frequent suggestions to the effect that the Anthophyta are polyphyletic in origin (e. g. Coulter and Chamberlain[3], Kubart[4]) the two groups Monocotyledoneae and Dicotyledoneae have too much in common to permit these suggestions to be adopted. Thus we observe the complete identity of floral structures (leaving out the much reduced forms) such as calyx, corolla, stamens, carpels, ovules; of the methods of pollination; of the development of micro- and megagametophytes (embryo-sac) and endosperm; of fertilization ("double fertilization"); of early embryonic development and nourishment; of seed dissemination; as well as of vegetative structure in general. It is true that many differences occur, but almost every character that we ordinarily call monocotyledonous

1. For the titles of the more important papers on this subject, the reader is referred to the appended bibliography.
2. Bessey, C. E. A Synopsis of Plant Phyla, p. 52. 1907.
3. Coulter and Chamberlain. Morphology of Angiosperms. Chapt. XV. 1903.
4. Kubart, B. Bemerkungen zur Pseudanthien- und Strobilustheorie. 1914.

can be matched within the Dicotyledoneae themselves, e. g. single cotyledon, scattered vascular bundles, of the "closed" type; trimerous flowers; parallel veins, etc., so that it would seem a not well grounded assumption to base a separate origin of the two groups upon these minor differences when so many of the more important characters are identical in both groups.

These facts have led botanists in recent years to seek for a group or groups of plants that might represent transitional forms from one class to the other. Some have sought to derive both groups independently from a hypothetical ancestral complex of true flowering plants from which have emerged on one hand the Monocotyledoneae, and on the other, the Dicotyledoneae; others have sought to derive the latter from the former or *vice versa*. Under the influence of Eichler, whose system was adopted in the main by Engler and Prantl[5] the primitive Monocotyledoneae as well as Dicotyledoneae were looked upon as being those forms whose mostly diclinous flowers were simple in structure and without a perianth. From these (respectively Typhaceae and Piperaceae) we find a gradual development to plants with more and more complete flowers, by the development of at first one, finally two series of perianth members, the attainment of hermaphroditism, the increase in numbers of the various floral parts and their subsequent gradual reduction and union until the Orchids in the Monocotyledoneae and the Composites in the Dicotyledoneae marked the respeective culminations of the two groups. This scheme of classification has several very serious defects. Thus we should expect to find the first, supposedly simplest, Monocotyledoneae and Dicotyledoneae to show the most numerous points of similarity, with greater and greater dissimilarity coming in as we progress further up each series. This is, however, far from being the case. Then, again, this scheme requires the independent development, in both classes, of flower types and structures that have very many points in common and that have rather a wide distribution in each class. I refer particularly to the pentacyclic type of flower and to the calyx and corolla as well as to flowers with numerous separate carpels, all of these being characters that would much better be looked upon as showing a common origin than as having developed independently in two distinct evolutionary lines. Other points might be brought forward but these will suffice.

C. E. Bessey proposed in 1893[6], after having taught it for many years previously, a scheme of classification in which a common

5. Engler, A. und Prantl, K. Die natürlichen Pflanzenfamilien. 1889-1914.
6. Bessey, C. E. Evolution and Classification, 1893.

origin was assumed for both classes in an ancestral plexus of plants very closely allied to and scarcely different from the apocarpous Ranales. Alismatales and Rosales, which were made, respectively, the first orders in three divergent evolutionary lines. (Pl. XIII fig 1). This system has been worked out in greater detail in subsequent publications by the same author.[7] The fundamental point of this classification is the assumption that the most primitive type of flower is that type most nearly representing a strobilus; i. e. with numerous separate sporophylls on a more or less elongated axis. This requirement is met in the apocarpous flower of the Ranales (e. g. Magnolia (Pl. XIII, figs. 2-4), Ranunculus (Pl. XIII, figs. 5-6) etc.) and of the Rosales (e. g. Rubus, Potentilla), both belonging to the Dicotyledoneae, and of the Alismatales in the Monocotyledoneae (Sagittaria, Alisma (Pl. XIII, figs. 7-11), etc.) This scheme of classification thus places as lowest in the evolutionary scale in both Monocotyledoneae and Dicotyledoneae forms whose similarity had long ago been recognized.[8]

Others have also proposed classifications with the same general features, viz. Ranales and Alismatales (Helobiae) as the beginning groups of the Dicotyledoneae and Monocotyledoneae, respectively, e. g. Delpino[9], Hallier[10], and Lotsy[11]. These three authors suggest that actually the Monocotyledoneae are directly derived from the Ranales, a view which C. E. Bessey soon accepted. This is supported on anatomical grounds by Miss Sargent[12]. This author also comes to the conclusion that the apocarpous (i. e. strobilar) type of flower is the most primitive. In 1904 Fritsch[13] expressed his idea that the apocarpous Monocotyledoneae are the most primitive and derived from the vicinity of the Ranales in the Dicotyledoneae.

In the discussions as to the phylogeny of the Anthophyta most writers seem to have had in mind the herbaceous families as the typical ones through which the evolution of the various groups has passed. The woody forms have been looked upon as having originated independently from herbaceous ancestors by the increase in cambial

7. See Bibliography.

8. Buchenau, Fr. Alismaceae. in: Engler & Prantl. Die Natürlichen Pflanzenfamilien. 2 Teil. Abt. 1. pp. 227-232. 1889. Particularly p. 229 where the author remarks upon the similarity in appearance of many Alismataceae with Ranunculaceae; also

Mussat, article Alismacees in: Baillon, A. Dictionnaire de Botanique, Vol. I, p. 116. 1876, who writes—"Finally, let us add that the Alismataceae show the greatest analogy in their floral structure, with the Ranunculaceae, with which they form a parallel group among the Monocotyledoneae."

9. Delpino, T. Applicazione di nuovi criterii per la classificazione delle piante. Memoria VI. 1896.

10. Hallier, H. Ueber die Morphogenie, Phylogenie und den Generations-wechsel der Achsenpflanzen, 1902, and other papers (see Bibliography).

11. Lotsy, J. P. Vorträge über Botanische Stammesgeschichte. Band 3. 1911.

12. Sargant, Ethel. The Origin of the Seed-leaf in Monocotyledons. 1902. (See Bibliography for other papers.)

13. Fritsch, K. Die Stellung der Monokotylen im Pflanzensystem. 1905.

activity, production of secondary bundles, etc. This viewpoint probably arose from the fact that most of the active botanists of the world have resided in the North Temperate zone where the majority of species and the prevalent families are herbaceous. Another possible reason for this viewpoint lies in the teaching of dicotyledonous stem-structure from forms with separate vascular bundles, it being taught directly or by inference that this is the typical dicotyledonous structure and that the woody cylinder is derived from it. I plead guilty to having both taught and written to this effect even in recent years. A third reason for this view is perhaps the fact that the forms of ferns and lycopods with which the botanist of the North Temperate zone is mostly familiar are herbaceous, so that in considering these as in the ancestral line of the Anthophyta, he is naturally inclined to look for herbaceous forms in the flowering plants, too, as being the more typical.

More recently, however, it has begun to be pointed out that the line of development within the Dicotyledoneae must have been, not along a series of herbaceous families, but rather along a line of woody families with numerous short side-lines of herbaceous plants as offshoots from the main line. Thus for example Eames, in 1911[14] pointed out that the primitive Angiosperms were more probably woody, with a continuous woody cylinder. That this structure is primitive is shown by the fact that it still occurs in the seedlings of many herbaceous plants. In 1913 various considerations led C. E. Bessey and the writer to this same conclusion which was expressed by the former[15] in the assignment of the first (i. e. most primitive) place among the Dicotyledoneae to the Magnoliaceae instead of to the Ranunculaceae as was done in his earlier writings. Recently Sinnott and Bailey[16] have been devoting much thought and research to this question of the phylogeny of the Angiosperms and have pointed out that whereas in the Temperate zone the herbaceous plants make up from 54 to 93 per cent (depending upon the region) of the species of flowering plants, they make up only for 12 to 54 per cent of the species in the Tropics, and this in spite of the large number of Monocotyledons which (excepting Palms and a very few other families) are all herbaceous.

Viewed in this light we would now consider the primitive Anthophyta to have been trees, dicotyledonous in stem and seedling structure, with large apocarpous flowers; with as their nearest

14. Eames, A. J. On the Origin of the Herbaceous Type in the Angiosperms. 1911.
15. Bessey, C. E. Revisions of Some Plant Phyla. p. 41. 1914.
16. Sinnott, Edward W. and Bailey, Irving W. Investigations on the Phylogeny of the Angiosperms: No. 4. The Origin and Dispersal of Herbaceous Angiosperms. 1914.

surviving relatives such plants as the Magnoliaceae and kindred families. (Pl. XV) The Monocotyledoneae are then to be regarded as derived from some of the herbaceous relatives of these, e. g. Ranunculaceae, Nymphaceaceae, etc. Whether it was as an adaptation to an aquatic or moist habitat that they were developed, as Henslow[17] would have us believe, or otherwise, they are prevailingly herbaceous. Such arboreal forms as do exist (e. g. Palmaceae, Pandanaceae, etc.) possess a type of woody stem derivable from the typical herbaceous monocotyledonous stem, and are certainly only secondarily woody. On the other hand, we can follow a woody backbone in the Dicotyledoneae up from the woody Ranales to the Malvales, Geraniales, Guttiferales and Caryophyllales respectively, and from the latter to the Ebenales, Ericales and Primulales. From the latter, a woody backbone runs up with many herbaceous branches, through the Polemoniales to the Scrophulariales on the one hand and to the Lamiales on the other. Coming back to the Ranales, we find it an easy step to the Rosales from which arise at one side, the Myrtales and at another, the Celastrales which terminate in two orders, the Sapindales and Umbellales. Even these latter are woody as to their central line (Cornaceae) which give rise to the woody Rubiales and eventually through these to the partially woody Campanulales and Asterales.

Such a system as outlined above requires us to seek as our hypothetical ancestral form a woody plant, presumably branched, with at least moderately large leaves (for the woody Ranales have rather large leaves); and with the sporophylls arranged in large strobili, the megasporophylls above, numerous and spirally arranged, the microsporophylls below, and similarly arranged, and with several large bracts below, forming a "floral" envelope. Such structures we fail to find in the Strobilophyta (Conifers) for there we find needle-shaped leaves and naked strobili with the different sexes in separate cones. The suggestion by Hallier and by Coulter that the Anthophyta may have arisen from Lycopodinean ancesters has some things in its favor, viz. the strobilar arrangement of the sporophylls. However, the leaf and stem structures are far from satisfying our hypothesis. The arrangement of the megasporophylls and microsporophylls, the absence of perianth leaves, etc., are points against this group. The Cordaitineae have small, reduced and crowded strobili of separate sexes and so fail to fit the requirements. The Cycadineae have separate strobili that fail to satisfy conditions. Furthermore, the stems are practically unbranched. The Bennet-

17. Henslow, G. The Origin of Monocotyledons from Dicotyledons, through Self-adaptation to a Moist or Aquatic Habit. 1911.

titineae, however, show so many points of similarity that Wieland[18] in 1906 called attention to this group as being possibly related to the ancestors of the Anthophyta. It was Arber and Parkin in 1907[19] who elaborated this suggestion of Wieland's and worked out an elaborate hypothesis as to the ancestry of the Flowering Plants from the vicinity of this interesting group. The more important of these suggestions are given below with the addition of a few minor points by the writer.

As revealed by the marvellously patient and detailed investigations of Wieland, we find the Bennettitineae to have been, in the main, woody plants with short, stout trunks, unbranched or with the crown divided into several very short branches. In general structure, the trunk as well as the leaves resembled closely the modern Cycads. Not all of the group, however, were unbranched or shortly branched, for one species (*Williamsonia angustifolia*) has been found in which the plant is much branched (Pl. XIII, fig. 12). It is noteworthy that in this type the leaves are much smaller and not so deeply pinnately-cleft, which fits in with Arber and Parkin's theory that with the acquirement of a branching habit megaphylly becomes transformed to microphylly. It is, however, the reproductive strobilus that is the most interesting. (Pl. XIII, fig. 13.) This consists of an axis arising in the axil of a foliage leaf. The upper parts of the axis is occupied by spirally arranged structures terminating in ovules and interspersed with sterile bracts. Apparently, we have here much reduced megasporophylls, each with one ovule, the bracts perhaps representing megasporophylls that have become sterile and used for protection purposes. The seed is dicotyledonous. (Pl. XIV, fig. 14.) Below the "gynoecium" is a whorl of microsporophylls, just where the stamens belong in a flower, and below these several to many large spirally arranged bracts which overtop the "flower," forming a sort of "perianth." The microsporophylls are of great interest as they point forward by their position in the "flower" to the flower of the Magnolia type while by their structure they point backward to the Pteridospermeae or "Seed Ferns." Each microsporophyll is a large, pinnately-compound structure along whose pinnae are arranged numerous pairs of microsporangia. The whole sporophyll is very fern-like and reveals an undoubted relationship of the Bennettitineae to the fern-like, woody Pteridospermeae. In this latter group, however, the strobilar arrangement of the sporophylls is lacking, and the mega- and microsporophylls are more nearly of the foliage-leaf type of

18. Wieland, G. R. American Fossil Cycads. 1906.
19. Arber, E. N. and Parkin, J. On the Origin of the Angiosperms. 1907.

structure (Pl. XIV, figs. 15-16). This group is, in its turn, undoubtedly descended from some of the Marattia-like Eusporangiate ferns. We must assume that in the ancestral Pteridospermeae some such a tendency to strobilus formation arose as is shown among modern ferns such as the Ostrich fern (*Matteuccia struthiopteris*) where the fertile leaves (sporophylls) arise in a cluster together, or as in *Osmunda cinnamomea*. Indeed, these first steps towards strobily are found in many, if not most, ferns, for from a bud arise usually sterile leaves first and subsequently fertile ones. In the Cycads we see in the genus Cycas the last steps in this same tendency. Here the microsporophylls are already in a definite strobilus but this is still rather lax as to the megasporophylls.

With the adoption of heterospory among the ancestral Eusporangiatae and subsequent acquirement of the seed habit both microsporophylls and megasporophylls began to be modified. In the line of descent that led to the Cycadineae the modification was about equal in each and by some chance the strobili that developed were unisexual. In another slightly different direction of strobilar development a bisexual strobilus arose, but in this group the megasporophylls were far more reduced than the microsporophylls and we have arising the Bennettitineae. Probably from some point early in this development line that ultimately produced the Bennettitineae there started a third line of modification, like the latter in producing a bi-sexual strobilus and in possessing a "perianth" but differing in that the megasporophylls were not so completely reduced. These latter were probably more or less pinnate, much like those of Cycas, and not reduced to a stalk and terminal ovule as in the Bennettitineae (Pl. XIV, fig. 17). On the other hand it may well be that the microsporophylls had nearly lost their pinnate structure or that the pinnae instead of being long with two rows of sporangia were reduced to very short pinnae with but two sporangia each. If the pinnae now became crowded by the shortening of the microsporophylls and the microsporangia fused with one another longitudinally, there would be produced a microsporophyll with four longitudinal rows of fused sporangia or four pollen-sacs such as the typical stamen possesses. The slightly pinnate megasporophylls by infolding would produce the closed pistils (Pl. XIV, fig. 18). At first these were probably open at the tip to permit access of the microspores to the megasporangia (ovules) but as the microspores increased their ability to produce pollen tubes the closure gradually became complete. The writer's[20] investigations upon the development of the pistils in the Ranunculaceae, Alismataceae and

20. Bessey, Ernst A. The Comparative Morphology of the Pistils, etc. 1898.

Rosaceae showed that these arise as open megasporophylls with the megasporangia (ovules) exposed to the air, but that gradually the edges fold together, from below first, eventually closing entirely only shortly before pollination.

The origin of the embryo-sac, "double fertilization" etc., cannot be traced out in any available fossils. Whatever theory as to the ancestry of the Anthophyta is followed, the explanations as to these structures must be about the same.

It remains to be pointed out that such branched forms of Bennettitineae as Williamsonia augustifolia show that the single trunk habit of most of the group was not fixed to so great a degree that the vicinity of this group can not be regarded in the ancestral line of the Anthophyta. Likewise the small leaves of this form with their but slightly lobing may well forecast the small, simple (but strongly pinnately veined) leaves of Magnoliaceae (small leaves as compared with the Cycads and Bennettitineae in general, but large as compared with many Anthophyta.) The strobili of the Bennettitineae were about the size of the flowers of the Magnolia.

Summarizing briefly:—the Eusporangiatae among the ferns gave rise to the Pteridospermeae, from which arose two main lines of descent, each accompanied by the development of the strobilar structure. One of these lines, that with bi-sexual strobili with a "perianth," gave rise, on the one hand, to the Bennettitineae and, on the other, to the Anthophyta whose most primitive forms are the Ranales, with large strobilar flowers. From these have arisen all other groups of Anthophyta.

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HELICOSTYLUM AND CUNNINGHAMELLA: TWO GENERA OF THE MUCORALES NEW TO THE STATE.

With two plates.

BY ALFRED H. W. POVAH.

The mucorales are divided into two sub-orders; a. Sporangiophorae, b. Conidiophorae, according to whether the asexual spores are borne in sporangia or on conidia. Under the first sub-order Lendner* (4) recognizes four families: Mucoraceae, Thamnidiaceae, Pilobolaceae and Mortierellaceae, while under the Conidiophorae he has but two: Chaetocladiaceae and Cephalidaceae.

While studying the Mucors during the past few years, I have found several interesting forms, among them the two which I wish to discuss, since they appear only in the foreign literature, never having been found, or at least, not reported in this country to the best of my knowledge. They are Helicostylum piriforme Bain. and Cunninghamella elegans Lend. and belong to the Thamnidiaceae and the Chaetocladiaceae respectively.

Helicostylum (Pl. XVI) differs from the more common Thamnidium by the fact that the sporangiophores, bearing the sporangioles are circinate, and also that the sporangioles are deciduous. Cunninghamella differs from Chaetocladium by the fact that the conidia are born on the globular, distal portions of the conidiophore. Moreover Cunninghamella is a saprophyte.

HELICOSTYLUM PIRIFORME BAIN.

This species was found, during the fall of 1913, on horse dung which had been brought into the laboratory and placed in a moist chamber. It showed as a tiny black-headed stalk, not more than 2 mm. tall. Gross transfers were made to insure its growth, and then a single spore culture was made, Kauffman's (3) method being used.

When cultivated on bread it forms a dense, pale gray, sericeus turf, up to 4cm. tall, which in old cultures, becomes brownish black. The branching of the sporangiophores is quite as variable as that of Thamnidium elegans. Instances of unbranched sporangiophores,

*Figures refer to the bibliography at the end of the paper.

bearing at the apex either a large sporangium or a cluster of sporangioles, are common. In younger cultures the proportion of unbranched sporangiophores is relatively greater than in older cultures, where the unbranched sporangiophores remain short, not more than 1 mm. tall. The sporangiophores, however, may be branched, bearing one or more lateral branches, terminating in a sporangium, or sterile at the tip, with sporangioles clustered below. The sporangiophores are usually brown, about the same shade as the zygophoric hyphae of Sporodinia.

The sporangia are sub-globose to globose 100-160u in diameter,, (average 120-130 microns) with a readily deliquescent membrane, covered with minute crystals. The columella is hyaline, oval to pyriform 82-148 microns tall by 62-117 microns broad. The deciduous sporangioles are pyriform, 20-31 x 23-33 microns and are borne on long pedicels, circinate at the distal end. They may arise in small clusters of three or four, as forkings of a short, lateral branch of a sporangiophore. More often, however, they are born in a cluster of 100 or more, on a whorl of short, thickened, forked, lateral outgrowths of the sporangiophore. As many as five or six such clusters of sporangioles have been observed on a single sporangiophore, so close together as to resemble a row of loose-strung beads. The wall of the sporangioles is persistent, finally breaking into pieces to allow the escape of the spores, which are gray, smooth and measure 5-10 x 4-6 microns, in both the sporangia and the sporangioles.

This mucor is readily cultivated on gelatin, agar, bread, etc.

Helicostylum was first described by Bainier in 1880 and since then, so far as I know, has been reported and figured but once, viz. by Massee and Salmon (5).

CUNNINGHAMELLA ELEGANS LEND.

Cunninghamella echinulata was first described by Thaxter (7) under the name Oedocephalum in 1891, before the genus was known to belong to the zygomycetes. Matruchot (6), by an unique morphological and physiological study, proved Cunninghamella echinulata to be a Mucor, and his work was later confirmed by Blakeslee (2) who described the zygospores. The species with which we are concerned is C. elegans Lend. Pl. XVII). It was first described by Lendner (4) in 1905, he having isolated it from soil.

I also obtained this species from garden soil, in the fall of 1914. The method used, because of its good results, I shall give in detail. Five or six Petri dishes were wrapped in paper and then dry sterilized. In the field the dishes were quickly filled with soil, exposing them to the air as short a time as possible. The Petri dishes were then sealed with a gummed label, on which was written the data. After return to the laboratory, the soil samples were generously moistened with sterile water, drops of which were transferred to agar plates with a platinum needle. From these one additional transfer usually gave a culture free from contaminations, and from which a single spore culture could be made.

On bread Cunninghamella elegans forms a white, slightly ashey, cottony mass up to 3.5 cm. tall. In older cultures the mycelial mass becomes darker, reaching a pale, grayish-tan. No sporangia are formed, but asexual reproduction takes place by means of conidia. The conidiophores are erect, more or less branched, with, or without septa, and terminate in spherical heads 39-51 microns in diameter, furnished with papillae, which are the points of insertion of the conidia, sometimes the persistent pedicels of the conidia. Below this terminal sporiferous head, there is usually a whorl of smaller conidia-bearing heads, up to 23 microns in diameter. The number of branches in the whorl is generally three to five, but varies somewhat. Not seldom the conidiophore forms a swelling, similar to an early stage in the formation of a sporiferous head, but, from which arise branches, which may bear conidia at their swollen distal ends, or may end in a sterile tip.

The conidia arise as a simple projection from the sporiferous head, which enlarges at the tip and is finally cut off by a wall. The conidia borne on the terminal sporiferous head are oval to pyriform and measure 16-21 x 12-16 microns, those on the lateral swollen heads are spherical or slightly oval and are from 10-16 microns in diameter. The membrane of the spores, in many cases, is furnished with very delicate spines, which may equal one-half the diameter of the spore in length. Sometimes, however, the spines are very short and inconspicuous, or in some cases the membrane of the spores appears practically smooth.

This mucor is also readily cultivated on bread, agar, etc.

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GROWING ALIEN CACTI IN MICHIGAN.

BY W. E. PRAEGER.

In the Spring of 1911 I received from the Desert Laboratory of Tucson, Arizona, a collection of Cacti. My intention was to see if any of the mountain species from Arizona that yearly endure a freezing temperature would grow in Michigan. Dr. Forrest Shreve kindly sent me representatives of thirteen species including some from the mountains, mesas and foothills. The vertical range of some of these was several thousand feet.

The following species were represented:

Echinocereus polyacanthus
E. acanthocarpa
E. fendleri
Mamillaria arizonica
M. grahami
Carnegia gigantea
Opuntia neo-arbuscula
O. arizonica
O. leptocaulis
O fulgida
O. santarita
O. spinosior
O. versicolor

The specimens were planted in a raised bed, the soil of which had a good proportion of sand. They were in full sun most of the day though the morning and evening lights were interfered with by trees. During the summer they thrived and several of them flowered. I started some new plants from cuttings and as winter approached potted duplicates and kept them in the house.

This fall from the middle of September was very wet. On the 12th of November there was a drop of 50 degrees in twenty-four hours, the thermometer at that time reached 18 F. and cold and snow lasted for two weeks. December was mostly mild, 56 degrees being registered on the 10th. I went botanizing on Christmas day and found many things growing. On the 30th it became cold again and for ten weeks there was continuous and severe cold with frequent zero weather. Deep snow prevented the ground being much frozen.

At the end of the winter only one plant was alive, a low specimen of Mamillaria arizonica that had been well protected by snow. All the others had been apparently killed by the first cold snap in November, or, weakened by the cold, died in the warm period that followed. The exact time of death was difficult to determine.

Nine species that I had carried over were established out of doors in the summer of 1912. The fall was again very wet and the early part of the winter wet and mild. January was unseasonably warm with heavy rain storms. With February, winter really began bringing cold and snow and the lowest temperature was in the first week of March when –4 F. was reached.

The specimen of Mamillaria arizonica that survived the previous winter died but another plant of the same species lived and this was the only survivor. Most of the others died early in the winter but in some cases death seemed to have been caused by decay rather than by cold.

The last of my plants were left out this past winter. They had proved their ability to endure twenty degrees of frost in the enclosed porch where they had been kept the previous season. There was one plant each of Mamillaria arizonica, Opuntia spinosior, O. santarita and O. leptocaulis. They all died early.

The general conclusion from my experience is that Arizona cacti will not survive Michigan winters. The most obvious of probable reasons is temperature. Dr. Shreve informs me that at their 8,000 foot station the minimum temperature in severe winters is about +5 F. None of my species range above that height and most of them are found considerably lower down. In Michigan a winter temperature 20 degrees lower than what they have to endure in Arizona would be usual. But most of my specimens were dead before the minimum was reached, sixteen degrees of frost being fatal to many of them. In the case of those species that inhabit the lower ranges as Carnegia gigantia this is not surprising, but Echinocereus polyacantha ranges to 7,800 feet, Mamillaria grahami to 7,000, Opuntia santarita to 5,400, O. spinsior to 5,000, O. versicolor to 5,200. These were killed by temperatures probably no lower than that they might have experienced in their native habitat. It is rather curious in this connection that the species which seemed hardiest with me, M. arizonica, has a range up to 6,000 feet, not as high as E. polyacantha or M. grahami.

I think that the warm wet falls that are so common with us have much to do with the death of these plants. We have had such a condition for four successive years. Last winter there was growth of some plants as late as the second week of December. In the drier climates farther west this must be very unusual.

It is often difficult to determine the exact time of death as a loss of turgidity in winter is characteristic of our own hardy species.

I have now seven species of Cactacea growing that have proved hardy. Echinocereus viridiflоris and Echinocactus simpsoni are not killed by our most severe frosts but do not thrive and I am inclined to think our humid climate is unsuited to these rotund species, they tend to decay but perhaps I do not know how to take care of them. Five species of Opuntia (arenaria, phaeocantha, polyacantha, rafinesquii and vulgaris) grow well and are perfectly hardy. All these become flaccid in winter with drooping stems and shrunken joints. This change takes place in part before winter sets in while it is particularly noticeable that with none of the Arizona cacti was there any apparently response to the early light frosts nor any loss of turgidity until they were hit by real winter weather.

This gradual loss of turgidity in the fall, which is shown best perhaps in our native species Opuntia rafinesquii, seems to be equivalent to a deciduous habit and probably has much to do with the ability of certain species of Cacti to stand our winters.

Kalamazoo, Michigan, 1915.

DOES THE MOVEMENT OF AIR AFFECT THE GROWTH OF PLANTS?[1]

BY ALMA HOLLINGER.

There is a general opinion that plants grow better in moving air than in still air.

This opinion was tested in a series of experiments with plants. The work was all done in a dark room. On one side there was a shelf, at the end of which was an electric blower that kept a continual current of air moving over that shelf. On another shelf the plants were kept under bell jars, thus excluded from all moving air.

The first tests were made with seedlings, with the result that after seven days the radish, lupine and buckwheat showed an average gain of .23 to .93 inch in the current of air; the corn, several varieties, showed an average gain of 3.9 to 5.4 inches in the still air under the bell jars.

The moisture was not controlled in these tests; the humidity under the bell jars was 100% while that in the moving air was much less. The temperature varied from 20° to 22° C. in the current, while it was 1° to 2° C. warmer under the jars.

In order to have the moisture conditions nearly equal, a third set of seedlings was tested with the other two. These were placed in a large wooden case closed, except on one side, five inches from the wall. In these tests the moisture conditions were kept nearly equal with those in the current of air. Again the greater gain was in the moving air; here the corn, also, gained more in the current.

The growth was not quite so rapid at first in the moving current as in the still air, but continued for a period of two to five days longer. When there was any noticeable difference in the vitality, it was greater in the moving air. The seedlings showed a deeper yellow color, stronger stems and a little more leaf expansion.

After a number of tests had been made with seedlings, green plants were tested. Small potted Fuchsias were selected as near the same size and vitality as possible. These tests were also made in the dark room. One set was placed in the moving air, another in the case and a third under the bell jars. This was repeated; each time the Fuchsias in the moving air gained a greater average length

1. Abstract of paper. The paper will be printed in full only after the completion of further investigations.

and kept their vigor four to five days longer than either those under the bell jars or in the case. The growth continued through the first three days in all plants, but growth was noticed the fourth day only in those in moving air.

The result of these tests shows that moving air does affect the growth of plants; for the plants in the current lived longer than those in still air.

This is only a preliminary report. The writer is under great obligations to Prof. F. C. Newcombe of the Botanical Department of the University for most valuable assistance in carrying out the above experimental investigations. A more complete report cannot be given until more work has been done.

University of Michigan, Ann Arbor, 1915.

THE RELATION OF THE STORAGE OF THE SEEDS OF SOME OF THE OAKS AND HICKORIES TO THEIR GERMINATION.

BY C. C. DELAVAN.

The work described in the following paragraphs was carried on during the winter of 1913-14 under the direction of Professor Newcombe at the Botanical Laboratories of the University of Michigan. It was desired to compare different methods of storing the seeds of these two important genera of South-Michigan timber trees so as best to retain their germinating ability.

Three species of hickory—Carya glabra, ovata and cordiformis; three species of the white oak group—Quercus alba, macrocarpa and bicolor; and two species of the black oak group—Quercus rubra and velutina, were used in these experiments. These seeds were collected from trees in the vicinity of Ann Arbor in October 1913. At this time the seed of all eight species were thoroughly ripe and most of the acorns had fallen.

The seed of the white oak group, Quercus alba in particular, was possibly not in the best of condition at the time they were collected. Many of them had already germinated and it is possible that some of those not germinated had failed to do so from lack of vitality.

The seed of each species was divided into four equal parts. One part was placed in glass fruit jars and put in a pit about one foot under the surface of the ground. The minimum temperature reached in this pit was –5° C. and the seeds placed there had, on April 1, 1914, a moisture content, in per cent of their weight, of 16 to 40. The relative humidity in the pit was fairly high.

A second part was placed in closed, but not sealed, fruit jars and placed in the ice box of the Homeopathic Hospital. The temperature here varied between 1° and 8° C., the relative humidity averaged about 95% and the moisture content, in per cent of the weight, was, on April 1, 1914, between 13 and 42, depending on species. The moisture content of the seeds was, with one exception, higher than that of the seeds in the pit.

A third part was weighed and then dried at a temperature less than 40°C. until the seeds had lost about 5% of their original weight. They were then placed in closed, but not sealed, fruit jars and kept in the laboratory where the temperature averaged about 22° C. and the relative humidity about 47.5%. On the 1st of April, 1914, the moisture content, in per cent of the weight, varied, with species, between 7 and 26.

The fourth part was stored in closed glass fruit jars in the laboratory where the above stated laboratory conditions prevailed. On April 1, 1914, the moisture content, in per cent of the weight, varied with species, between 7 and 13.

Ten seeds of each species from each condition were planted each month from October to April inclusive. The seeds were planted in loam in the greenhouse and were kept moist and under good conditions for germination. The ungerminated seeds were examined each week for signs of germination and when a seed had germinated it was not further disturbed.

The detailed tables of germination show that the results may be expressed fairly accurately by making three groups, i. e. hickories, white oaks and black oaks. A table of the results for each group under each condition follows. The figures give the average per cent of germination of the species in the group from the given condition.

	Pit	Ice Box	Dried	Untreated
Hickories	83%	88%	41%	37%
White Oak group	77%	87%	62%	45%
Black Oak Group	81%	99%	18%	29%

As seen by the above table the seeds of all the species tested kept better in the ice box than in any of the other conditions. The germination per cent of the seeds from this condition was fairly constant throughout the series of tests. With the hickories and the black oaks the length of time it took them to germinate, or period of germination, decreased steadily as the tests proceeded.

The seeds from the pit showed the next highest germination per cent. Here, too, the germination remained fairly constant throughout the tests and the period of germination decreased in the case of the hickories and black oaks as the season progressed. In the case of the white oaks this decrease was preceded by an increase.

The seeds that had been artificially dried showed up rather poorly. The germination per cent was very low in all species and in all except the Quercus bicolor, Carya cordiformis and Carya ovata the germination dropped to 0 after the first few plantings. The period of germination was more erratic than in the two preceding cases but was normally longer than in either.

The untreated seeds behaved, on the whole, even worse than those artificially dried and acted very much in the same way.

From the results obtained in these few tests with a small number of seeds it would appear that, for the storage of the seeds of these species at least, a cold, even temperature even if the atmosphere is very moist is better than a warm and, in this case, drier condition of storage.

University of Michigan, Ann Arbor.

DR. BEAL'S SEED VITALITY EXPERIMENTS.

BY H. T. DARLINGTON.

In the autumn of 1879 Dr. Beal began an experiment to test the vitality of the seeds of some of the most common plants, growing in the vicinity of the Agricultural College. An account of the experiment appeared in the Botanical Gazette, August 1905, giving a report for the first twenty-five years, and again in the Thirty-first Annual Report of the Society for Agricultural Science, bringing the results up to and including the year 1909. I shall give a brief survey of the experiment up to date.

As to the nature of the experiment, I cannot do better than quote Dr. Beal himself. He says, "I selected fifty freshly grown seeds from each of twenty-three different kinds of plants. Twenty such lots were prepared with the view of testing them at different times in the future. Each lot or set of seeds was well mixed in moderately moist sand, just as it was taken three feet below the surface, where the land had never been plowed. The seeds of each set were well mixed with the sand and placed in a pint bottle, the bottle being filled and left uncorked, and placed with the mouth slanting downwards, so that water could not accumulate about the seeds. These bottles were buried on a sandy knoll in a row running east and west and placed fifteen paces northwest from the west end of the big stone set by the class of 1873. A boulder stone, barely even with the surface soil, was set at each end of the row of bottles, which was buried about twenty inches below the surface of the ground." So much for Dr. Beal's description of the experiment.

A set of seeds has been tested every five years. At this rate, as twenty sets were buried, there will be enough to last a whole century from the time the experiment was started.

The following is a list of the seeds tested, giving the names then in use:—Amaranthus retroflexus, Ambrosia artemisiaefolia, Brassica nigra, Bormus secalinus, Capsella Bursa-pastoris, Erechthites hieracifolia, Euphorbia maculata, Lepidium virginicum, Lychnis Githago, Maruta Cotula, Malva rotundifolia, Oenothera biennis, Plantago major, Polygonum Hydropiper, Portulaca oleracea, Quercus rubra, Rumex crispus, Setaria glauca, Stellaria media, Thuja occidentalis, Trifolium repens and Verbascum Thapsus.

Some black walnuts were also buried at different depths but these and acorns were not put in bottles. None of the walnuts planted deeply germinated.

Dr. Beal made all the tests up to 1909, the thirtieth year. This last fall, the thirty-fifth year, I have endeavored to get germinations from another set. So far, I have only been partially successful. You will notice from the table that out of the twenty-two in this list, eight failed to germinate up to and after the fifth year. The remaining species have germinated some years. Lepidium virginicum has germinated every year. Probably this is also true of Rumex crispus.

In inducing the seeds to germinate, Dr. Beal obtained the best results by moistening the sand, getting a few to come up and then allowing the soil to dry out for a while, and then moistening it again and so on. This was repeated at varying intervals for several months. I have adopted the same plan and hope to get some more to germinate. When the germinations were started, a flat was planted with similar seeds for checks on the seedlings.

In closing, I shall quote Dr. Beal's opinion as to the behavior of these seeds. "It is to the advantage of the plants not to shoot up all their seeds at one time, but to retain a good portion alive in the soil ready for stocking the earth in successive years. Again, we must consider that it makes very little difference whether all the seeds live over for a time or only a small portion of those which were produced, as a living seed now and then left is enough to save the stock and produce a new crop of seeds.

Names of seeds tested.	5th yr.	10th yr.	15th yr.	20th yr.	25th yr.	30th yr.	35th yr.
Amaranthus retroflexus	+	+	+	+	+	+	O
Ambrosia artamisiaefolia	O	O	O	O	O	O	O
Brassica nigra	O	+	+	+	+	+	+
Bromus secalinus	O	O	O	O	O	O	O
Capsella Bursa-pastoris	+	O	+	+	+	+	+
Erechthites hieracifolia	O	O	O	O	O	O	O
Euphorbia maculata	O	O	O	O	O	O	O
Lepidium virginicum	+	+	+	+	+	+	+
Lychnis Githago	O	O	O	O	O	O	O
Maruta Cotula	+	+	+	O	+	O	?
Malva rotundifolia	+	O	O	+	O	O	O
Oenothera biennis	+	+	+	+	+	+	O
Plantago major	O	O	+	O	O	O	O
Polyganum Hydropiper	O	+	+	+	+	possibly	O
Portulaca oleracea	O	+	+	+	+	O	O
Quercus rubra	O	O	O	O	O	O	O
Rumex crispus	+	?	+	+	+	+	+
Setaria glauca	+	+	+	O	+	+	O
Stellaria media	+	+	+	+	+	+	O
Thuja occidentalis	O	O	O	O	O	O	O
Trifolium repens	O	O	O	O	O	O	O
Verbascum Thapsus	+	?	+	+	O	O	+

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CONTRIBUTIONS TO THE BOTANY OF MICHIGAN NO. 14.

BY OLIVER ATKINS FARWELL.*

MICHIGAN NOVELTIES.

When any botanical field is, for the first time, subjected to an intensive study, it will produce a number of new and interesting forms, at least to the student of systematic botany. During my field work in and around Rochester, Oakland Co., Michigan, in 1914, a number of such were discovered some of which form the basis of this paper. Two species, *Mitella diphylla* and *Apocynum Farwellii*, evidently in that condition which DeVries calls "Mutable", may be mentioned as especially illustrating one way of producing what he terms "elementary species." This is by way of suppression or obliteration of some part of the plant body. That the former species is in a mutable condition is more apparent as two variations have already been described and named, which are not due to a suppression or reduction of any part of the plant body.

The variations already named include forms with a third leaf on the scape situated between the normally opposite nearly similar leaves and the infloresence and another wherein the leaves are long petioled. The form I have found has but one leaf on the scape. Here one of the normally opposite leaves has been suppressed; the species wherever it grows is found in large patches, and in such patches where this form with one leaf occurs, one will always find a series of individual plants that will show a complete gradation from the normal to this form; that is, with one leaf gradually getting smaller, while the other remains normal, until the blade has entirely disappeared and then a similar shortening of the petiole until there is no evidence on the surface of the scape of a second leaf. I have seen plants in which the leaf blade had been reduced to the size of a minute bract, perhaps 1-16 of an inch in length, and others on which the only indication of a second leaf was a small mucro of similar length and one that even had a flower opposite. Evidently the flower was of axial origin but there was no indication whatever of the subtending leaf. It may also be remarked that an axillary flower is quite an unusual condition in this species.

The other plant is one of our dogbanes. When first collected I had referred it to *Apocynum pubescens* R. Br., but Dr. E. L. Greene, of Washington, D. C., considered it distinct and has named it *Apocynum*

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Farwellii. It is common at Detroit and probably throughout lower Michigan. The typical form is glabrous and glaucous below pubescent on the upper parts as well as on the under side of the leaves; the flowers are small, a line in length, white, the lanceolate calyx lobes nearly as long as the corolla.

At Rochester, Oakland Co., there is a form that is glabrous and glaucous throughout. Both of these forms typically have a normal opposite phyllotaxis and the stems, are more or less obtusely four angular. Each has a form that shows a triangular stem with leaves in whorls of three and the glabrous form has also shown a state wherein the leaves are partly alternate, partly opposite, and partly subverticillate. One leaf of the three is occasionally wedge-shaped with a large indenture at the apex as though a wedge-shaped section had been cut out, a transition towards four leaves to a whorl. Some of the branches are divided to the middle, the lower part being triangular with leaves in threes while each of the upper divisions are normal with the normal opposite phyllotaxis. These facts would seem to indicate a coalescense of two stems or plants, the condition known as fasciation. In a coalescense of two plants one might naturally expect a four angular stem with, possibly, an intermediate angle or rib on each side and four leaves in a whorl; but the triangular stems and verticills of three leaves seems to indicate a reduction or suppression of a part of the stem and its accompanying leaf.

It might, incidentally, be remarked here that if the intensive studies of the American flora continue to be as productive in the future as they have been in the past, then in a very short period our manuals will necessarily be greatly restricted in range if all the forms are to be included and the manual maintained at a convenient size and within economical limits. Probably the time is not far distant when there will be a manual of botany for each state of the union each of which will include all the known forms of the region it covers. Some of the states, not Michigan, however, are already supplied with their local manuals. I have considered preparing such a work but present duties and obligations will not permit. Some one should, however, take up the work and carry it on to an early completion.

Corylus Americana. Walt. Var. **altior** N. Var.

Taller (15 to 18 feet) than the species. The involucre remaining erect over the nut, simulating a tube, the pubescence being generally thinner and shorter, and the glandular setae fewer, rarely absent.

The fruit is fairly well represented by Plate XIII fig. 9 in the Department of Agriculture Bulletin on Nut Culture in the United States, 1896. Farwell, No. 2822, July 7, 1912 in swamps at Algonac; No.

3154, Sept. 8, 1912 in swamps at Algonac; No. 3266, Oct. 27, 1912 on dry hills at Stoney Creek.

Hepatica Hepatica (Lin.) Karst. var. **albiflora** (Raf.) N. Comb.

Hepatica alba Mill Dict. Mo. 3 1768.

Hepatica triloba var. *albiflora* Raf. Medical Flora 1,239, 1828.

Hepatica triloba var. *alba*, Hort.; K. C. Davis in Bailey Cyclo. Amer. Hort. 2,730, 1900.

Anemone Hepatica L. f. *alba* Mill.; Hegi Illus. Fl. Mit. Euro. 3,529, 1913.

Flowers white or white flushed with a pale-bluish tinge. Rich woods, Farwell No. 3c June 1, 1883 from the Keweenaw Peninsula; No. 3593, April 6, 1914 from Rochester.

Hepatica Hepatica (L.) Karst. var. **purpurea,** N. Var.

Flowers purple. Rich woods. Farwell No. 3595 April 16, 1914 from Rochester; No. 3d, June 1, 1883 from the Keweenaw Peninsula.

Hepatica Hepatica (L.) Karst. var. **vulgaris** (Mill) N. Com.

Hepatica vulgaris Mill. Dict. No. 4, 1768.

Anemone Hepatica. L. f. *rosea* Neumann; Hegi Illus. Fl. Mit. Euro. 3,529, 1913.

Flowers pink or white and streaked with pink. Rich woods. Farwell, No. 3b June 1, 1883 from the Keweenaw Peninsula; No. 3592 April 16, 1914, near Rochester.

Hepatica Hepatica (Lin.) Karst. var. **parviflora** (Raf.) N. Comb.

Hepatica triloba var. *parviflora* Raf. Med. Fl. 1,239, 1828.

Flowers blue as in the specific type but only half as large, sepals usually shorter than the involucre. Farwell No. 3 June 1, 1883, Keweenaw Peninsula.

Ranunculus Michiganensis, N. Sp.

Similar to R. abortivus but coarser in all its parts and more succulent. Radicle leaves long-petioled, orbicular or reniform, cordate with a deep and narrow, or broad and shallow sinus often 2½ inches in diameter or more, coarsely crenate, some three-divided, the divisions stalked; lower cauline leaves often long petioled and three-divided, the divisions long-stalked, both gradually reduced until in the uppermost, leaves and divisions are sessile; the lateral divisions cuneate-obovate, two-parted, the larger three-lobed, crenate; the middle division lanceolate often 3 inches long, mostly entire or few toothed. Swamp lands near Rochester, Michigan. Farwell, No. 3627, May 17, 1914.

This may be the *R. abortious* var. *eucyclus* Fernald, but it is more succulent than *R. abortivus* while that variety is said to be not so succulent.

Mitella diphylla, Lin. Var. **monophylla,** N. Var.

Differs from the species in having but one leaf upon the stem. Farwell No. 3629, May 15, 1914, near Rochester, Michigan.

Apocynum Farwellii E. L. Greene, PITTONIA.

A pubescent species that I had collected at Detroit July 7, 1893, and distributed as *A. pubescens* under the No. 1263a. It is quite common about Detroit.

Closely related to *A. hypericifolium* but has differently shaped leaves.

Apocynum Farwellii. E. L. Greene f. **verticillare.** N. Form.

Differs from the species in having the leaves in whorls of threes instead of opposite. Farwell No. 3684 June 20, 1914.

Apocynum Farwellii E. L. Greene var. **glaucum,** N. Var.

Differs from the species in having the entire plant glaucous and glabrous. In moist ground on thinly wooded hillsides at Rochester. Farwell No. 3815, August 9, 1914.

Apocynum Farwellii. E. L. Greene var. **glaucum f. ternarium,** N. Form. Differs from the var. *glaucum* in having the leaves in threes instead of opposite. Rich, moist grounds on thinly wooded hillsides at Rochester. Farwell No. 3724 July 19, 1914.

Apocynum Farwellii. E. L. Greene var. **glaucum,** f. **anomalum,** N. Form.

Differs from the var. *glaucum* in having some of the leaves alternate, some opposite, and some verticillate or subverticillate. Moist grounds on thinly wooded hillsides at Rochester. Farwell No. 3803, July 30, 1914.

Apocynum Milleri, Britton var. **pauciflorum** N. Var.

Plant, low, six or eight inches in height, bushy, the cymes mostly reduced to one or two flowers. Hills near Rochester. Farwell No. 3725½, July 19, 1914.

Eupatorium urticaefolium, Rich. var. **trifolium,** N. Var.

Differs from the species in having the leaves in threes instead of opposite. Occasional with the ordinary form. Farwell No. 3843, Aug. 23, 1914.

Lacinaria scariosa (Lin.) Hill var. **trilisioides,** N. Var.

I collected at Rochester, Mich. (3838½) on August 23, 1914, a plant that will answer very closely to the variety *sphaeroidea* (Mx.) Farwell, but it differs in some essentials. Michaux described his *Liatris sphaeroidea* as with stipitate heads, but in this plant the heads terminate foliolose peduncles two inches long, as in the specific type but the heads are several times as numerous as in that, making a rather close spike; the plant agrees with Michaux's description in all other respects. What I chiefly wish to bring to your notice, however, is the fact that the plant has a distinct vanilla-like odor as in *Trilisa odoratissima* Cass. of the southern states, but not so pronounced. So far as I am aware no species of *Lacinaria* has this odor, so I give it the varietal name *trilisioides*.

Lacinaria cylindracea (Mx.) O. K. Var. **solitaria** (MacM.) N. Comb.

Liatris cylindracea Var. *solitaria* MacM; Gray, Man. Ed. 7, 785, 1908.

This variety is described in the Manual as with one, slightly enlarged, terminal head. At Rochester I collected a plant (No. 3818) on August 9, 1914, that was of the usual height for the species but was more slender, the leaves shorter, proportionately narrower, with but one terminal head which was reduced in size, the lower involucral bracts being foliaceous and nearly as long as the oblong head only slightly narrowed at base. I have no doubt but that it belongs here.

Solidago patula, Muhl. Var. **macra** N. Var.

Plant about 2 feet high, very slender and delicate, leaves very thin and infloresence, a short wand like thyrse, 2 inches long. The infloresence is that of *S. uliginosa* and allied species, i. e., a thyrse with puberulent peduncles and involucres but the leaves and stem are those of *S. patula* in everything but stoutness; the lower cauline leaves have ovate or oval, finely serrate blades 5-7 inches long by 3-4 wide on broadly winged petioles 2-5 inches long; the upper are ellipital, oblong, or oval, 3 inches or less long and $\frac{2}{5}$ to $\frac{1}{2}$ as wide, acute, tapering into a short but distinct winged petiole; all very rough on the upper surface, otherwise glabrous; heads 2-2½ lines high and nearly as broad; involucral bracts oblong, narrowed at the apex but obtuse, ciliate; achenes pubescent. Rich woods at Rochester, Farwell No. 3868, Sept. 17, 1914.

Aster puniceus, Lin. Var. **monocephalus** N. Var.

Stem simple, terminated by a single head; otherwise as in the species. Rochester, Farwell No. 3866, Sept. 7, 1914.

Aster puniceus Lin. Var. **albiflorus,** N. Var.

Rays white, otherwise as in the species. Rochester, Farwell No. 3862, Sept. 7, 1914.

NOTES ON MISCELLANEOUS SUBJECTS, INCLUDING SOME NEW VARIETIES AND ADDITIONS TO THE MICHIGAN FLORA.

Ceanothus sanguineus, Ph. While sojourning in the Keweenaw Peninsula in the autumn of 1914, I came across a small *Ceanothus* in fruit with still a few leaves adhering to the shoots of the season. As I was there for the single purpose of making a search for this particular plant, I gathered a few specimens, notwithstanding the rather poor condition it was in. The fruiting racemes were not over 3 inches in length, the peduncles were rather stout and clustered together at what appeared to be the apex of the branch of the preceding year, or on the old wood, and below any of the leaves then remaining on the branches. The leaves and racemes, as to length and position, agree very well with those of specimens of *Ceanothus sanguineus*, collected by Henderson in Oregon and now in the herbarium of Parke, Davis & Co.; also with *Ceanothus Oreganus* as shown on t. 5177 of the Botanical Magazine. There can be no doubt that the plant is either *Ceanothus sanguineus* or a new species closely allied to it. Rocky woods at Copper Harbor, Farwell No. 3915½ Oct. 17, 1914.

Circaea Lutetiana L. Var. **intermedia** (Ehrh) N. Comb.

Circaea intermedia, Ehrh. Beitr. 4, 42, 1790 (?)

Circaea alpina Lin. Var. *intermedia* (Ehrh) D. C., Prod. 3, 63, 1828. Farwell No. 3814½ August 9, 1914. Rich woods near Rochester.

Circaea Lutetiana L. Var. **alpina** (Lin.) N. Comb.

Circaea alpina Lin. Sp. Pl. 1, 9, 1753.

There is a perfect gradation between *C. Lutetiana* and *C. alpina* through the varieties *Canadensis* and *intermedia* and it therefore seems best to unite the species. Indeed, this was accomplished by Sprengel in his edition of the Systema Vol. 1, 89 in 1825 and he did not there consider any of the forms worthy of being distinguished even by varietal names.

Vaccinium Pennsylvanicum Lam. Var. **myrtilloides** (Mx.) Fernald.

This pubescent form of the common low blueberry is frequent at Algonac, where I collected it in 1914 and probably throughout the state. As indicated by Mr. Fernald it has been confused with *V. Canadense*. Farwell No. 3638 and No. 3639, May 24, 1914.

AMELANCHIER.

So much has been written about these plants by botanists of all times that it seems hardly possible that there is anything left to write about. Confusion has arisen by a misinterpretation of descriptions or by actually ignoring them. The "Species" of Linnaeus differed widely from the "species" as understood today by such progressive botanists as are perusing an intensive study of systematic botany. The species listed in the Species Plantarum are not based upon type specimens as are species of today; that work is primarily an application of the binomial system to plants that had been described by other botanists under the polynomial phrases according to the custom of old. It would not be surprising, therefore, if Linnaeus, under his broad concept of a species, included under a specific name some references which at the present time would not be considered as appertaining thereto, or that even Linnaeus, himself, upon a better knowledge of them, would accept as having been properly referred. It is not too much to say that the advanced student of systematic botany with his proclivities for intensive work now looks upon most species of Linnaeus as aggregates.

Linnaeus in the Species Plantarum Ed. 1 478, 1753, described *Méspilus Canadensis* as follows:

"Mespilus inermis, foliis ovato-oblongis, glabris serratis, caule inermi.

Mispilus inermis, foliis subtus glabris obverse-ovatis, Gron. Virg. 54. Habitat in Virginia, Canada. 5."

In Systema Naturae XII, 343, 1767 as follows:

"M. inermis, fol. ovato-oblongis glabris serratis actuisisculis. *Tenera lanata; adultior nuda.*"

In the Species Plantarum both the description and the specific name indicate the northern plant that is glabrous from the beginning or very early becoming so. Even the reference to Gronovius is to a plant with glabrous leaves. The inference is that at the time of Gronovius there was in Virginia an Amelanchier with glabrous leaves or what is the same thing from a bibliographical aspect, Gronovius thought they were glabrous. In the Systema the description is of a plant, the young leaves of which are lanate. In other words, Linnaeus, in the earlier publication described the smooth-leaved plant and later revised the description to include the one with tomentose leaves. As above indicated, considering his concept of a species, this is not at all surprising. The younger Linnaeus noticing the discrepancy, raised the plant with tomentose leave to specific rank as Mespilus Botryapium in Suppl. 255, 1781.

In any discussion of the application of the name *Crataegus spicata*, Lam. Enyc. 1, 84, 1783, one must not lose sight of the work of K. Koch. (Dendr. 1, 1823, 1869) who has demonstrated, as far as it is possible so to do, that the trees or their descendents, upon which LaMarck based his species are still in existence in certain parks in France and at the school of forestry there, and that these trees are what has later been known as *A. sanguina* D. C. Furthermore, that the description of LeMarck fits these trees in all particulars. The evidence seems to be conclusive. The Michigan species of Amelanchier are as follows:

A. Canadensis (Lin.) Medic, Gesch. 79, 1793.

Mespilus Canadensis Lin. Sp. Pl. 478, 1753.

A. laevis Wiegand, Rhodora 14, 154, 1912.

A small tree the young leaves of which are very thin, brownish-purple, and generally glabrous from the beginning. Farwell No. 48b, Aug. 10, 1883 and No. 53, Aug. 17, 1883 from the Keweenaw Peninsula; No. 1351½, May 6, 1893 from Belle Isle and No. 48c, May 1, 1910 from Orion. This species in all its varieties has the young leaves thin and more or less brownish-purple. The type is a tree and the leaves are glabrous from the beginning. Moist woods and thickets.

A. Canadensis (Lin.) Medic. Var. **rotundifolia,** (Mx.) T. & G. Fl. N. A. 1, 473, 1840.

Crataegus spicata Lam. Encyl. 1, 84, 1783.

Mespilus Canadensis var. *rotundifolia* Mx. Fl. Bor. Am. 1, 291, 1803.

Amelanchier sanguinea (Ph) D. C. Prod. 2, 633, 1825.

Amelanchier spicata (Lam.) K. Koch, Dendr. 1, 682, 1869.

A tall shrub or tree but not so large as the specific type. The leaves broader, often orbicular but acute. Thinly tomentose but glabrous or nearly so at time of flowering. Moist or dry woods and thickets. Farwell No. 48, Aug. 9, 1883. No. 48a, Aug. 10, 1883 and No. 50, Aug. 13, 1883 from the Keweenaw Peninsula; No. 49b, May 13, 1893 from Detroit; No. 48c, April 23, 1910, No. 2777, June 30, 1912, No. 3339, May 4, 1913 and No. 3354, May 11, 1913, from near Rochester; No. 3330, May 4, 1913, from Parkedale Farm.

Amelanchier Canadensis (Lin.) Medic. var. **alnifolia** (Nutt.) T. & G. Fl. N. A. 1, 473, 1840.

Amelanchier Canadensis alnifolia T. & G. Fl. N. A. 1, 473, 1840.

Aronia alnifolia Nutt Gen. 1, 306, 1818.

Amelanchier alnifolia Nutt. Roemer, Syn. Man. 3, 147, 1847. Nuttall described his *Aronia alnifolia* as a low shrub 4 or 5 ft. in height. The name as at present understood is applied to a tree 30 ft. or thereabouts. All the Michigan plants have been referred to A. florida and A. alnifolia has been eliminated from the eastern flora; but this is an error. True *A. alnifolia* is found here and is quite frequent in the Lake Superior region. A. florida is frequent around Rochester and probably at other places. Both have ovate to obicular leaves, but A. alnifolia has a bole and is therefore tree-like in habit if not in stature while A. florida is densely caespitlose, producing many stems; both have about the same height, 2-10 feet. It is customary to apply the name A. alnifolia to certain western *trees* but why so is difficult to determine, as the species was originally described as a *shrub*, but whether tree-like or caespitose is not indicated. Farwell No. 51, August 13, 1883, from the Keweenaw Peninsula; No. 907½, August 29, 1895, from near Orion.

Amelanchier Canadensis (Lin.) Medic. var. **semiintegrifolia** (Hook) N. Comb.

Amelanchier ovalis var., *semiintegrifolia* Hook Fl. Bor-Amer. 1, 202, 1834.

A. florida Lindl. Bot. Reg. 19 pl. 1589, 1833.

A caespitose shrub 10 feet or less high with smaller leaves than those of the preceding though of the same general shape. Farwell No. 51d April 23, 1910, and No. 3332 May 4, 1913 from Rochester; No. 2779 June 30, 1912, from Parkedale Farm; No. 3335 May 4, 1913, from

Stony Creek. *Amelanchier florida* table 8611 of Curtiss' Botanical Magazine is scarcely the same as Lindley's plate 1589. It has little in common with that outside of the leaf serratures. It agrees better with that of Lindley's A. sanguinea plate 1171 of the Botanical Register. It has the appearance of being the result of a cross between the two; it is briefly characterized as with the foliage of the former and the infloresence of the latter.

Amelanchier Canadensis (Lin.) Medic. Var. **oligocarpa,** (Mx.) T. & G. Fl. No. Amer. 1, 474, 1840.

Mespilus Canadensis Lin. var. *oligocarpa,* Mx. Fl. Bor. Am. 1, 291, 1803.

Amelanchier Bartramiana Roemer Sys. Rosif. 145, 1847.

A low shrub not over 3 feet high forming dense clumps, having a habit much like that of *Rhamnus alnifolius* or *Juniperus communis,* var. *depressa.* The leaves are oval or ellipitical, acute at apex and more or less cuneately acute at base, glabrous; flowers one or two, rarely three, and apparently in the axils of the leaves. Swamps, Farwell No. 52d August 17, 1883, from the Keweenaw Peninsula.

Amelanchier Canadensis (Lin.) Medic. var. **pauciflora** N. Var.

A low tree-like shrub, eight feet or less; leaves ovate, oblong, obovate, oval or elliptical, obtuse or acute and from cuneate to slightly cordate at base; all these variously shaped leaves are to be found on the same twig; they are glabrous or nearly so from the beginning; the flowers are in the axiles of the leaves and single or from two to five in a lax and often a fastigiate raceme. Apparently this is a cross between the varieties *rotundifolia* and *oligocarpa.* Moist thickets and swamps. Farwell No. 52, No. 52a, No. 52b, August 15, 1883, and 52c, August 17, 1883, from the Keweenaw Peninsula.

Amelanchier Botryapium (Lin. f.) Borkh. Handb. Forstb. 2, 1260, 1803 (?); D. C. Prod. 2, 632, 1825.

Mespilus Canadensis Lin. Syst. Nat. XII, 343, 1767, in large part, not Lin. Sp. Pl. 478, 1753.

Pyrus Botryapium Lin. f. Suppl. 255, 1781.

Mespilus Canadensis Lin. b. *cordata* Mx. Fl. Bor. Am. 1, 291, 1803.

A tree of generally drier situations than that of the preceding, but may be found in swampy places. Leaves never brownish purple, thicker and stouter, ovate, acute, finely serrate, always densely tomentose at flowering time, becoming glabrous or glabrate only with age. Farwell No. 49, August 10, 1883 from the Keweenaw Peninsula; No. 49c April 23, 1910 from Rochester, Nos. 3317, 3327, and 3329, May 4, 1913 and No. 3613, July 20, 1913, from Parkedale Farm.

Amelanchier Botryapium (Lin. f.) Borkh. var. **obovalis** (Mx.) N. Comb.

Mespilus Canadensis Var. obovalis Mx. Fl. Bor. Am. 1, 291, 1803.

Amelanchier Canadensis B. *oblongifolia* T. & G. Fl. N. Am. 1, 473, 1840.

Amelanchier oblongifolia Roemer Nat. Syst. Rosifl. 147, 1847.

A shrub never attaining the size of a tree; leaves often broader above the middle than below. Farwell No. 49a, August 10, 1883 from the Keweenaw Peninsula, No. 1351⅓, May 6, 1893 from Belle Isle; No. 49d, April 23, 1910 from Rochester; No. 3333, May 4, 1913, from Parkedale Farm. Gronovius described his Mespilas with glabrous, "obverse-ovatis" leaves; he may have had this variety with mature leaves which would have been glabrous or glabrate.

Amelanchier Botryapium (Lin. f.) Borkh. Var. *micropetala* (Robinson) N. Comb.

Amelanchier oblongifolia var *micropetala* Robinson, Rhodora, 10, 33, 1908.

A. humilis Wiegand, Rhodora, 14, 141, 1912.

A. stolonifera Wiegand, Rhodora, 14, 144, 1912.

A low stoloniferous shrub of rocky or sandy soils from half a foot to three or four in height. Farwell No. 51a, August 13, 1883 and No. 3075, Aug. 22, 1912, from the Keweenaw Peninsula; No. 51b, July 16, 1905 from Island Lake; No. 51c, April 23, 1910, from Rochester; No. 3322, May 4, 1913, from Parkedale Farm.

Amelanchier Botryapium (Lin. f.) Borkh. Var. **conferta** N. Var.

Small shrub similar to the preceding variety; raceme of 12 to 15 flowers about an inch in length, compact; calyx lobes five with an inner row of five alternating and 10 petals in the interstices; petals equalling the calyx lobes or just overtopping them, about a line long, linear or spatulate and like the calyx lobes more or less woolly. Farwell No. 3625 May 15, 1914 near Rochester.

Callistachya Virginica (Lin.) Raf. Variety **lanceolata**, N. Var.

Differs from the species in having narrowly lanceolate, acuminate leaves. Farwell No. 1165, July 18, 1891 from Ypsilanti, No. 1165a, July 25, 1892, from Belle Isle, No. 2937, July 28, 1912 and No. 3834, Aug. 9, 1914 from Parkedale farm, No. 2884, July 20, 1912, from Rochester.

The type of *Veronica Virginica* Lin. is the plant with broad (oval or ellipitical) acute leaves. Both forms occur in Michigan but the variety is much the commoner form. *Callistachya* Raf. in Med. Repos. New York, 5, 60, 1808 is the oldest name for this genus and is available under Articles 50 and 57 of the Vienna Rules. The former provides that no genus-name should be rejected, changed, or modified on account of an earlier homonym universally regarded as non-valid; and the latter that two generic names, differing only in the termination even if only by one letter, must be considered as distinct names. *Callistachys* Vent. (1803) and *Callistachya* Raf. (1808) must therefore be considered as distinct and valid generic names. Sir James Edward Smith used *Callistachya* in the same year as Rafinesque but whether earlier or later I cannot say; but that is immaterial as it is a pure synonym of Callistachys, Vent., and, therefore, even if it antidates the use of the name of Rafinesque, the latter under Article 50 is valid. The species is of wide distribution, being found in Europe and Asia as well as in North America and has received many specific names. Two other forms may be worth recording here. One from Dahuria has blue flowers and very broad leaves and may be known as Callistachya Virginica (Lin.) Raf. Var. **Sibirica** (Lin.) N. Comb. *Veronica Sibirica* Lin. Sp. Pl. Ed. 1, 12, 1762. The other has purple flowers and is from Virginia according to Pursh and others and may be known as Callistachya Virginica (Lin.) Raf. Var. **purpurea** (Raf.) N. comb. *Eustachya purpurea* Raf. Am. Month. Magaz. 190, 1819; *Leptandra Virginica* (Lin.) Nutt Var. *purpurea* Ph. in Eaton & Wright N. Am. Bot. Ed. 8, 297, 1840.

Plantago lanceolata, Lin.

This is a very variable species but four well defined forms are recognizable. One with linear or linear-lanceolate, 3-5-ribbed, thinly hirsute blades, 3-5 inches long by 5 lines wide, on marginless petioles nearly or quite of their own length which together are about ¾ the length of the scape. Spikes oblong or nearly ovate. This apparently is the Linnea type. Another form is much taller and more robust, scapes about 20 inches long. The leaves are elliptical or oblong-lanceolate, over a foot in length by 1¾ inches in width, tapering into short winged petioles which with the blades are more or less boat-shaped; the blades are 7-nerved and cross-wrinkled; spikes cylindrical; this probably is Var. contorta, Guss. (*P. lanceolata* var. *altissima* Dcne.) A third form is somewhat similar but has smaller leaves (six inches or so long), not cross-wrinkled, and with the margined petioles flat; this appears to be var. irrigua, Dcne. A fourth form is found in sand or rocky grounds, and is not over 10 inches in height with 3-ribbed sessile or subsessile acute or accuminate leaves two or three inches long and not over 3 lines wide, generally densely hirsute; spikes short, ovate or sub-globular; this probably is Var. eriophylla, Webb. I have collected the forms from various places as follows:

Plantago lanceolata, Lin.

In fields and pastures No. 1138, June 13, 1891, Ypsilanti; No. 1138a, June 10, 1895, Belle Isle; No. 1138b, June 10, 1895, Mackinac Isle.; No. 1138c, June 27, 1895, Keweenaw Peninsula; No. 3002, August 4, 1912, Parkedale Farm.

Plantago lanceolata Lin. Var. **contorta,** Guss.

In rich grounds on the banks of the Detroit River, No. 3849½ Sept. 2, 1914.

Plantago lanceolata, Lin. Var. **irrigua,** Dcne.

Banks of Stoney Creek, No. 3924, Oct. 25, 1914.

Plantago lanceolata, Lin. Var. **eriophylla** Webb.

On stony or sandy grounds in the Keweenaw Peninsula where it is very common, No. 3916, October 17, 1914; No. 2643, June 9, No. 2763, June 30th, and No. 3017, Aug. 4, 1912, Parkedale Farm.

Galium aparine L. Var. **Vaillantii** (D. C.) Koch.

Differing from the species only in its smaller size in all its parts. Farwell No. 3652, May 30, 1914, in rich muck lands on Parkedale Farm.

Solidago bicolor, Lin.

In Michigan this is a very variable species, but several well defined forms can be distinguished. The stems are simple up to the infloresence, single or several from the same crown. The heads are 2 to 3½ lines high, the involucral scales have a green midrib broadened above, are oblong or obovate, rounded at top and often ciliate; mature achenes several nerved, scabrous on the nerves and with or without a few appressed hairs; the lower cauline and root-leaves vary from obovate or oblanceolate to oval, oblong and lanceolate; cauline leaves below the infloresence from 12 to 30; the ray flowers are white, cream color, yellow, or orange-yellow; the upper-leaves are oblanceolate, oblong, or lanceolate passing into the floral bracts, entire or minutely incurved denticulate; the whole plant is more or less hirsute. The inflorescence is a simple or branched thyrse, more or less interrupted. When all features are considered it seems best to maintain the species intact as was done by Torrey and Gray. The Michigan varieties are as follows:

The typical plant is from 1 to 2 feet high, has the lower cauline and root leaves oblanceolate, 1 to 4 inches long by ½ to 1½ wide, and gradually tapering into a short (1½ inches or less) broadly winged petiole, coarsely dentate; upper cauline ¾ to 1½ inches long, by ¼ to ½ inches wide. Involucral scales greenish, head 2½ lines high, rays white. Infloresence a slender, interrupted thyrse and globular clusters or short racemes in the axils of the upper leaves; cauline leaves 12 to 24. Fields and hillsides at Rochester. Farwell, No. 3857, Sept. 7, 1914; No. 877, Sept. 27, 1895, Detroit; No. 3534, Oct. 5, 1913, Parkedale Farm.

Solidago bicolor L. var. **luteola** N. Var.

Similar; lower cauline and root leaves obovate or oblanceolate, the blade shorter and broader, ¾ to 1½ inches wide by 1½ to 2½ inches in length, tapering into a somewhat longer and more narrowly winged petiole ¾ to 1½ inches long; upper leaves smaller, an inch or less in length and less than a $\frac{1}{4}$ inch wide; rays of the color of cream or honey. With the species but less common. Farwell No. 3801, Sept. 7, 1914.

Solidago bicolor Lin. Var. **paniculata** N. Var.

Taller,—$2\frac{1}{2}$ feet high; root-leaves oblong or lanceolate $2\frac{1}{2}$-$3\frac{1}{2}$ inches long by 1-$1\frac{1}{2}$ inches wide, coarsely dentate, acute, tapering into slender, narrowly margined petioles, about twice as long as the blades which are hirsute on each face with scattered, appressed short hairs becoming more thickly placed as they pass on to the petioles; the cauline leaves about 30, the lower similar to the root leaves in shape but on short petioles $1\frac{1}{2}$ inches or less, the more copious pubesence on the under surface spreading, upper cauline similar but smaller, $1\frac{1}{2}$ by $\frac{1}{2}$ inch or less; infloresence paniculate, the branches 1 to 4 inches long, virgate, ascending densely flowered; rays white. The lanceolate, acute leaves and paniculate infloresence give this form a very distinct appearance. In fields at Algonac. Farwell No. 3903, Sept. 13, 1914.

Solidago bicolor Lin. var. **ovalis**, N. Var.

About 2 feet high. Leaves very thin, proportionately broader than in any of the other varieties, the lower cauline and root leaves oval, 2-3 inches long, 1-$1\frac{3}{4}$ wide, crenate-serrate on petioles of their own length, the upper cauline 2 inches or under and $\frac{2}{3}$ of inch wide or less. Thyrse, simple; rays yellow fading to white. With the species but less common. Farwell No. 3838 August 23, 1914. In the above varieties of this species the heads are $2\frac{1}{2}$ lines high and the bracts of the involucre are greenish with a pale border giving the whole thyrse a pale or ash-colored appearance. In the next two varieties the whole thyrse has a yellowish appearance as the involural bracts are greenish with a yellowish border and the heads are 3 to $3\frac{1}{2}$ lines high.

Solidago bicolor Lin. Var. **concolor** Torr. & Gray.

Solidago hispida Muhl.

Solidago hirsuta Nutt.

Similar to S. bicolor Lin. but the rays are a deep yellow and the heads larger. In similar situations; Farwell No. 3859, Sept. 7, 1914; No. 481a, August 29, 1895, Orion; No. 481b August, 1908, Detroit.

Solidago bicolor Lin. Var. **spathulata** N. Var.

One or two feet high, 15 to 18 cauline leaves below the infloresence; the lowest and the root leaves oblong-spatulate, about 4 inches long by $1\frac{1}{2}$ inches broad near the rounded apex, crenate serrate, rather abruptly cuneately tapering into broadly winged petioles an inch or so long; upper cauline elliptical, $1\frac{1}{2}$ inches or less in length by a third as wide, generally obtuse; heads and rays as in the preceding variety. Farwell No. 481, Sept. 12, 1886. Generally on rocky, sandy or poor soil, Keweenaw Peninsula.

Solidago graminifolia (Lin.) Salisb. Var. **Nuttallii** (Greene) Fern.

The more hispidulous pubescent variety of the species. Farwell Nos. 3871, Sept. 17, 1914, Parkedale Farm; 484a, Aug. 31, 1892, Belle Isle. Probably the common form in the southern part of Michigan.

Aster puniceus, Lin. Var. **demissus**, Lindl.

A form in which the leaves are longer than their axillary infloresences. Rochester. Farwell No. 3865, Sept. 7, 1914.

Helianthus giganteus Lin. Var. **virgatus** (Lam.) N. Comb.

Helianthus virgatus Lam. Encycl. 3, 85, 1789.

Helianthus altissmus Var. *virgatus* Pers. Syn. 2, 476, 1807.

Stem slender, simple, 4 feet or less high, terminated by a single head with one or two additional in the axils of as many of the uppermost leaves; leaves opposite, except the uppermost, very thin and delicate, lanceolate, coarsely serrate, green, nearly of the same hue on both faces; pubescence copius on the upper parts, much as in the species but *white* not rusty. Swamps. Farwell, No. 1623c, Aug. 23, 1914, Stoney Creek; No. 1623b, Sept. 2, 1901, Lakeville; No. 1623a, Aug. 20, 1892, Belle Isle.

Helianthus giganteus Lin. Var. **oppositifolius** N. Var.

Stems three feet or under; leaves mainly opposite, some conduplicate, firm, narrowly lanceolate, acuminate at both ends, 4 or 5 inches long or less, bluish green, paler below; heads few, sometimes only one, when more, terminating axillary branches, forming a simple 3-6-flowered corymb; pubescence appressed, only on the uppermost parts. Fields at Algonac. Farwell, No. 3884, Sept. 13, 1914; No. 1623, Sept. 27, 1898, Birmingham. Bears about the same relation to H. giganteus as H. Maximiliani Var. **Dalyi** (Britton), N. comb. (*Helianthus Dalyi* Britt. Journ. N. Y. Bot. Gard. 2, 89, 1901) does to H. Maximiliani. Bears slender fusiform rhizomes or these ending in small tubers.

Helianthus giganteus Lin. Var. **altissimus** (Lin.) N. Comb.

Helianthus altissimus Lin. Sp. Pl. Ed. 2, 2, 1279, 1863.

Like the species but glabrous and glaucous on the stem, the branches and peduncles sparsely appressed hirsute; the tips of the chaff in this variety are not black as in the species; No. 3883, Sept. 13, 1914, Algonac.

Helenium autumnale Lin. Var. **grandiflorum** (Nutt.) T. & G.

In addition to the typical form with narrow-lanceolate, entire or denticulate leaves there is another with broadly lanceolate leaves that are coarsely serrate or dentate; the achenes are shorter, broader and wider above than in the former and the pappus scales are smaller and longer awned. It seems to be Torrey and Gray's Var. grandiflorum. Farwell No. 3874, Sept. 7, 1914, Parkedale Farm.

Hieracium florentinum All.

This was found in fields near Calumet and Lake Linden. One of the plants that is known in the eastern states as King Devil. Farwell, No. 3915, Oct. 11, 1914.

CORRECTIONS IN NOMENCLATURE.

In rearranging the plants in my herbarium I found it necessary, in order to give them the correct names that they should have, to make some new combinations which may be recorded here.

Elodea minor (Engelm) N. Comb.

Udora verticillata? Var. *minor* Engelm; Casp. Jahrb. Wiss. Bot. 1, 654, 1858.

Muhlenbergia brevifolia (Nutt.) N. Comb.

Agrostis brevifolia Nutt. Gen. 1, 144, 1818.

Vilfa cuspidata Torr.; Hook. Fl. Bor. Am. 2, 238, 1840.

Mühlenbergia cuspidata Rydberg in Bul. Torr. Bot. Cl. 599, 1905.

Sporobolus brevifolius Scribn. Mem. Torr. Bot. Cl. v. 39, 1895, p. p.

Muhlenbergia Mexicana (Lin.) Trin. Var. **commutata** (Scribn.) N. Comb.

Muhlenbergia Mexicana (Lin.) Trin. Subsp. *commutata,* Schribn. Rhodora, 9, 18, 1907.

Reboulea, Kunth, Rev. Gram. 1, 341, Pl. 84, 1830.

In Rhodora for August 1906 Mr. Scribner in a discussion of the grasses then known as Eatonia points out that they are without a generic name and so creates a new genus Sphenopholis to include them and some others from Trisetum. He passes by Reboulea Kunth 1830 on account of Reboulea, Raddi 1820 a genus of Liverworts (Hepaticae). But Mr. Scribner is in error as Raddi's genus is *Rebouillia,* a name that cannot conflict with Reboulea, Kunth nor cause confusion in any way by maintaining both as valid genera. Nees ab Essenbeck in 1846 changed Raddi's genus to Reboulia but as this was 16 years after Kunth's genus was established it cannot be accepted as valid; the original spelling of the hepatic genus must therefore be maintained and Reboulea, Kunth is valid for the Eatonias. Michigan forms are:

Reboulea obtusata (Mx.) A. Gr. Var. **pubescens** (S. & M.) N. Comb.

Eatonia pubescens, Scribn. & Merr. Circ. U. S. Dep. Agr. Agrost. 27, 6, 1900.

Reboulea pallens (Spr.) N. Comb.

Aira pallens Spr. Fl. Hal. Mant. 33, 1807.

Reboulea nitida (Spr.) N. Comb.

Aira nitida Spr. l. c. 32.

Reboulea nitida var. glabra (Nash.) N. Comb.

Eatonia glabra Nash. In Britt. Man. 1043, 1901.

Other species and varieties not already transferred are as follows:

(*Sphenopholis palustris*, Scribn. and allied species will be better taken care of if allowed to remain in Trisetum).

Reboulea obtusata var. **lobata** (Trin.) N. Comb.

Trisetum lobatum Trin. in Mem. Acad. Petersb. Ser. 6, 1, 66, 1831.

Reboulea filiformis (Chapm.) N. Comb.

Eatonia Pennsylvanica var. *filiformis* Chapm. Fl. S. St. 560, 1860.

Reboulea pallens var. **longiflora** (Vasey) N. Comb.

Eatonia longiflora (Vasey) Beal, Grasses N. Am. 2, 494, 1896.

Reboulea pallens var. **major** (Torr.) N. Comb.

Koeleria tunicata var. *major* Torr. Fl. N. & M. U. S. 117, 1824.

Eragrostis capillaris var. **Frankii** (Steud.) N. Comb.

Eragrostis Frankii Steud. Syn. Pl. Gram. 273, 1855.

More robust and more freely branched than in the species, with shorter panicle branches.

Eragrostis Eragrostis var. **megastachya** (Koeler) N. Comb.

Eragrostis vulgaris a *megastachya* Coss u Germ. Fl. Paris 2. 641, 1845.

Eragrastis pilosa var. **Caroliniana** (Spr.) N. Comb.

Poa Caroliniana Spr. Fl. Hal. Mant. 33, 1807.

Eragrastis Purshii Schrad. Linnaea, 12, 451, 1838.

Potamogeton gramineus Lin. Sp. Pl. 1, 27, 1753.

Potamogeton gramineus A *graminifolius* Fries. Nov. Fl. Suec. 36, 1828 and a *fluvialis* l. c. 37.

Floating and submerged leaves alike, sessile or subsessile.

Potamogeton gramineus var. **lacustris** (Fries) N. Comb.

Potamogeton gramineus A *graminifolius b lacustris* Fries l. c. 37.

Similar to the next but the floating leaves are membranaceous, not coriaceus.

Potamogeton gramineus var. **parvifolius** (Nolte) N. Comb.

Potamogeton heterophyllus var. *parvifolius* Nolte in Wallr. Shed. 1822, ex Fries, l. c.

Potamogeton gramineus B *heterophyllus* and d *stagnalis* Fries l. c.

Potamogeton heterophyllus Wallr. Sched. Crit. 1, 64, 1822 and Amer. Authors not Schreb according to Fries.

Floating leaves coriaceous, petioled, elliptic, ovate, rounded at base, shorter and broader than the submersed leaves.

Eriocaulon aquaticum (Hill) G. C. Druce Pharm. Journ. 29, 700, 1909, should be adopted for E. *septangulare*, With.

THE EFFECT OF FUNGICIDE ON THE SPORE GERMINATION OF LONGYEAR'S ALTERNARIA.

BY R. W. GOSS AND S. P. DOOLITTLE.

History. It is a common occurrence to find apparently sound apples having a core cavity filled with a dark, grayish mold.

For the most part, this condition received little attention from mycologists and pathologists until 1902, when Prof. W. Paddock, at the Colorado Experiment Station, noted the disease as extensive in both Colorado and California.

In 1903, B. O Longyear, at the Michigan Experiment Station, noted the same core decay and considered it to be of widespread occurrence. He made his first reference to the disease in the Colorado Experiment Station Report for 1904. In 1905, he published a bulletin on the disease, in which he refers to his own and Paddock's observations.* Longyear in this publication, describes the conditions of fungous attack, the geographic distribution of the disease and the susceptible varieties. The fungus was an Alternaria and a brief description was given. It was not given a specific name, and since that time it has been referred to in literature on the subject as Longyear's Alternaria. Longyear proved the pathogenicity of the fungus, both at the Michigan Station and at Colorado.

The material used for the following work was obtained from specimens sent in from an orchard in South Haven and was compared with herbarium specimens collected by Loew at Michigan Agricultural College in 1903, (later examined by B. O. Longyear.) Fresh material was also compared with specimens obtained from Longyear in Colorado.

From the symptoms on the fruit and from the microscopic characteristics these specimens appeared to be identical. The cultural characteristics also appeared identical with the results published by Longyear in Colorado.

Distribution. The disease is found over a wide range of territory and investigation shows it to be of common occurrence in the fruit districts of Colorado and California. It has been found by the writers in Michigan and has been mentioned as appearing in Maine.

*Longyear, B. O. Col. Sta. Bul. 105.

Susceptibility of Varieties. The varieties of apples found to be the most susceptible to this fungus in Michigan are the Gideon, Wine Sap, Northern Spy, Ben Davis, and Jonathan. It was observed that apples having an open calyx seemed more subject to infection.

It is reported that the Kieffer is the only variety of pear susceptible to attack by the disease.

Symptoms on the Apple. The fungus is confined to the fruit, the common point of infection being the blossom end. In the case of infection through the calyx tube the disease is not noticeable in its first stages unless the core is exposed, when the typical dark hyphae are seen. This mycelial growth forms a gray mass which covers the carpels and in many cases fills the entire core cavity. In the later stages of infection, the fruit may become entirely rotted after being placed in storage. In many cases there occurs a characteristic splitting at the calyx end accompanied by a discoloration and rotting of the surrounding tissue. The fungus may gain entrance through wounds, resulting in a soft rot of a light brown color, with a characteristic sunken area in the center. This is essentially a ripe rot which works slowly, and is often obscured by more rapid soft rot fungi.

The fungus evidently passes the winter in the diseased fruit remaining in the orchard and in the spring infects the young fruit either at the blossom end or through wounds.

On the pear, the fungus is reported as being found on fruit, leaves and young sprouts.

Microscopic Characters. The mycelial threads of the fungus vary greatly in size and in the young stages are hyalin and septate. As spores are produced they become brown in color.

The spores are characteristic of the genus Alternaria. Under the microscope they appear brown in color and vary in size from 12x4 microns to 17 x 6. They vary in the number of cells composing them, having from 2 to 7 and averaging about 5. They are produced either singly or in chains.

Germination is very rapid, usually taking place in from 10 to 15 hours, the germ tube being sent out from any cell or from several.

Cultural Characteristics. The organism was found to grow especially well on pear agar. On this medium, an abundant growth was very quickly produced and rapid spore production took place. It was also found to grow fairly well on nutrient, potato and bean agar, but spore formation appeared to be slower. On pear agar the colonies appeared in two days, the mycelial growth was rapid, the colonies reaching a diameter of 2.5 cm. in five days. The colonies are at first composed of much branched, hyalin, septate mycelium. These colonies become dark brown in the center on the appearance of spores, which are formed in four days.

Tests of Fungicides on the Alternaria. Michigan grown Northern Spy apples from an orchard that had been thoroughly sprayed with lime-sulfur, as shown by the entire absence of scab, were found to contain in one barrel about 25 per cent of fruit infected with this Alternaria.

The question was thus brought up as to the effect of lime-sulfur when directed against this organism and accordingly the following tests were made with various sprays.

Method of Testing the Fungicides. The method was the slide germination test developed by Reddick and used by Wallace and Blodgett in their work with lime-sulfur. Slides were sprayed with the fungicides to be tested, one-half of the slide being left bare to serve as a check. The slides were dried under atmospheric conditions to allow for any chemical changes which might result from atmospheric activity. A water suspension of spores was made up containing sufficient number to give a satisfactory count in each drop. From three to ten slides of each strentgh were made and five fields were counted in each drop, to obtain the percentage of spore germination.

The slides were sprayed with a hand atomizer which produced a fine spray, care being taken not to let the drops run together, thus reproducing field conditions as closely as possible.

The viability of spores was very high, the checks averaging almost 100 per cent germination.

Lime-Sulfur Tests. A concentrated lime-sulfur was used testing 32 degrees Baumé and various dilutions were tried. This was repeated with the addition of lead arsenate at the rate of 2 lbs. to 50 gal. of water.

PERCENTAGE OF SPORE GERMINATION ON SPRAYED SLIDES.

Strengths	1-10	1-20	1-30	1-40	1-50	1-100
Lime-sulfur.	25%	45%	64%	81%	95%	98%
Lead arsenate added	12%	18%	33%	42%	43%	88%

From the above results it is concluded that lime-sulfur will not prove effective in controlling this fungus with any strength which could be used on the foliage with safety. The ordinary strength of 1-40 killed only 19% of the spores. Hence it is possible to account for the presence of the Alternaria rot from orchards free from other diseases.

It may also be concluded that lead arsenate combined with lime-sulfur improves the fungicidal value of the mixture as the tests show a uniform decrease in germination over the same strengths of lime and sulfur alone.

Self Boiled Lime-Sulfur. This was made up equivalent to a 8-8-50 mixture. This was also repeated with the addition of arsenate of lead at the rate of 2 lbs. to 50 gals.

PERCENTAGE OF SPORE GERMINATION ON SPRAYED SLIDES.

Self boiled lime and sulfur	76% germination
Self boiled lime and sulfur plus lead arsente	67% germination

While this did not reduce germination enough to be effective, it controlled germination more than the 1-40 lime and sulfur. The addition of lead arsenate reduced germination but not so much as in the case of lime-sulfur plus lead arsenate.

Soluble Sulfur. This is a patented compound prepared by the Niagara Spray Co.

PERCENTAGE OF SPORE GERMINATION ON SPRAYED SLIDES.

Strengths	3½-200	3½-50	10-50	1-10	1-50
Soluble sulfur	96%	95%	90%	56%	51%
Sol. Sulfur plus lead arsenate	91%	83%	7%	53%	50%

The results obtained in this experiment show that it has little fungicidal value; the addition of lead arsenate increased the efficiency of the spray as with the other sulfur compounds.

Bordeaux Mixture.

PERCENTAGE OF SPORE GERMINATION ON SPRAYED SLIDES.

Strengths	2-2-50	3-4-50	4-4-50
Bordeaux and lead arsenate	23%	12%	10%
Bordeaux	32%	26%	11%

These results show that Bordeaux is more effective than any of the other compounds tried.

Arsenate of Lead.

PERCENTAGE OF SPORE GERMINATION ON SPRAYED SLIDES.

Strengths	1-50	2-50
Lead arsenate	92%	86%

These results show that lead arsenate used alone has but little fungicidal value, but when combined with the other spray it seems to aid in reducing germination.

Summary. Many apples in widely scattered regions of the United States are found to be infected with a core rot which is not controlled by many of the ordinary sprays used in orchard management.

The causal organism is a species of Alternaria which is often mentioned as Longyear's Alternaria. The fungus is confined to the fruit in the apple, the most common point of entrance seeming to be through the calyx tube.

Fungicides. Lime-sulfur did not prove effective in the control of this fungus, as any strength which would prevent germination could not be used on the foliage. Self boiled lime-sulfur while it did not prove an effective agent in preventing germination, showed a greater value than the 1-40 strength of commercial lime-sulfur. Soluble sulfur proved to be slightly more effective than either of the above fungicides.

Lead arsenate when used alone showed little fungicidal value, but when combined with other sprays it increased their efficiency to a very great extent.

Bordeaux mixture was found to be the most effective fungicide. The weakest dilution gave better results than many of the others in their greatest strengths.

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AN EPIDEMIC OF CRONARTIUM COMPTONIAE AT THE ROSCOMMON STATE NURSERIES.

BY C. H. KAUFFMAN AND E. B. MAINS.

During the first week of August, 1914, information came to hand that the pine plantations at Roscommon were seriously affected by a rust. At the request of the Public Domain Commission, Mr. E. B. Mains was sent to investigate conditions there. It was found that 12 to 15 acres devoted to Western Yellow Pine (*P. ponderosa*) and Lodgepole Pine (*P. contorta*) already five year old seedlings, were infested with one of the blister rusts: *Cronartium Comptoniae.* Almost every seedling was attacked, some dead, the majority in the last stages of the disease. The stems of the seedlings were strongly hypertrophied so that fusiform swellings resulted. Breaking through the bark of the swollen parts were large clusters of the aecidia. This stage is *Peridermium Comptoniae.* Large plantations of Scotch Pine bordered the affected areas, but were not affected. In the nursery the rust had also destroyed or was destroying the younger seedlings. Here it had attacked also some Austrian Pine seedlings but these had been pulled up by that time. The disease was first noticed in 1911 in the nursery. Diseased seedlings and those which had died were occasionally pulled up by the men in charge, but as the serious nature of the disease was not realized no especial attempt was made to eradicate it.

As these rusts are heteroecious, before any certainty concerning the species could be arrived at, it was necessary to determine what the teleutospore host might be. This was comparatively easy, since merely a glance at the leaves of the Sweet Fern (*Myrica asplenifolia*) which grew abundantly throughout the plantations and over all the surrounding country, showed them to be badly infected with a rust. Examination showed the leaves to be covered in places by the pustules of the uredospore and teleutospore stage of *Cronartium Comptoniae.* The Sweet Fern in both the nursery and the two fields of Yellow and Lodgepole Pine was densely rusted. The prevailing winds here are from the west. On examination of the Sweet Fern beyond the edge of the plantations, Mr. Mains found the rust absent from the Sweet Fern on the west side and the north-west side; but on the east where the wind had carried the spores from the pines, he found the Sweet Fern rusted to a distance of about forty yards. On the south the rusted area extended about 15 yards. He also found that along the path which the workmen took from the pine plantation to the nursery, the Sweet Fern bordering this path had considerable rust.

The pustules on the Sweet Fern first contain only uredospores, but later masses of teleutospores form a column arising from the old uredosporic sori. This is characteristic of the genus Cronartium.

The teleutospores are carried from the Sweet Fern to the pine seedlings which they then infect. In this case the infection is not observable till after the first two to three years. The mycelium is growing slowly under the bark of the pines and the hypertrophy and decidia, which are the means of recognizing the disease, do not show for the first few years. As soon as aecidiospores are produced by the peridermium stage on the pine, they infect the Sweet Fern during spring or early summer and here development is rapid and crops of uredospores and teleutospores are soon produced.

The authorities at Roscommon were strongly advised to thoroughly burn over and destroy the portion of land occupied by the infected Pine, as well as the area of Sweet Fern surrounding the tract at least as far as the spores were shown to have been carried by the wind. This is reported to have been done. The complete annihilation of the rust or sterilization of the region by this method can however scarcely be considered perfect and a sharp lookout will have to be kept in the future. The eradication of either host if this were feasible, is of course the most desirable.

The question naturally arises how did the rust get a foot-hold. The Western and Lodgepole Pine seedlings were raised from seeds sown in 1906, hence there is only a slight chance that the seeds carried teleutospores of the Sweet Fern. Infection appears to have occurred later, as the first sign of the disease appeared in 1911. Mr. Mains examined the native pines within reach, but found no rust. It is possible that the rust is harbored by the Jack Pine or one of the other native pines. It seems to me much more likely that some stray spores were brought in on one of the many articles which a civilized community nowadays imports for its use.

STERILIZATION OF POP CORN.

BY REED O. BRIGHAM.

The necessity of obtaining sterile seeds of pop corn, incidental to another problem, became evident to me when I began this major problem; consequently I have endeavored to find the best method to obtain completely sterile seeds. The problem upon which I am working and for which I need the sterile seeds is, the availability of nitrogen from certain organic compounds in sterile and inoculated cultures, for the growth of the plants. This work was started and carried on under the direction of Professor James B. Pollock in the Botanical Laboratory of the University of Michigan. Some preliminary work on this was done by Mr. LeVan. Because of the nature of this problem it is evident that complete sterilization of the seeds is necessary. Mr. LeVan used Zea maize (Yellow Dent Corn) in his work, and sterilized the seeds by means of mercuric chloride. For my work I determined that pop corn would be more advisable. I then proceeded to sterilize by the same method which Mr. LeVan used in his work. However I found that my plants were severely injured by this treatment; so that some other means must be obtained for sterilization of the seeds.

I then made a brief review of the literature upon seed sterilization, to try to find some suggestions for a better means. DeZeeuw (2) found that to obtain complete sterility of the seeds and obtain good seedlings was very difficult; he found that cleaning fluid, mercuric chloride, hydrogen peroxide and bromine water, if properly applied to the seeds which he used, would produce sterilization; he also found that some of the fungus and bacteria found upon the seeds were not merely on the surface, but were deep in the seed coats; this fact also making the process more difficult. He also suggested that we might have to look to antisepsis rather than to disinfection for practical results.

Robinson (4) concluded in his investigations, that the usual methods of disinfection, employing metallic poisons such as mercuric chloride, are objectionable, it having been shown that these poisons cling to seeds, even after they have been rinsed, in amounts sufficient to be harmful and often fatal to organisms placed on the seeds for inoculation.

Brown (1) has further shown that sulfuric acid and copper sulfate were unable to penetrate as far into Barley seeds as mercuric chloride, and attributed this to a "selective action" of the seed coat; hence this method might not injure the young seedlings as much.

Lipman and Fowler (3) sterilized seeds of Vicia sicula by placing them in 1:1,000 mercuric chloride solution for twenty minutes, then rinsing in sterile water and treating with sulfuric acid for twenty minutes to aid germination and take off the mercuric chloride.

Selby and Manns (5) found that the treatment most practical in sterilizing seeds containing internal infection in work on wheat was to soak the kernels eight to ten hours in water and then immerse one to two minutes in alcohol (50%) containing two grams of mercuric chloride in each 1000 cc. This solution poured off and the seeds covered with 93% alcohol (absolute alcohol is less liable to contain germinable spores) to remove traces of the fungicide. As far as showing internal infection, the above method is reliable only for those organisms which manifest their presence by growth on agar or through injury to the plantlets.

Experiments. I found as above stated that the mercuric chloride 1:500 was injurious to my young seedlings when the seeds were treated for twenty minutes; I made some trials with lower concentrations and for shorter time of treatment, but still found it injurious to the young seedlings. My next method was to try sulfuric acid (sp. gr. 1.84) for different lengths of time. After a few preliminary tests I found that if the seeds were treated for three to four minutes with concentrated acid that practically all of the seeds remain sterile; only one occasionally showed infection and this after some time, showing probably that the infection was deep in the seed coats and is not reached by the disinfectant.

I also tried dipping the seeds in alcohol and then burning this alcohol off, but this treatment killed all of the seeds, so would be of no use in sterilizing pop corn seeds.

I next made an experiment following the suggestions made by Lipman and Fowler (3). First placing the seeds in a solution of mercuric chloride 1:1000 and then in sulfuric acid (sp. gr. 1.84) and the results will be seen in the accompanying table:

TABLE 1.

	$HgCl_2$ 20 min.	$HgCl_2$ 20 min. H_2SO_4 4 min.	$HgCl_2$ 10 min. H_2SO_4 4 min.	$HgCl_2$ 5 min. H_2SO_4 4 min.	H_2SO_4 4 min.
Germination.........	100%	96%	84%	76%	100%
Good Growth........	24%	20%	24%	20%	60%
Poor Growth.........	76%	80%	76%	80%	40%
Fungus..............		3		1	

The seeds were germinated in sterile test tubes on nutritive agar medium. one seed being placed in each tube; and the above records were made five days after the seeds were placed in the tubes. The germination took place at room temperature.

From this table it is readily seen that the mercuric chloride did not hinder the germination of the seeds, but that it greatly checks the further development of the young seedlings. I also noted that those seeds treated only with sulfuric acid germinated about twenty hours sooner than the others and had therefore a better start. The plants were left for about a week and some that made only a feeble start continued their growth but only feebly. Not enough data is here recorded to make any definite statement upon the percentage of sterile seeds but the great majority are sterile and enough so that I can proceed with my problem unhindered.

Conclusions. The results which I have obtained in my work on sterilization of pop corn seems sufficient to warrant the following conclusions:

1. That mercuric chloride even at very low concentrations and for short durations of time is toxic to the developing young seedling of pop corn.

2. That sulfuric acid (sp. gr. 1.84) in which the seeds were treated for four minutes is the best disinfectant which I have obtained.

3. That absolute sterility cannot be obtained because probably there are some fungi and bacteria so deep in the seed coats that they are not reached by the disinfectant. Sterile seeds, however, are obtained in approximately 90% of the seedlings.

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UNREPORTED MICHIGAN FUNGI FOR 1911, 1912, 1913 AND 1914.

BY C. H. KAUFFMAN.

Several dry seasons and lack of opportunity to visit the parts of the state where rainfall was sufficient for the growth of fungi, have been responsible for omitting the annual reports since 1911. During this period, however, some more species have come to hand, mostly from Ann Arbor, Detroit and New Richmond. Mrs. T. A. Cahn, secretary of the mycological section of the recently formed Detroit Institute of Science has sent in quite a number of important finds. My own activities were limited to southern Michigan.

In the meantime, several lines of work undertaken by students in our laboratory makes it possible to report on a number of groups hitherto somewhat neglected. Mr. A. J. Pieters has been studying the Saproleginales and some more species of this important group are here included. Mr. A. H. W. Povah contributes a number of rare and interesting species of the Mucorales. Through the assistance of Mr. E. B. Mains, a preliminary account of the Uredinales of the state is made possible. The rusts are usually considered difficult, and until the appearance of Professor Arthur's publications in the North American Flora, this was largely due to the scattered data in the literature. The species here included are deposited in the Cryptogamic Herbarium of the University. The older collections found in the herbarium were made by Professors Beal and Wheeler of Michigan Agricultural College and by Professor Spalding, Mr. J. N. Johnson, Mr. A. J. Pieters and Mr. G. H. Hicks at Ann Arbor and elsewhere; the recent collections mostly by Mr. Mains and myself. A full set of these was submitted to Professor J. C. Arthur, who verified or identified them and to whom grateful acknowledgment is made. Mr. Mains has compiled an index to the heteroecious rusts, from which the data are included for those species.

PHYCOMYCETES.

Mucoraceæ.

Absidia glauca Hagem. On decaying wood. Washt. County. Feb. 14, fide Povah.

Mucor botryoides Lendner. On Ricinus seeds, germinating on sphagnum. Bot Lab. Ann Arbor. Mar., fide Povah.

Mucor circinelloides van Tiegh. On Rabbit (?) dung, Washt. Co. Nov. 22, fide Povah.

Mucor hiemalis Wehmer. On decaying tomato. Washt. Co. Nov. 4, fide Povah.

Mucor Moelleri Vuill. (Zygorhynchus Moelleri Vuill.) Isolated from sandy soil. Washt. Co. Nov. 5, fide Povah.

Mucor proliferus Schostak. On dung. Washt. Co. Nov. 20, fide Povah.

Mucor ramannianus Moell. On decaying mushroom. Chippewa Co. July 9, fide Povah.

Mucor spinescens Lendner. Isolated from soil on greenhouse bench. Washt. Co. Nov. 5, fide Povah.

Phycomyces nitens (Ag.) Kunze. On horse dung from livery stable. Ann Arbor. Oct. 7, fide Povah.

Pilobolus crystallinus Tode. On sheep dung. Washt. Co. Oct. 19, fide Povah.

Pilobolus longipes Van Tiegh. On horse dung. Washt. Co. Oct. 12, fide Povah.

Pilobolus oedipus Mont. On horse dung. Washt. Co. Oct 31, fide Povah.

Helicostylum piriforme Bain. On horse dung. Washt. Co. Nov. 12, fide Povah.

Chaetocladiaceæ.

Chaetocladium brefeldi van Tiegh. Parasitic on Mucor sp. On dung. Washt. Co., fide C. H. K.

Cunninghamella elegans Lend. Isolated from garden soil. Washt. Co., Nov. fide Povah.

Piptocephalidaceæ.

Piptocephalis Freseniana De Bary. Parasitic on Mucor sp. On dung. Washt. Co., fide C. H. K.

Syncephalis cornu van Tiegh. & Le Monn. Parasitic on Mucor sp. On dung, Ypsilanti.

Saprolegniaceæ.

Achyla racemosa Hildb. Washt. Co., fide Pieters.

Aphanomyces phycophilus De Bary. Among Spirogyra. Washt. Co., fide Pieters.

Dictyuchus monosporus Leitgeb. Washt. Co., fide Pieters.

Saprolegnia monoica Pringsh. Washt. Co., fide Pieters.

Saprolegnia Thureti De Bary. Washt. Co., fide Pieters.

Saprolegnia asterophora De Bary. Washt. Co., fide Pieters.

Saprolegnia diclina Humphrey. Washt. Co., fide Pieters.

ASCOMYCETES.

Exoascaceæ.

Taphrina caerulescens (Desm & Mont) Tul. On leaves of Quercus velutina. Washt. Co. June 23, fide Mains.

Pezizaceæ.

Discina ancilis (Pers.) Rehm. On the ground, Washt. Co., fide Mains.

Helotiaceæ.

Lachnum virgineum (Batach) Rehm. On decayed wood. Washt. Co., fide Mains.

Sclerotinia urnula (Weinm.) Rehm. On berries of Vaccinium. Washt. Co. May, fide Mains.

Mollisiaceæ.

Pseudopeziza medicaginis Sacc. On alfalfa. Coldwater, Mains; E. Lansing, Beal. etc.

Tapesia cinerella Rehm. On decayed log. May 6, fide Mains.

Hypocreaceæ.

Hypocrea rufa (Pers.) Fr. On wood. New Richmond. Nov. 22, fide C. H. K.

Hypomyces lateritia Fr. On Lactarius trivialis. Houghton. July 26, fide C. H. K. (Peckiella lateritia (Fr.) Maire.)

Hypomyces viridis B. and Br. On Russula, Boletus, etc. Allegan and Washt. Co. Aug.-Sept., fide C. H. K.

BASIDIOMYCETES.

Ustilaginaceæ. (*Smuts.*)

Doassansia Alismatis (Nees) Cornu. On Alisma Plantago-aquatica. Ann Arbor. July 18. Spalding.

Entyloma australe Speg. On Physalis pubescens. Lansing. Sept. 18. Hicks.

Entyloma compositarum Farl. On Ambrosia artemisiifolia and Lepachys pinnata. Ann Arbor. June 28 and July 11. Spalding, Merrow.

Entyloma lineatum (Cke.) Davis. On Zizania aquatica. E. Lansing. Beal.

Entyloma Nymphaeæ (Cun) Setck. On Castalia tuberosa. Aug. 4 and Oct. 15. Merrow, Johnson.

Schizonella melanogramma (D. C.) Schroet. On Carex Pennsylvanica. Ann Arbor. Apr. 12 and 25. Spalding, Maine.

Sorosporium Syntherismæ (Pk.) Farl. On Cenchrus tribuloides. Ann Arbor. Oct. 4. Spalding.

Urocystis Anemones (Pers.) Wint. On Anemone quinquifolia. Ann Arbor. May 22. Merrow.

Ustilago Avenæ (Pers.) Jens. On Avena sativa. Common in the state.

Ustilago bromivera (Tul.) Fisch. de W. On cultv. Bromus sp. E. Lansing. June 15. Beal.

Ustilago Hordei (Pers.) K. and S. On Hordeum sp. cultv. Ann Arbor, Lansing, etc. June 16-Aug. 1, etc.

Ustilago longissima (Sow.) Tul. On Glyceria aquatica. E. Lansing. June 12. Beal.

Ustilago nuda (Jens.) K. and S. On Hordum sp. cultv.

Ustilago neglecta Niessl. On Setaria glauca and italica. Ann Arbor, E. Lansing. Aug. 25, Oct. 4. Spalding, Beal.

Ustilago Rabenhorstiana Kühn. On Digitaria sanguinalis. Ann Arbor. Aug. Spalding.

Ustilago striaeformis (West.) Niessl. On Poa pratensis and Phleum pratense. Ann Arbor. May 17 and 23. Mains. Merrow.

Ustilago Tritici (Pers.) Rostr. On Triticum vulgare. Common in the state.

Ustilago utriculosa (Nees.) Tul. On Polygonum lapathifolium and acre. E. Lansing. Sept. 12 and 18. Beal, Hicks.

Ustilago Zeæ (Beckm.) Unger. On Zea Mays. Common in the state.

Melampsoraceæ. (Rusts.)

Coleosporium Campanulæ (Pers.) Lev. (I. Peridermium Rostrupi E. Fisch.) On Campanula americana. New Richmond. Aug. 15. C. H. K.

Coleosporium Solidaginis (Schw.) Thüm. (I. Peridermium aciculum N. and E.) On Solidágo sp. Aster sp. Ann Arbor, Battle Creek. Aug. 6, Oct. 21. Spalding, Mains.

Chrysomyxa Pyrolæ (D. C.) Rost. On Pyrola americana. Ann Arbor. May 14.

Cronartium Commandræ Pk. On Commandra umbellata. (I. Peridermium pyriforme Pk.) Ann Arbor, Battle Creek, Lansing, Roscommon. Aug. 3-Sept. Spalding, Beal, Mains.

Cronartium Comptoniæ Arth. On Myrica asplenifolia. (I. Peridermium Comptoniæ (Arth.) Orton & Adams. Roscommon, Aug. 8. Mains.

Melampsora Beglowii, Thüm (I. Ceoma Biglowii. nov. com.) On Salix amygdaloides, etc. Coldwater, Ann Arbor. Oct. Mains.

Melampsora Medusæ Thüm. On Populus monilifera, tremuloides, deltoides, etc. (I. Ceoma Medusæ nov. com.) Ann Arbor, Salem, Coldwater, Park Lake, etc. Spalding, Beal, Mains.

Pucciniastrum Agrimoniæ (Schw.) Trans. On Agrimonia sp. Eupatoria sp. Battle Creek, New Baltimore. Aug. 3 and 13. Spalding, Pieters.

Pucciniastrum pustulatum (Pers.) Diet. (I. Aecidium columnare. A. and S.) On Epilobium coloratum. Ann Arbor. June 22. Merrow.

Uredinopsis Atkinsonii Magn. On Dryopteris thelypteris. Jackson, Ann Arbor. July-Aug. Hicks, Mains.

Uredinopsis mirabilis (Pk.) Magn. On Onoclea sensibilis. Coldwater. Nov. Mains.

Pucciniaceæ.

Gymnosporangium clavariaeforme (Jacq.) D. C. (I. Roestelia lacerata X. Thax.) On Juniperus communis. Ann Arbor. Apr.-May. C. H. K. Mains, etc.

Gymnosporangium Juniperi-viginianæ. Schw. (I. Roestelia py-Pk.) On Juniperus communis. Ann Arbor. May. Spalding.

Gymnosporangium corniculans Kern. On Juniperus horizontalis. Leland. June 4. F. D. Kern. (See Mycologia II. p. 236.)

Gymnosporangium globosum Farl. (I. Roestelia lacerata, Y. Z. Thaxt.) On Juniperus virginiana. Ann Arbor. Apr. 24 and 30. Spalding, Mains.

Gymnosporangium Juniperi-virginianæ. Schw. (I. Roestelia pyrata Schw.) Thaxt. On Juniperus virginiana. Ann Arbor, Battle Creek. Spalding.

Phragmidium americanum Diet. On Rosa sp. Coldwater. Sept. 3. Mains.

Phragmidium potentillæ (Pers.) Karst. On Potentilla canadensis. Ann Arbor. June 7. C. H. K.

Phragmidium Rosae-acicularis Liro. On Rosa sp. (cultv.) Ann Arbor. Oct. Pieters.

Phragmidium Rubi (Pers.) Wint. On Rubus villosus. Gull Lake. Aug. 25. Spalding.

Phragmidium subcorticium (Schrenk) Wint. On Rosa (cultv.) R. carolina and R. humilis. Ann Arbor, Battle Creek, Eagle Harbor (Lake Sup.), E. Lansing. May 30-July 19. Spalding, Pieters, Beal, Campbell.

Puccinia Andropogonis Schw. On Andropogon scoparius. Park Lake. Oct. 7. Beal.

Puccinia angustata Pk. (I. Aecidium Lycopi Ger.) On Scirpus atrovirens, S. cyperinus, S. sylvaticus. Ann Arbor, Battle Creek. Aug. 15-Oct. 24. Spalding, Johnson, Mains.

Puccinia Amorphæ Curt. On Amorpha canescens. Battle Creek. Oct. 15. Spalding.

Puccinia Anemonæ—virginianæ Schw. On Anemone virginiana and A. canadensis. Ann Arbor, New Richmond, Battle Creek. July 3-Aug. 1. Spalding. C. H. K.

Puccinia Asparagi D. C. On Asparagus, escaped from cult. Ann Arbor. Oct. 11. Povah.

Puccinia Asteris Duby. On Aster macrophyllus, A. sp., etc., etc. Coldwater, Battle Creek, Ann Arbor, Grand Ledge. July 8-Oct. 24. Beal, Spalding, Merrow, Mains.

Puccinia Bolleyana Sacc. (I. Aecidium Sambuci Schw.) On Carex comosa.

Puccinia Calthæ Lk. An Caltha palustris. Ann Arbor. June 10. Johnson.

Puccinia Caricis (Schum) Rabenh. (I. Aecidium Urticæ Schum.) On Carex lurida, C. crinita, C. comosa, etc. Coldwater. Aug. 26-Sept. 30. Mains.

We have this on a number of other species of Carex, collected by Spalding, Beal, Pieters.

Puccina Caricis—asteris Arth. (I. Aecidium Asterum Schw.) On Carex pennsylvanica. Ann Arbor. Oct 19. Mains.

Puccinia Circaeæ Pers. On Circaea lutitiana. Ann Arbor, Battle Creek, Charlevoix, July 11-Aug. 5. Spalding, Merrow.

Puccinia Cirsii—lanceolata Schoet. On Cirsium lanceolatum, Ann Arbor, E. Lansing, New Balitmore. Sept. 6-25. Spalding, Beal, Pieters.

Puccinia Clintonii Pk. On Pedicularis canadensis. E. Lansing. Sept. 30. Yoshida.

Puccinia conglomerata (Str.) Kze & Schum. On Senecio aureus. Spalding. Aug. 29. Ann Arbor.

Puccinia Convolvuli (Pers.) Cast. On Colvolvulus sepium. Ann Arbor, E. Lansing, New Baltimore, Coldwater. July 17-Sept. 30. Spalding, Pieters, Wheeler, Mains.

Puccinia coronata Cord. (I. Aecidium Rhamni Gmel.) On Avena sativa, Calamagrostis canadensis. Ann Arbor. Oct. Mains.

Puccinia Cyperi Arth. On Cyperus esculentus & strigosus. Coldwater, New Baltimore, Battle Creek. Aug. 1-30. Spalding, Pieters, Mains.

Puccinia Dayi Clinton. On Steironema ciliatum. Battle Creek, Grand Ledge. Aug. 6. Spalding, Beal.

Puccinia emaculata Schw. On Panicum capillare. Ann Arbor, E. Lansing. Sept. 8. Spalding, Beal.

Puccinia fusca (Relhan) Wint. (=Polythelis fusca (Pers.) Arth.) On Anemone quinquefolia. Ann Arbor. May-June. Spalding, Mains, etc.

Puccinia Galii (Pers.) Schw. On Galium. Ann Arbor, Battle Creek, E. Lansing. July 23-Oct. 3. Spalding, Pieters, Hicks.

Puccinia Gentianæ (Str.) Pk. On Gentiana andrewsii and Saponaria officinalis. Coldwater, E. Lansing. Sept. 1-Oct. 6. Mains, Hicks.

Puccinia graminis Pers. (I. Aecidium Berberidis Gmel.) On Agrostis alba, Cinna arundinacea, Agropyrum repens, etc. Ann Arbor, Coldwater. Oct. 17, etc. Mains, etc.

Puccinia Helianthi Schw. On Helianthus giganteus, H. annuus, H. divaricatus, H. decapetalus. Ann Arbor, Park Lake, Battle Creek, Coldwater. July 8-Sept. 11. Spalding, Beal, Merrow, Mains.

Puccinia Hieracii (Schw.) Mart. On Hieracium canadense. Ann Arbor, Harrison. Aug.-Oct. Spalding, Beal.

Puccinia Iridis (D. C.) Wallr. On Iris versicolor. Coldwater. Oct. Mains.

Puccinia Malvacearum Mont. On Althea rosea, Malva rotundifolia and M. sylnestris (cultv.) Ann Arbor, E. Lansing. July-Nov. Beal, C. H. K., etc.

Puccinia Mariæ—Wilsoni Clint. On Claytonia virginica. Ann Arbor, etc. May-June. Johnson, etc.

Puccinia Menthal Pers. On Mentha cardica, M. arvensis canadensis, Monarda fistulosa, M. Didyma, Pycnanthenum lanceolatum. Battle Creek, Ann Arbor, E. Lansing, Charlevoix, Fenville, etc. July 1-Oct. 20. Spalding, Beal, Wheeler, Pieters, etc.

Puccinia microsperma B. & C. On Lobelia syphilitica. E. Lansing. Sept. 23. Hicks.

Puccinia obscura Schroet. (I. Aecidium bellidis Thüm.) On Luzula campestris. Ann Arbor, E. Lansing. June 16. Merrow, Hicks.

Puccinia obtecta Pk. On Scirpus valida. Ann Arbor. June 22-Aug. 4. Merrow.

Puccinia Phragmitis (Schw.) Körn (I. Aecidium rubellum Gmel.) On Phragmites communis. Coldwater, Battle Creek. Aug. 28-Sept. 8. Mains, Spalding.

Puccinia Poarum Niels. (I. Aecidium compositarium on Tussilago.) On Poa pratensis. Ann Arbor. Sept. 4. Mains.

Puccinia Pimpinellæ. Strauss) Lk. On Cryptotaenia canadensis and Osmorhiza Claytoni. Ann Arbor, Battle Creek, Grand Rapids, New Richmond, July 13-Aug. 1. Spalding, Merrow, Pieters. C. H. K.

Puccinia Podophylli Schw. On Podophyllum peltatum. Ann Arbor, etc., etc. July-Aug.

Puccinia Polygoni Pers. On Polygonum Convolvulus, P. virginianum & P. careyi. Chelsea, Battle Creek. Aug. 3-Oct. 11. Mains, Spalding.

Puccinia Polygoni-amphibii Pers. (I. Aecidium sanguinolentum Lindr.) On Polygonum amphibium, P. Muhlenbergii, P. virginianum and P. acre. E. Lansing, Grand Rapids, Coldwater. July 13-Sept. 1. Hicks, Pieters, Mains.

Puccinia Pruni-spinosæ Pers. (I. Aecidium punctatum Pers.) On Prunus serotina. Ann Arbor. July 24. Mains, Merrow.

Puccinia punctata Lk. On Galium Aparina. Ann Arbor. July. Mains.

Puccinia Sorghi. Schw. (I. Aecidium Oxalidis Thüm.) On Zea Mays. Battle Creek, Ann Arbor, Coldwater, etc. etc. Aug.-Oct. Mains, etc.

Puccinia spreta Pk. On Mitella diphylla. Ann Arbor. Aug. 9. Mains.

Puccinia suaveolens (Pers.) Rostr. On Cirsium arvense. Ann Arbor, Sandy Beach. July-Sept. 5. Spalding, Mains.

Puccinia Taraxaci Plow. On Taraxcum officinale. Ann Arbor. All summer. Mains, etc.

Puccinia Triticina Erikss. On Triticum vulgare. Ann Arbor. etc. Aug. 4. Mains.

Puccinia Vernoniæ Schw. On Vernonia fasciulata. Ann Arbor. Hicks.

Puccinia Violæ (Schum) D. C. On Viola pubescens, blanda, scabriuscula. Sand Beach. Sept. Spalding.

Puccinia Xanthi Schw. On Xanthium canadense. Ann Arbor, E. Lansing. Aug. 8-Sept. 5. Spalding, Mains.

Puccinia Zopfii Wint. On Caltha palustris. July 3. Hicks.

Ravenelia epiphylla (Schw.) Diet. On Tephrosia virginiana. Jackson Co. Aug. Hicks.

Triphragmidium echinatum Lev. On Aralia nudicaulis. Jackson Co. Aug. Hicks.

Uromyces appendiculatus (Pers.) Lk. On Phaseolus vulgaris. Ann Arbor, etc., etc. Sept. Spalding, Hicks, C. H. K., etc.

Uronyces Caladii (Schw.) Farl. On Arisaema triphyllum and dracotium, Peltandra virginica. Battle Creek, Coldwater, July 24-Aug. 29. Spalding, Mains.

Uromyces caryophyllinus Wint. (I. Aecidium Euphorbiae-Gerardianæ E. Fisch.) On Dianthus cultv. in greenhouses. Ann Arbor, etc.

Uromyces Euphorbiæ C. and P. On Euphorbia spp. Ann Arbor, Battle Creek, E. Lansing, Grand Haven. July-Oct. Spalding, Wheeler, Beal.

Uromyces Fabæ (Pers.) De Bary. On Lathyrus venosus, L. palustris and L. ochroleucus, Lakeland, Battle Creek. Aug.-Oct. Spalding, Beal, LaRue.

Uromyces hedysari—paniculata (Schw.) Farl. On Desmodium spp. Ann Arbor, etc. Aug. 20-Sept. Spalding Pieters, Beal, etc.

Uromyces Howei Pk. Asclepias Syriaca and A. incarnata. Coldwater, Ann Arbor. Sept. 12-Oct. 1. Mains, Spalding, Merrow.

Uromyces Hyperici (Spreng.) Curtis. On Hypericum prolificum and H. virginicum. Ann Arbor, New Baltimore. Aug. 23-Sept. 18. Johnson, Pieters.

Uromyces Lespidezæ-procumbentis (Schw.) Curtis. On Lescpedeza capitata and L. reticulata. Ann Arbor, Battle Creek. Oct. 4-16. Spalding, Pieters, Merrow.

Uromyces minutus Diet. On Carex muskingumensis. Ann Arbor. Oct. 17. Mains.

Uromyces perigynius Halsted. (I. Aecidium —.) On Aster sp. On Carex tribuloides and C. gracillima. Ann Arbor, E. Lansing. Apr. 2 and Oct. 14. Mains, Hicks.

Uromyces pyriformis Cke. On Acorus Calamus. New Baltimore. Aug. 5. Pieters.

Uromyces Polygoni (Pers.) Fuck. On Polygonum aviculare and P. erectum. E. Lansing, Ann Arbor. May 30 and Oct. 30. Beal, Spalding.

Uromyces Silphii (Burr.) Arth. (I. Aecidium Silphii Syd.) On Juncus tenuis. Ann Arbor, E. Lansing. July 23-Oct. 17. Hicks, Pieters, Mains.

Uromyces Sparganii C & P. On Sparganum eurycarpum. Ann Arbor, New Baltimore. Aug. 2-13. Johnson, Pieters.

Uromyces Terebinthi (D. C.) Wint. On Rhus toxicodendron. Ann Arbor, E. Lansing. Sept. 11-Oct. 3. Spalding, Hicks.

Uromyces Trifolii (Hedw.) Lev. On Trifolium repens. T. pratense and T. incarnatum. Ann Arbor, E. Lansing. Spalding, Mains, Beal.

Hyalopsora Polypodii (D. C.) Mag. On Cystopteris fragilis. Ann Arbor. May 12. Merrow. (As Uredo Polypodii.)

Chrysomyxa Cassandræ Tranz. On Chamaedaphne calyculata. Ann Arbor, Lansing. June-Oct. Pieters, Hicks, Mains.

Form-genera. (Aecidial stage.)

Aecidium Allenii Clint. On Shephardia canadensis. Ann Arbor, Mackinac Island. May 17-June 30. Johnson, Hicks.

Aecidium Asterum Schw. (III. Puccinia asteri-caricis) On Aster sp. Ann Arbor. June. Spalding.

Aecdium Berberidis Gmel. (III. Puccinia graminis.) On Berberis vulgaris. Ann Arbor, E. Lansing. May 30-June 12. Merrow, Beal.

Aecidium Caladii Schw. (III. Uromyces Caladii) autoecious.

Aecidium claytoniatum Schw. (III. Puccinia Mariæ-Wilsoni) Autoecious.

Aecidium Clematidii E. & E. (III. Puccinia Clematidis-agropyri E & E.) On Clematis virginiana. Ann Arbor, Howard City. June 28-July 9. Spalding, Beal.

Aecidium compositarum var Eupatorii Schw. (III. Puccinia Eleocharidis Arth.) On Eupatorium perfoliatum. Ann Arbor, June 22-July 19. Mains, Merrow.

Aecidium compositarum var Solidaginis (III. Puccinia Solidaginis-caricis Arth.) On Solidago, Ann Arbor. Spalding.

Aecidium Euphorbiæ Pers. (III. Uromyces Euphorbiæ C. & P.) Autoecious.

Aecidium Geranii D. C. On Geranium maculatum. Ann Arbor, etc., etc. May-June. Johnson, C. H. K., etc.

Aecidium Gerardiæ Pk. On Gerardia virginica. Ann Arbor. June 18. Merrow.

Aecidium grossulariæ Schum. On Ribes floridum, R. Cynobasti, R. oxyacanthoides, and R. sp. cultv. Ann Arbor, etc., etc. May-June. Mains, C. H. K., etc. Heteroecious. (American forms not yet understood.)

Aecidium impatientis Schw. (III. Puccinia Impatienti Elymi Arth.) On Impatiens biflora. Ann Arbor, Coldwater, New Richmond, etc. May 23-July 12. Mains, C. H. K., etc.

Aecidium importatum Henn. See Aecidium Caladii.

Aecidium Iridis Ger. On Iris versicolor. Ann Arbor, Battle Creek. June 29-July 6. Spalding, Mains.

Aecidium leucostictum B. & C. Autoecious. On Lespedeza hirta. E. Lansing. July 10. Hicks.

Aecidium Lycopi. Ger. (III. Puccinia angustata Pk.) On Lycopus virginicus. E. Lansing, Ann Arbor. June 19-July 19. Hicks, Mains.

Aecidium Neeseæ Ger. On Decodon verticillatus. Goguac Lake, New Baltimore, Ann Arbor. July 4-17. Spalding, Pieters, Mains.

Aecidium orbicula Pk. (III. Puccinia orbicula) Autoecious. On Prenanthes alba. Ann Arbor. May 25. Spalding.

Aecidium Oxalidis Thüm. (III. Puccinia Sorghi Schw.) Raised in greenhouse by infection. Ann Arbor, Mar. 1915 Mains.

Aeciudim Peckii DeToni. (III. Puccinia peckii (DeToni) Kell. on Carex sp.) On Oenothera biennis. Battle Creek, E. Lansing, Ann Arbor. June 7-July 2. Spalding, Beal, Mains.

Aecidium Penstemonis Schw. (III. Puccinia americana Lagerh.) On Pentstemon pubescens. Ann Arbor. May 31. Spalding. This should be compared with aecidial stage of Puccinia Andropogonis Schw.

Aecidium Podophylli Schw. (III. Puccinia Podophylli Schw.) Autoecious.

Aecidium Polygalinum Pk. On Polygala senega. Ann Arbor. May. Spalding.

Aecidium punctatum Pers. (III. Puccinia Pruni-spinosa Pers.) On Anemone quinquefolia. Ann Arbor. May 26. Merrow.

Aecidium pustulatum Cert. (III. Puccinia pustulatum (Curt.) Arth. on Andropogon sp.) On Commandra umbellata. Ann Arbor. June 19. Pieters.

Aecidium Ranunculacearum. D. C. (III. Puccinia perplexans Plowr. P. calamagrostis Syd. P. magnusiana Körn. Uromyces dactylidis Ottlr. and U. poæ. Rabenh: these have been connected with Aecidia on Ranunculus sp. Puccinia simillima Arth., connected with Anemone canadensis.) On Anemone quinquefolia, Isopyrum biternatum, Ranunculus canadensis, etc. Ann Arbor, E. Lansing, New Richmond, etc. May-June. Pieters, Mains, C. H. K., Beal.

Aecidium Ranunculi Schw. (III. Puccinia Aetoniæ Arth.) On Ranunculus abortivus. Ann Arbor, New Richmond, etc. May-June, Spalding, Mains, C. H. K., etc.

Aecidium Rhamni Pers. (III. Puccinia coronata Cke.) On Rhamnus alnifolia. Ann Arbor, Lansing. May 18-June 12. Spalding, Beal.

Aecidium rubellum Gmel. (III. Puccinia Phragmitis (Schum.) Körn.) On Rumex sp. Battle Creek. July 2. Spalding.

Aecidium Sambuci Schw. (III. Puccinia Bolleyana Sacc.) On Sambucus canadensis. Ann Arbor, Battle Creek, New Richmond, etc. June. Spalding, C. H. K., etc.

Aecidium Senecionis Desm. (III. Puccinia conglomerata Autoecious.

Aecidium Thalietri Grev. (Heteroecious, but connections not clear.) On Thalictrum revolutum. T. dioicum. Ann Arbor. May 30. Spalding, Pieters.

Aecidium Urticæ Schum. (III. Puccinia caricis (Schum.) Rebent.) On Urtica gracilics. Ann Arbor, E. Lansing, Battle Creek. May-Oct. Spalding, Hicks, Pieters.

Aecidium Verbenicola Kell & Swing. (III. Puccinia Vilfæ Arth. & Holw.) On Verbena hastata. Ann Arbor. June 7. C. H. K.

Aecidium Violæ Schum. (III. Puccinia Violae (Schum) D. C.) Autoecious. On Viola pubescens, blanda, etc. Ann Arbor, etc. May. C. H. K., etc.

Ceoma arctica new comb. (III. Malampsorfa arctica Rostr.) On Abies balsamea. Alpena. June 20. C. H. K.

Ceoma Medensæ new comb. (III. Melampsora medusæ Thüm.) On Larix laricina. Ann Arbor. June 10 Mains.

Ceoma nitens Schw. (Autonomous.) On Rubus occidentalis, R. villosus, etc. Throughout the state. May-July. Spalding, C. H. K., etc.

Peridermium Comptoniæ (Arth.) Ort & Adams. (III. Cronartium comptoniæ Arth. On Pinus ponderosa, P. contorta and P austriaca. Roscommon. State Nursery and Plantations. Aug. 1914. Mains.

Peridermium consimile Arth. & Kern. (III. Chrysomyxa cassandræ Tranz.) On Picea rubra & P. nigra. Alpena, Ann Arbor, June 20 and July. C. H. K., Mains.

Peridermium decolorans Pk. On Picea nigra. Lansing. July 27. Beal.

Peridermium pustulatum. (Puccimastrum pustulatum (Pers.) Diet. On Abies balsamea. Alpena. June 20. C. H. K.

Peridermium cerebrum Pk. (III. Cronartium Quercus. (Bron) Schröet.) Seen and reported by several collectors in the northern part of state. (No specimens in University herbarium.)

Roestelia aurantiaca Pk. (III. Gymanosporangium clavipes Cke. & Pk.) On Amelanchier canadensis. Charlevoix, Marquette. Aug. Spalding, D. H. Campbell.

Rôestelia cornuta (Gmel.) Tul. (III. Gymnosporangium Juniperinum (L) Fr.) On Amelanchier canadensis. Park Lake. Sept. 2. Beal and Wheeler.

Roestelia lacerata X Thax. (III. Gymnosporangium clavariaeforme (Joeq) D. C.) On Amelanchier canadensis and Crataegus sp. Ann Arbor. July 4. Mains, C. H. K., etc.

Roestelia pyrata (Schw.) Thax. (III. Gymnosporangium. Juniperi-virginianæ. Schw.) On Pyrus malus, P. coronaria. Ann Arbor, Battle Creek. Aug.-Sept. Spalding, Merrow.

Roestelia lacerata Y and Z. Thaxt. (Gymnosporangiumglo gbosum.)

Dacryomycetaceæ.

Calocera furcata Fr. On rotten wood. Ann Arbor. June. fide C. H. K.

Thelephoraceæ.

Peniophora gigantea (Fr.). On logs and debris of white pine. New Richmond. Sept. fide Lloyd.

Clavariaceæ.

Clavaria Botrytis Fr. On the ground. Ann Arbor. Mackinac Island. Aug. fide C. H. K.

Clavaria juncea Fr. Among fallen leaves in woods. Ann Arbor. Sept.-Oct. fide C. H. K.

Hydnaceæ.

Caldesiella ferruginosa Sacc. On rotten woood. Ann Arbor. July. fide C. H. K.

Odontia crocea Schw. On rotten wood. Ann Arbor. fide Lloyd.

Radulum orbiculare. Fr. On sticks. Ann Arbor. fide C. H. K.

Hydnum ferruginosum Fr. On rotten wood. Ann Arbor. Aug. fide C. H. K.

Hydnum scabripes Pk. On the ground. Ann Arbor. Aug. fide C. H. K.

Hydnum strigosum Schw. On logs. Ann Arbor. Aug. fide Lloyd.

Polyporaceæ. Merulius ceracellus B & C. Ann Arbor. fide C. H. K. (cf. N. A. F. No. 2603.)

Polyporus dryophilus Berk. On oak. Lakeland. Oct. fide C. H. K.

Polyporus floriformis Quel. On wood. Ann Arbor. Oct. fide Lloyd.

Polyporus glomeratus Pk. On soft maple log and stump, forming extensive patches 5 ft. long by 2 ft. wide, with an apparent stratose pore structure which is greenish-yellow when fresh. New Richmond. Ann Arbor. Sept., Nov. fide Lloyd.

Polyporus hispidus Fr. On Ash. Ann Arbor. Oct.-Nov. fide C. H. K.

Polyporus robiniophilus (Murr.) On black locust trunks. Coll. Povah. Ann Arbor. Oct.-Nov. fide C. H. K.

Polyporus spumeus Fr. On maple, etc. Roscommon and Ann Arbor. Coll. Mains. Aug.-Nov. fide Lloyd.

Polyporus semipileatus Pk. On decaying beech wood. Sept. Bay View. fide C. H. K.

Poria ambigua Bres. On Wood. New Richmond. Oct. fide Lloyd.

Poria cinerea Schw. On wood. Ann Arbor. July. fide Lloyd.

Poria Gordoniensis B and Br. On wood. Ann Arbor. Nov. fide C. H. K.

Poria purpurea Fr. On sycamore. Ann Arbor. Nov. fide Lloyd.

Poria salmonicolor B & C. On wood. Ann Arbor. fide C. H. K.

Porothelium fimbriatum Fr. On wood. New Richmond. Sept.-Oct. fide C. H. K.

Trametes hispida Bagl. On oak and poplar. Ann Arbor, New Richmond. Oct.-Nov. fide C. H. K.

Agaricaceæ. (fide C. H. K.)

Amanita Peckiana Kauff. On sandy soil. New Richmond. Sept.

Amanita porphyria Fr. On low ground in thicket. Ann Arbor. July.

Amanita recutita Fr. On sandy soil under conifers. New Richmond. Sept.

Amanita solitaria Fr. In rich woods. Ann Arbor. Aug.

Amanita spissa Fr. On clay soil of woods. Ann Arbor. July.

Amanita tomentella Kromb. In conifer forests. Houghton, Munising, etc. Aug.-Oct.

Armillaria caligata Vitt—Bres. On the ground in oak woods. Ann Arbor. Oct.

Armillaria focalis Fr. var. Among debris and humous, hemlock, mixed woods. New Richmond. Sept.

Bolbitius tener Berk. On lawns. Ann Arbor, Marquette, Ypsilanti. July-Aug.

Claudopus depluens Fr. On very rotten wood or humus. New Richmond. Sept.

Clitocybe albidula Pk. On the ground in conifer woods. Bay View. Sept.

Clitocybe angustissima Fr. On the ground among leaves. New Richmond. Sept.

Clitocybe candida Bres. In conifer forests. Marquette. Aug.

Clitocybe catina Fr. In woods of beech and pine. New Richmond. Sept.-Oct.

Clitocybe compressipes Pk. Among leaves in frondose woods. Ann Arbor. Sept.-Oct.

Clitocybe ditopoda Fr. Under tamarack trees. Ann Arbor. Oct.-Nov.

Clitocybe maxima Fr. On the ground in frondose woods. Lakeland. Aug.-Sept.

Clitocybe metachroa Fr. On the ground in woods. Ann Arbor, Marquette. Sept.-Nov.

Clitocybe morbifera Pk. Among grass, lawns, roadsides, etc. Ann Arbor, Detroit, Adrian. Sept.-Oct.

Clitocybe ochropurpurea Berk. On ground in open woods. Throughout the state. July-Oct.

Clitopilus undatus Fr. On debris or ground in woods. Ann Arbor. Aug.

Collybia alcalinolens Pk. Among leaves in frondose woods. Ann Arbor. Oct.-Nov.

Collybia conigenoides Ellis. On cones of Pine. New Richmond. Sept.

Collybia floccipes Fr. On debris and fallen leaves, etc., in frondose woods. Ann Arbor. May-June.

Coprinus arenatus Pk. In sandy loam. Ann Arbor. May. fide Pennington.

Coprinus Brassicæ Pk. On stalks of corn, herbs, grass, etc. Ann Arbor, Palmyra. fide Pennington.

Coprinus bulbilosus Pat. cultv. On horse dung. fide Pennington.

Coprinus domesticus Fr. On vegetable debris. fide Pennington.

Coprinus insignis Pk. On the ground in swampy woods. Ann Arbor. fide Pennington.

Coprinus Jonesii Pk. On plaster of the wall in a cellar. Ann Arbor. fide Pennington.

Coprinus niveus Fr. On manured ground, etc. Ann Arbor. fide Pennington.

Coprinus ovatus Fr. On lawn. Palmyra, Mich. fide Pennington.

Coprinus Patouillardi Quel. On dung. Common. fide Pennington.

Coprinus radians Fr. On wood, rubbish, etc. fide Pennington.

Coprinus radiatus Fr. Very common on dung. fide Pennington.

Coprinus sterquilinus Fr. On manured soil and dung. Ann Arbor, etc. fide Pennington.

Coprinus sylvaticus Pk. On debris of wood. Ann Arbor, Bay View. fide Pennington.

Cortinarius brunneofulvus Fr. On the ground in frondose woods. Ann Arbor. Sept.

Cortinarius caesiocyaneus Britz. On the ground in frondose woods. Ann Arbor. Sept.-Oct.

Cortinarius erugatus Fr. Under hemlock and pine. New Richmond. Oct.

Cortinarius herpeticus Fr. (Formerly reported as C. olivaceus Pk.)

Cortinarius imbutus Fr. In low woods. Ann Arbor. Oct.

Cortinarius intrusus Pk. On soil of benches in green houses. Detroit. Jan., etc.

Continarius lignarius Pk. On very rotten wood. New Richmond. Sept.

Continarius livor Fr. Under beech and pine. New Richmond. Sept.

Cortinarius malicorius Fr. In cedar and spruce swamp. Ste. St. Marie. July.

Cortinarius scandens Fr. In frondose and mixed woods. Ann Arbor and New Richmond. Sept.

Cortinarius scutulatus Fr. On sandy soil under thickets. New Richmond. Sept.

Crepidatus applanatus Fr. On decayed logs, stumps, etc. Ann Arbor, New Richmond. Sept.

Crepidotus calolepis Fr. On fallen branches of bass-wood. Houghton. July.

Crepidotus dorsalis Pk. On decaying logs. Ann Arbor, New Richmond. July-Sept.

Eccilia mordax Atk. On the ground in woods. Ann Arbor. Aug.

Entoloma cuspidatum Pk. On mosses, e. g. Sphagnum, Leucobryum, etc., in bogs. Eloise. Aug. Coll. by Mrs. T. A. Cahn.

Entoloma scabrinellum Pk. On the ground. New Richmond. Sept.

Galera antipus Lasch. On dung-hills in beech and pine woods. New Richmond. Sept.

Galera capillaripes Pk. Among grass. Ann Arbor. Sept.

Galera plicatella Pk. Among grass, lawns and roadsides. Ann Arbor. Aug.-Oct.

Galera pubescens Gill. On cow-dung, fields, etc. Ann Arbor, New Richmond. June-Sept.

Galera teneroides Pk. On horse-dung, ground or decayed debris in woods. Ann Arbor, New Richmond. Aug.-Sept.

Gomphidius maculatus Fr. In tamarack bog on sphagnum, etc. Ann Arbor. Oct.

Hebeloma fastibile Fr. In woods on the ground. New Richmond. Sept.

Hebeloma longicaudum Fr. In swamps of cedar, tamarack, etc. Ann Arbor, New Richmond. Sept.-Nov.

Hebeloma velatum Pk. On the ground in woods. New Richmond. Sept.

Hygrophorus ceraceus Fr. On moist ground in woods. New Richmond, Marquette, etc. July-Sept.

Hygrophorus Colemannianus Blox. In moist mossy places in low woods. Ann Arbor, New Richmond. July.

Hygrophorus flavodiscus Frost. On the ground in hemlock woods. New Richmond. Sept.

Hygrophorus leporinus Fr. Among fallen leaves in woods. Ann Arbor. Oct.

Hrgrophorus olivaceoalbus Fr. On the ground in frondose woods. Ann Arbor. Oct.

Hygrophorus sordidus Pk. On the ground in frondose woods. Ann Arbor, New Richmond. Sept.-Nov.

Hygrophorus virgineus Fr. On sandy ground, in mixed woods. New Richmond, Detroit. Sept.-Oct.

Hypholoma coronatum Fr. Among leaf mould and very rotten wood. Ann Arbor. July-Aug.

Hypholoma velutinum (Fr.) Quel. On low ground in woods. Ann Arbor, etc. July-Oct.

Inocybe albodisca Pk. On the ground, hemlock and beech woods. New Richmond. Sept.

Inocybe caesariata Fr. On moist ground. Ann Arbor, New Richmond, etc. Aug.-Oct.

Inocybe Curreyi Berk. In grassy frondose woods. Ann Arbor. July-Aug.

Inocybe decipiens Bres. In grassy low frondose woods. Detroit. June.

Inocybe destricta Fr. Under conifers. Bay View, New Richmond. Aug.-Sept.

Inocybe eutheloides Pk. On the ground in low frondose woods. Ann Arbor, etc. June-Sept.

Inocybe fibrosa Bres. In low, frondose woods. Ann Arbor. June-Aug.

Inocybe frumentacea Fr. In low, moist, frondose woods. Detroit, Ann Arbor. July-Aug.

Inocybe mutata Pk. Low frondose woods. Ann Arbor. Sept.

Inocybe nodulospora Pk. In coniferous woods. Bay View, New Richmond, Ann Arbor. June-Sept.

Inocybe pyriodora Bres. In frondose woods. Ann Arbor. Aug.

Inocybe repanda Bres. In low, frondose woods. Ann Arbor. July-Aug.

Lactarius controversus Fr. On the ground in low, moist woods. Ann Arbor, Detroit, etc. Aug.-Sept.

Lactarius hygrophoroides B & C. (Reported by Longyear by its synonym: L. distans Pk.)

Lactarius isabellinus Burl. In coniferous woods. Marquette. Aug.

Lactarius oculatus (Pk.) Burl. In moist places in low woods, often on moss. Ann Arbor. July-Sept.

Lactarius rimosellus Pk. In wet places in woods. Ann Arbor. Aug.

Lactarius varius Pk. In mixed woods. Marquette. Aug.

Lacterius vietus Fr. On the ground in hemlock and maple woods. New Richmond. Sept.

Lentinus umbilicatus Pk. In pine and beech woods, on the ground. New Richmond. Sept.

Lentinus ursinus Fr.—Bres. On prostrate trunks in woods of beech and hemlock. New Richmond. Sept.

Leptonia lampropoda Fr. Wet places in mixed woods, on the ground. Bay View, Marquette, New Richmond.

Leptonia seticeps Atk. On rotten logs in mixed woods. Bay View, Ann Arbor. July-Sept.

Marasmius cohaerens Fr. (As Collybia lachnophylla by Longyear).

Marasmius Olneyi B. & C. On fallen leaves and twigs in woods. New Richmond. Sept.

Marasmius prasiosmus Fr. On midribs of fallen oak leaves. Ann Arbor. Sept.

Marasmius urens Fr. On the ground among leaves, etc. Ann Arbor. July-Oct.

Marasmius varicosus Fr. Among fallen leaves and debris in frondose woods. Ann Arbor. Sept.

Mycena atroalboides Pk. On decayed wood, mosses, etc., in mixed woods. New Richmond. Aug.-Sept.

Mycena clavicularis Fr. Attached to fallen leaves in mixed woods. New Richmond. Sept.

Mycena cyaneobasis Pk. Among leaves and decayed wood, etc., in frondose woods. Ann Arbor. June-Oct.

Mycena excisa Fr. Among grass in woods. Ann Arbor. Oct.-Nov.

Mycena lasiosperma Bres. On very rotten wood in beech and maple forest. Ann Arbor. Aug.

Mycena parabolica Fr. On or about decaying logs, etc., in mixed woods. New Richmond. Sept.

Mycena pulcherrima Pk. On much decayed wood in conifer forests. New Richmond. Sept.

Mycena rosella Fr. On and among white pine needles, etc., conifer woods. New Richmond, Marquette. Sept.-Oct.

Mycena subincarnata Pk. On mossy logs or moist places, on the ground. Bay View, New Richmond. Sept.

Mycena vulgaris Fr. Attached to pine needles, sticks, etc., in woods. New Richmond, Marquette. Aug.-Sept.

Naucoria bellula Pk. On decayed coniferous wood. New Richmond, Bay View. Sept.

Naucoria centuncula Fr. On decayed wood. Ann Arbor. July-Sept.

Naucoria lignicola Pk. On decayed wood. Ann Arbor. July.

Naucoria siparia Fr. On soil or mosses in low woods. Ann Arbor. Aug.

Naucoria tabacina Fr. On the ground, cultv. field. Ann Arbor. June.

Naucoria triscopoda Fr. (Reported in 8th. Rep. Mich. Acad. Sci. as N. cuspidata Pk., never published.)

Nolanea papillata Bres. On the ground, low moist woods. Ann Arbor, Bay View, New Richmond. Sept.

Nolanea pascua Fr. In low, mossy woods. Ann Arbor. Sept.

Nolanea versatilis Fr. Among grass in low, moist woods. Ann Arbor, New Richmond. July-Aug.

Omphalia albidula Pk. On leaves and bark in frondose woods. Bay View. July.

Omphalia olivaria Pk. On decayed logs. Ann Arbor. Sept.

Omphalie scyphiformis Fr. On mosses or moist ground. Ann Arbor. Aug.

Panus strigosus B & C. On trunks of maple, birch and apple trees. Houghton. New Richmond. Aug.-Sept.

Pholiota destruens (Lasch.) Bres. (Syn. P. heteroclita Fr. & P. comosa Fr.) On trunks of poplar, birch and willow. Detroit. Autumn.

Pholiota discolor Pk. On decaying wood. Ann Arbor. New Richmond. May and Sept.

Pholiota luteofolia Pk. On decaying log of white oak. Ann Arbor. Sept.

Pholiota spectabilis Fr. On base of yellow birch trunks. Marquette. Aug.-Sept.

Pholiota unicolor Fr. On decaying logs in woods. Ann Arbor. Autumn.

Pleurotus albolanatus Pk. (= P. porrigens var. albolanatus Pk.) On decaying wood. Bay View, Houghton, Marquette. Aug.-Oct.

Pleurotus porrigens Fr. On decayed wood of conifers. Marquette, etc.

Pleurotus subareolatus Pk. On living trunks of maple and basswood. Ann Arbor. New Richmond. Sept.-Oct.

Pluteolus reticulatus Fr. Base of stumps and trunks in woods. Ann Arbor. Oct.

Psathyra persimplex Britz. On sticks and wood in hemlock forest. New Richmond. Sept.

Psathyra semivestita Berk. & Br. On horse dung. New Richmond. Sept.

Psilocybe atrobrunnea Fr. Among Sphagnum in bogs. Ann Arbor. Sept.-Nov.

Psilocybe arenulina Pk. On sandy soil. Port Huron, New Richmond. Sept.-Oct.

Psilocybe ericaea Fr. On the ground in mixed woods. New Richmond. Sept.

Psilocybe merdaria Fr. (Deconica merdaria.) On horse dung. Ann Arbor. May-June.

Psilocybe uda (Fr.) Battaille On horse dung and soil in wet woods. New Richmond. Sept.

Russula compacta Frost. On the ground in beech and maple woods. New Richmond. Aug.-Sept.

Russula foetentula Pk. On the ground in frondose woods. Ann Arbor, July-Aug.

Russula rubescens Beards. On the ground in frondose woods. Ann Arbor. July-Aug.

Stropharia coronilla Bres. On the ground in mixed woods. New Richmond. Sept.

Stropharia depilata Fr. Among debris in mixed woods. Marquette. Sept.

Tricholoma carneum Fr. On the ground among fallen leaves in woods. Ann Arbor. Aug.-Sept.

Tricholoma cinerascens Fr. On leaf-mould in frondose woods. Ann Arbor. Oct.

Tricholoma imbricatum Fr. On the ground in coniferous and mixed woods. In northern Michigan; also Detroit, etc.

Tricholoma saponaceum Fr. On the ground in frondose woods. Ann Arbor, New Richmond. Sept.-Oct.

Tricholoma sordidum Fr. On decaying vegetable matter, straw, etc. Ann Arbor. Aug.-Oct.

Tricholoma terriferum Pk. In frondose woods. Detroit. Oct.

Tricholoma tumidum Fr. Among fallen leaves in frondose woods. Ann Arbor. Oct.

Volvaria bombycina Fr. On trunks of living broad-leaved trees. Ann Arbor, Marquette, etc. July-Sept.

Volvaria gloiocephala D. C. On decaying vegetation, wood, etc. Ann Arbor. Aug.

FUNGI IMPERFECTI.

Sphaeropsidales.

Ascochyta caulicola Law. On Melilotus alba. Ann Arbor. July 25. fide Mains.

Coniothyrium Fuckelii Sacc. On Ribes sp. cultv. Coldwater. Apr. 8. fide Mains.

Coniothyrium Tiliæ Lasch. On Tilia americana. Ann Arbor. Aug. 11. fide C. H. K.

Coryneum Kunzei Corda. On Quercus Sp. Ann Arbor. Aug. 5. fide C. H. K.

Cytospora abietis Sacc. On Larix Laricina. Ann Arbor. Jan. 23. fide E. Levin.

Cytospora ambiens Sacc. On Acer sp. Ann Arbor. Feb. 3. fide E. Levin.

Cytospora carbonacea Fr. On Ulmus americanus. Ann Arbor. Jan. fide E. Levin.

Cytospora celastri Clements. On Celastrus scandens. Ann Arbor. Feb. 3. fide E. Levin.

Cytospora chrysosperma (Pers.) Fr. On Populus tremuloides. Ann Arbor. Feb. 3. fide E. Levin.

Cytospora incarnata Fr. On Ostrya virginiana. Ann Arbor. Jan. 18. fide E. Levin.

Cytospora miniata Thum. On Fraxinus sp. Ann Arbor. Jan. 23. fide E. Levin.

Cytospora microspora (Cord.) Rehm. On Crataegus sp. Coldwater. Apr. 10. fide Mains.

Diplodia acicola Sacc. On cones of Pinus austriaca. Ann Arbor. Mar. fide Mains.

Diplodia Linderi E & E. On Benzoin aestivale. Ann Arbor. Apr. 13. fide Mains.

Diplodia Rhois. Sacc. On Rhus glabra. Ann Arbor. Apr. 3. fide Mains.

Dothiorella quercina. On Quercus sp. Feb. 13. fide E. Levin.

Hendersonia sarmentorum West. On Ampelopsis quinquefolia. Feb. 3. fide E. Levin.

Phyllosticta Labruscæ Thum. On Ampelopsis quinquefolia. Ann Arbor. Aug. 7. fide Mains.

Phyllosticta Linderæ E. & E. On Benzoin aestivale. Coldwater Aug. 24. fide Mains.

Phyllosticta Orontii Ell. & Mart. var. advena Ell. On Nymphaea advena. Ann Arbor. July 25. fide Mains.

Phyllosticta Rosæ Desm. On Rosa sp. Coldwater. Sept. 13. fide Mains.

Phyllosticta spheropsidea E. & E. On Aesculus Hippocastanun. Ann Arbor. July 28. fide Mains.

Rabenhorstii Tiliæ Fr. On Tilia americana. Coldwater. Apr. 10. fide Mains.

Septoria Lobeliæ-syphiliticæ P. Henn. On Lobelia syphilitica. Quincy. Sept. 19. fide Mains.

Septoria lupulina E. & K. On Humulus lupulus. Coldwater. Aug. 24. fide Mains.

Septoria sambucina Pk. On Sambucus canadensis. Coldwater. Sept. 7. fide Mains.

Sphaeronema acerina Pk. On Acer. Ann Arbor. Apr. 4. fide Mains.

Sphaeropsis celastrina Pk. On Celastrus scandens. Ann Arbor. Feb. fide. E. Levin.

Sphaeropsis Macluræ Cke. On Maclura pomifera. Ann Arbor. Apr. 18. fide Mains.

Sphaeropsis Pinastri C. & E. On Pinus sylvestris. Ann Arbor. Apr. 15. fide Mains.

Sphaeropsis Sumachi C. & E. On Rhus glabra. Ann Arbor. Apr. 20. fide Mains.

Sphaerographium Fraxini (Pk.) Sacc. On Fraxinus sp. Ann Arbor. May 6. fide Mains.

Melanconiales.

Colletotrichum Lindemuthianun. (Sacc. & Mag.) Bri. & Cav. On Phaseolus sp. (cultv.) Common. Aug. Sept.

Marssonia Potentillæ ,(Desm.) Fisch. On Potentilla anserina. Coldwater. Aug. 9. fide Mains.

Naemospora croceola Sacc. On Quercus sp. Ann Arbor. May 16. fide Mains.

Steganosporium cellulosum Corda. On Acer saccharinum. Ann Arbor. Aug. 5. fide C. H. K.

Hyphomycetes.

Alternaria Brassicæ (Berk.) Sacc. On Radicula armoracia. Coldwater. Aug. 22. fide Mains.

Aspergillus citrisporus. On decayed wood. Legit Povah. Ann Arbor. Oct. 4. fide C. H. K.

Botryosporium pulchellum Maire. On dead leaves, greenhouse. Ann Arbor. fide C. H. K.

Cercospora squalidula Pk. On Clematis virginiana. Coldwater. Sept. 8. fide Mains.

Cercospora smilacina Sacc. On Smilax hispida. Coldwater. Aug. 24. fide Mains.

Cladosporium fulvum Cke. On cultv. tomato vine. Greenhouses. Ann Arbor. July. Legit and fide Mains.

Helminthosporium macrocarpum Grev. On Viburnum sp. Ann Arbor. May 17. fide Mains.

Volutella fructi S. & H. On fallen apples. Ann Arbor. Oct. Legit Povah. fide C. H. K.

Cryptogamic Herbarium, University of Michigan,
Ann Arbor, 1915.

A PRELIMINARY LIST OF THE BRYOPHYTES OF MICHIGAN.

BY C. H. KAUFFMAN.

No extensive collections of this group of plants seems to have been made in the state. Isolated records occur here and there in bryological literature and in a few of our state survey reports. For the present I have limited myself to my own collections which have been mostly made while prosecuting work in various parts of the state along other lines. The collections are therefore not exhaustive, but represent the most common of our liverworts and mosses.

HEPATICÆ.

Ricciaceæ.

Ricciella fluitans A. Br., *Riccia fluitans* L. Common throughout the state.

Ricciocarpus natans Corda, *Riccia natans* L. Common throughout the state.

Marchantiaceæ.

Conocephalus conicus Dum. Throughout the state. Fruiting April and May.

Lunularia cruciata Dum. Introduced into greenhouses. Native in the Mediterranean countries of Europe.

Marchantia polymorpha L. Throughout the state. Fruiting in summer.

Preissia quadrata Nees. *P. commutata.* South Haven, in deposits of marl, clay cliff facing Lake Michigan, fruiting in June.

Reboulia hemispherica Raddi. *Asterella hemispherica* Bauv. Banks along Huron river, Ann Arbor. Fruiting, May-June.

Jungermanniales.

Metzgeriaceæ.

Pallavicinia lyellii S. F. Gray. Holland, South Haven, Ann Arbor. Fruiting, April-June.

Pellia epiphylla Corda. Throughout the state. Fruiting, April-May.

Riccardia pinguis. S. F. Gray. *Aneura sessilis* Spr. Ann Arbor, New Richmond. Fruiting, May-June.

Jungermanniaceæ.

Calypogeia suecica. C. Müll. Ann Arbor, New Richmond.

Calypogeia trichomanis Corda. Throughout the state. Fruiting, May-June.

Cephalozia curvifolia Dum. Ann Arbor.

Cephalozia lunulæfolia Dum. South Haven, Ann Arbor.

Chiloscyphus pallescens Dum. Ann Arbor.

Frullania asagrayana Mont. Alpena, Mackinac I'd.

Frullania eboracensis Gottsche. Throughout the state. Fruiting, May-June.

Harpanthus scutatus Spruce. Ann Arbor, South Haven.

Jungermannia lanceolata L. *Liochlena lanceolata* Nees. Ann Arbor. Fruiting, May-June.

Lophocolea heterophylla Dum. Throughout the state. Fruiting, May-June.

Porella pinnata L. Alpena.

Porella platyphylla Lindb. Throughout the state. Fruiting, May-June.

Ptilidium ciliare Nees. Throughout the state. Fruiting, May-June.

Radula complanata Dum. Throughout the state. Fruiting, May-June.

Trichocolea tomentella Dum. Ann Arbor, South Haven, etc.

ANTHOCEROTES.

Anthocerotales.

Anthoceros laevis L. Ann Arbor, Chelsea, South Haven, New Richmond. Sparsely distributed throughout southern Michigan.

MUSCI.

Spagnales (omitted).

Andraeales (none).

Bryales.

(Acrocarpi)

Dicranaceæ.

Dicranella heteromalla Schimp. Throughout the state. On soil.

Dicranum flagellare Hedw. Throughout the state. On logs, often in dry situations.

Dicranum fuscescens Turn. Probably var. congestum Brid. Caseville. On wood. Legit. C. H. Coons.

Dicranum scoparium Hedw. Throughout the state. On rotten wood and soil.

Dicranum undulatum Ehrh. South Haven. On soil.

Pleuridium alternifolium Rabenh. Ann Arbor. Fields.

Ditrichum pallidum Hampe. South Haven. Sandy soil.

Ditrichum tortile Lindb. Throughout the state. On soil.

Leucobryaceæ.

Leucobryum glaucum Schimp. Throughout the state. On soil or rocks.

Fissidentaceæ.

Fissidens cristatus Wils. Mackinac I'd. On rocks.

Fissidens osmundoides Hedw. Throughout the state. On soil or base of trees.

Fissidens taxifolius Hedw. Coldwater. On clay banks. Coll. E. B. Mains.

Pottiaceæ.

Wissia viridula Hedw. Throughout the state. Fields and roadsides.

Barbula fallax Hedw. Vermillion, shore of Lake Superior. On sand dunes. Coll. A. H. W. Povah.

Barbula unguiculata Hedw. Ann Arbor. On soil; gravel, marl, etc.

Tortula subulata var. subinermis Schimp. South Haven, Holland. Sandy soil.

Orthotrichaceæ.

Orthotrichum Braunii Br. and Schimp. *O. strangulatum* Sull. Ann Arbor. On tree trunks.

Orthotrichum fallax Schimp. *O. Schimperi* Hamm. South Haven. On trunks of trees.

Orthotrichum obtusifolium Schrad. South Haven. With the preceding.

Orthotrichum ohiense Sull. and Lesq. Holland. On tree-trunks.

Ulota ulophylla Broth. *U. crispa* Brid. Alpena. On trunks of trees.

Ulota crispula Bruch. Throughout the state. On trunks of trees.

Funariaceæ.

Funaria hygrometrica Schreb. Throughout the state. Around ash-heaps, burnt ground, fields, roadsides, etc.

Physcomitrium trubinatum C. Müll. Throughout the state. Soil, in fields and gardens.

Bryaceæ.

Bryum argenteum. L. Throughout the state. On soil, everywhere.

Bryum caespititium L. Throughout the state. On soil, in fields, etc., or on thin soil of old wood, stone walls, tombstones, eaves of old houses, etc.

Bryum capillare L. South Haven. On river banks.

Bryum cuspidatum Schimp. South Haven. On soil.

Bryum intermedium Brid. Alpena and shore of Lake Superior.

Leptobryum pyriforme Wils. South Haven, Alpena and throughout the state. On soil.

Pohlia nutans Lindb. Detroit, Ann Arbor, Alpena, etc. On soil.

Rhodobryum roseum. Limpr. Throughout the state. On rotten logs and on soil.

Mniaceæ.

Mnium affine Bland. Mackinac I'd. On soil.

Mnium ciliare Lindb. *M. affine var. ciliare* C. Müll. Throughout the state. On soil in woods.

Mnium cuspidatum Leyss. Throughout the state. Everywhere, on lawns, roadsides, soil in woods, wet logs, etc.

Mnium marginatum Beauv. Ann Arbor, South Haven and northward. On moist hillsides and woods.

Mnium medium Br. and Schimp. Ann Arbor, South Haven and northward. On moist soil, banks of streams, etc.

Mnium orthorrhynchum Br. and Schimp. South Haven, Alpena. On clay banks, etc.

Mnium punctatum Hedw. Throughout the state. On rich swampy soil; var. elatum in similar localities.

Mnium rostratum Schrad. Throughout the state. On rocks or rich soil.

Aulocomniaceæ.

Aulocomnium heterostichum Br. and Schimp. Throughout the state. On moist banks, rocks, and around base of trees in the woods.

Aulocomnium palustre Schwaeg. Throughout the state. In bogs, swamps, and wet shaded soil.

Bartramiaceæ.

Bartramia pomiformis Hedw. South Haven, Ann Arbor. On rich wooded hillsides.

Philonotis fontana Brid. Throughout the state. On wet springy soil or rocks; on marly soil at Ypsilanti.

Timmiaceæ.

Timmia cucullata Michx. Ann Arbor, South Haven. Shaded banks.

Hedwigiaceæ.

Hedwigia albicans Lindb. Throughout the state. On rocks and boulders, often in dry woods.

Fontinalaceæ.

Fontinalis antipyretica L. Attached to stones and wood in flowing water. Ann Arbor, etc.

Leucodontaceæ.

Leucodon sciuroides Schwaeg. Holland. On tree-trunks.

Neckeraceæ.

Neckera pennata Hedw. South Haven and northward. On tree-trunks.

Entodontaceæ.

Entodon cladorrhizans C. Müll. *Cylindrothecium cladorrhizans Schimp.* Throughout the state. On rotten logs, earth and rocks.

Entodon seductrix C. Müll. *Cylindrothecium seductrix.* Throughout the state. On roots of trees, woods, earth, and rocks.

Platygyrium repens Br. and Schimp. Throughout the state. On trunks of trees, etc.

Pylaisia intricata Br. and Schimp. *B. velutina Schimp.* South Haven. On tree-trunks.

Pylaisia polyantha Br. and Schimp. South Haven. On logs.

Pylaisia Schimperi Card. Throughout the state. On tree-trunks.

Leskeaceæ.

Anomodon apiculatus Br. and Schimp. Holland. Base of tree-trunks and stumps.

Anomodon attenuatus Hüben. Throughout the state. On rocks, stumps, and base of trees.

Anomodon minor Fürn. *A. obtusifolius.* Br. and Schimp. Holland, Ann Arbor. On logs, tree-trunks, etc.

Anomodon rostratus Schimp. Throughout the state. On rocks and base of tree-trunks.

Haplocladium virginianum Broth. Caseville. On very rotten logs or soil.

Leskea obscura Hedw. South Haven. On inundated trunks along river.

Thelia asprella Sull. Ann Arbor. On stumps and base of tree-trunks.

Thuidium abietinum Br. and Schimp. Mackinac I'd. On the ground or rocks.

Thuidium delicatulum Br. and Schimp. Throughout the state. In moist woods, on the ground, logs or rocks.

Hypnaceæ. (Sense of Grout.)

Amblystegium compactum Aust. South Haven. On decaying wood.

Amblystegium juratzkanum Schimp. Alpena, Mackinac I'd. On wet stones or soil.

Amblystegium riparium Br. and Schimp. Throughout the state. On stones, earth, etc., in wet places. Var. longifolium B. & S. The variety from Caseville.

Amblystegium serpens. Br. and Schimp. Throughout the state. In wet places on stones, logs, soil, etc.

Amblystegium varium Lindb. *A. orthocladum* M. & K. *A radicale* B. & S. Throughout the state. In moist wood, on stones, logs, etc.

Brachythecium acuminatum Br. and Schimp. Throughout the state. On logs, tree-roots, etc.

Brachythecium acutum Sull. South Haven. On rotten logs in wet places.

Brachythecium oxycladon J. and S. Throughout the state. On the ground in woods.

Brachythecium plumosum. Br. and Schimp. Ann Arbor. In wet places.

Brachythecium rutabulum Br. and Schimp. Ann Arbor, South Haven. Also var. densum B. & S. On earth, rotting logs, stones, etc.

Brachythecium salebrosum Br. and Schimp. Throughout the state. On soil, roots, stones, etc.

Climacium americanum Brid. Throughout the state. In wet places, swamps and woods.

Climacium dendroides W. and M. South Haven. In wet swamps.

Drapnocladus aduncus Warnst. Alpena. In cedar swamps. var. graciliens. Holland.

Eurynchium hians J. and San. Ann Arbor. On ground, hillsides.

Eurynchium serrulatum Hedw. *Rhynchostegium serrulatum* J. and San. Holland and South Haven.

Eurynchium strigosum Br. and Schimp. Throughout the state. On lawns, roadsides, stones, logs, etc., in woods.

Hylocomium splendens Br. and Schimp. *H. proliferum*. Mackinac I'd., Bay View, Alpena, etc. On ground in woods.

Hylocomium triquetrum Br. and Schimp. Ann Arbor. On low ground.

Hypnum curvifolium Hedw. Southern Michigan. In wet places on logs, etc.

Hypnum crista-castrensis L. Throughout the state. On logs moist forests.

Hypnum cupressiforme L. Throughtout the state. On rotten logs, roots, etc. var. uncinatulum B. and S. South Haven.

Hypnum haldanianum Grev. Throughout the state. On moist logs.

Hypnum hispidulum Brid. Ann Arbor, Alpena. On stumps, logs, etc.

Hypnum imponens Hedw. Throughout the state. On soil, stones, logs, etc.

Hypnum pallescens Br. and Schimp. Mackinac I'd. On rocks and stumps.

Hypnum pratense Koch. South Haven. On soil and decayed wood.

Hypnum stellatum Schreb. South Haven. Rich hillsides.

Isopterygium turfaceum Lindb. South Haven. Rich hillsides.

Plagiothecium denticulatum Br. and Schimp. Throughout the state. On humous, stones, etc.

Plagiothecium striatellum Lindb. Throughout the state. On soil and logs in the woods.

Thamnium allegheniensis Br. and Schimp. *Porotrichum alleghen-iensis* Grout. Swamps and wet cliffs. Throughout the state.

Weberaceæ.

Webera sessilis Lindb. Mackinac I'd. On soil.

Buxbaumiaceæ.

Buxbaumia aphylla L. Battle Creek. On the ground in woods. Coll. T. L. Squiers. April.

Georgiaceæ.

Georgia pellucida Rabenh. Throughout the state. On decaying logs and stumps.

Polytrichaceæ.

Catherinea angustata Brid. Throughout the state. On the ground in open woods.

Catherinea undulata Web. and Mohr. Throughout the state. On the ground in open woods.

Polytrichum commune L. Throughout the state. In grassy fields, roadsides, and borders of woods.

Polytrichum juniperinum Willd. Throughout the state. Fields and hills or open woods.

Polytrichum ohiense Ren. and Card. Throughout the state. On the ground in woods or bordering swamps.

Polytrichum piliferum Schreb. Caseville, Vermillion. Not yet found in southern portion of state. Legit, Coons, Povah.

Cryptogamic Herbarium, University of Michigan,
Ann Arbor, 1915.

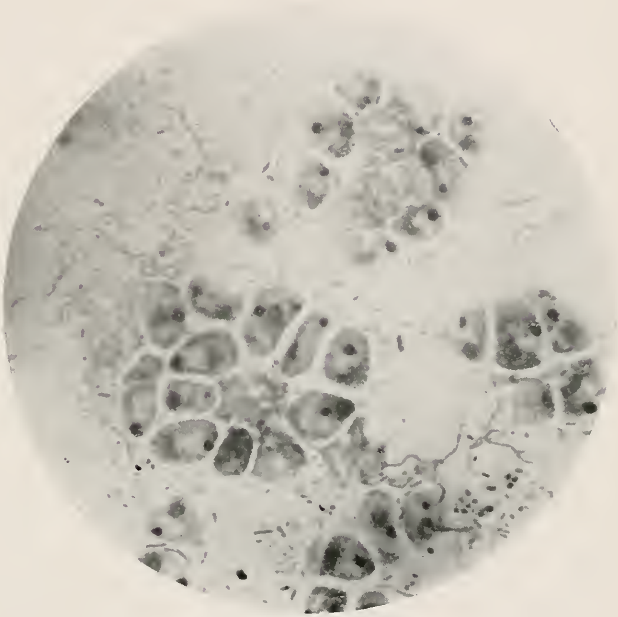
Plate I.

Iceberg Lake in August.

A. Ice rampart or "wall" formed by ice push on shore of Iceberg Lake.

B. Icebergs in Iceberg Lake.

Plate III.

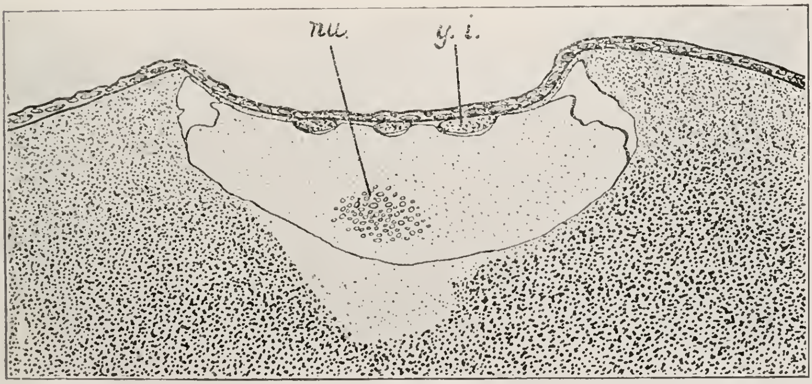


Protozoa from Decaying Manure. x 1200.

These are stained by the Romanowski method. The protoplasm is blue; the nucleus, the dark round body, is red; the food vacuole, the irregular body, filled with food, is of a dark blue. The surrounding organisms take the blue stain.

Nests built simultaneously by a single robin. One incomplete nest at the lower end of the series is not shown in the picture.

A. Living eggs of Cryptobranchus alleghenensis dissected from the ovary, and showing the germinal vesicle at the surface. Ovarian membranes containing blood-vessels wholly or partially cover the eggs. X 4.



B. Vertical section through the germinal vesicle of an egg in the stage shown in the preceding figure. X 60. nu., nucleoli; y. i., yolk islands.

Plate VI. An undescribed bark canker of apple. At left, typical canker on young limb, checked bark in place. In center, canker in which callus layers have met. At left, old canker with decorticated bark; Pycnidia may be seen on lower portion. In center, the knob-like swellings produced by aphis are evident.

Plate VI.

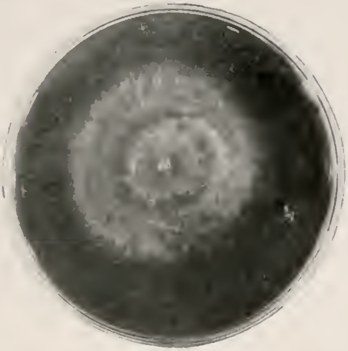
A. Potato plant affected with Leaf Roll. This plant was one of a row in which 90 per cent showed similar rolling of the leaves.

B. Cucumbers affected with White Pickle Disease. The larger warty ones show the early stage while the pale smooth pickles are the typical "White Pickles."

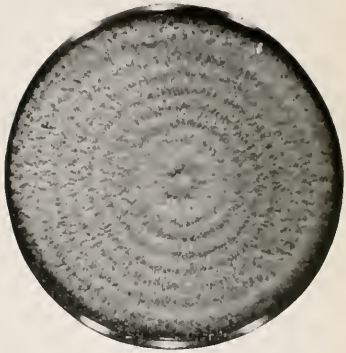
The Stunting Disease of celery. This plant which had been planted for more than a month showed a hollow heart. The growth is wholly from the lateral buds. The darkened root is the remnant of the old primary root.

Maple leaves showing effect of Anthracnose.

Horse-chestnut leaves affected by Phyllosticta paviae, Desm.



A

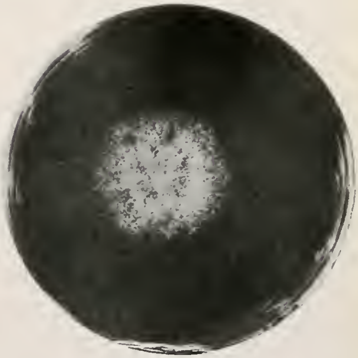


A.

B.

B.

C.



C.

Some cultural characteristics of Pestalozzia funera, Desm.

Plate XI. A. Growth on corn meal agar.
B. Growth on Duggar's synthetic agar and 1-20th per cent peptone.
C. Growth on Duggar's synthetic agar and one-half per cent peptone.

Plate XII. A. Growth on carrot agar.
B. Growth on dextrose agar.
C. Growth on beet gelatine.

Plate XIII. The Origin of the Anthophyta.

Figure 1. Scheme of evolution of orders of Anthophyta. (From C. E. Bessey, 1897.)

Figures 2, 3 and 4. Flowers and fruit of Magnolia. (2 and 3 from Baillon, 4 from Wettstein, all adapted from Lotsy.)

Figures 5 and 6. Flowers of Ranunculus. (From Baillon.)

Figures 7 to 11. Plant, flower and fruit of Alisma (from Baillon).

Figure 12. Plant of Williamsonia angustifolia (After Nathorst, from Coulter and Chamberlain.)

Figure 13. "Flower" of Cycadoidea (From Wieland.)

Plate XIII.

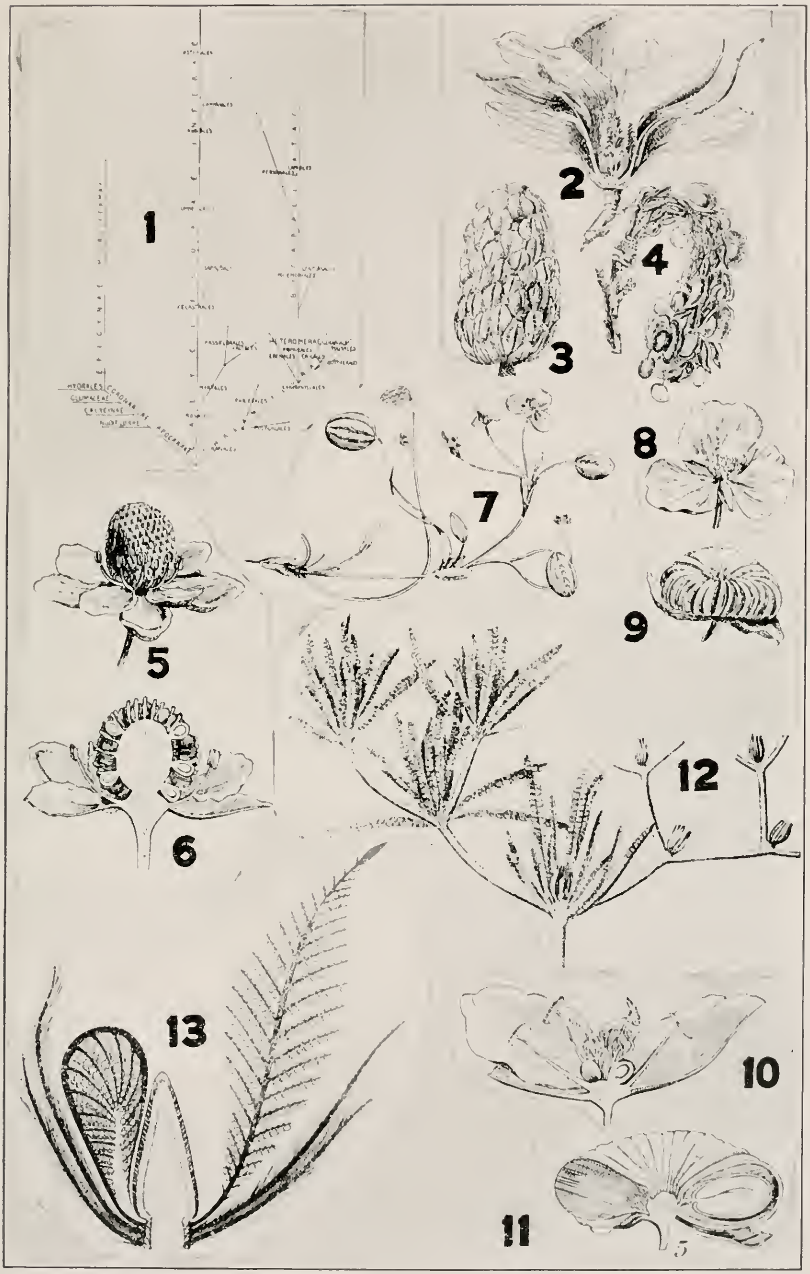


Plate XIV. The Origin of the Anthophyta.

Figure 14. Seed of Bennettites. (After Solms-Laubach from Coulter and Chamberlain.)
Figure 15. Part of leaf of Sphenopteris. (After Stur, from Coulter and Chamberlain.)
Figure 16. Part of leaf of Pecopteris, bearing seeds. (After Grand 'Eury from Coulter and Chamberlain.)
Figure 17. Hypothetical gymnospermous flower of early ancestor of Anthophyta. (From Arber and Parkin.)
Figure 18. Hypothetical angiospermous flower of somewhat later step in evolution of Anthophyta. (From Arber and Parkin.)

Plate XIV.

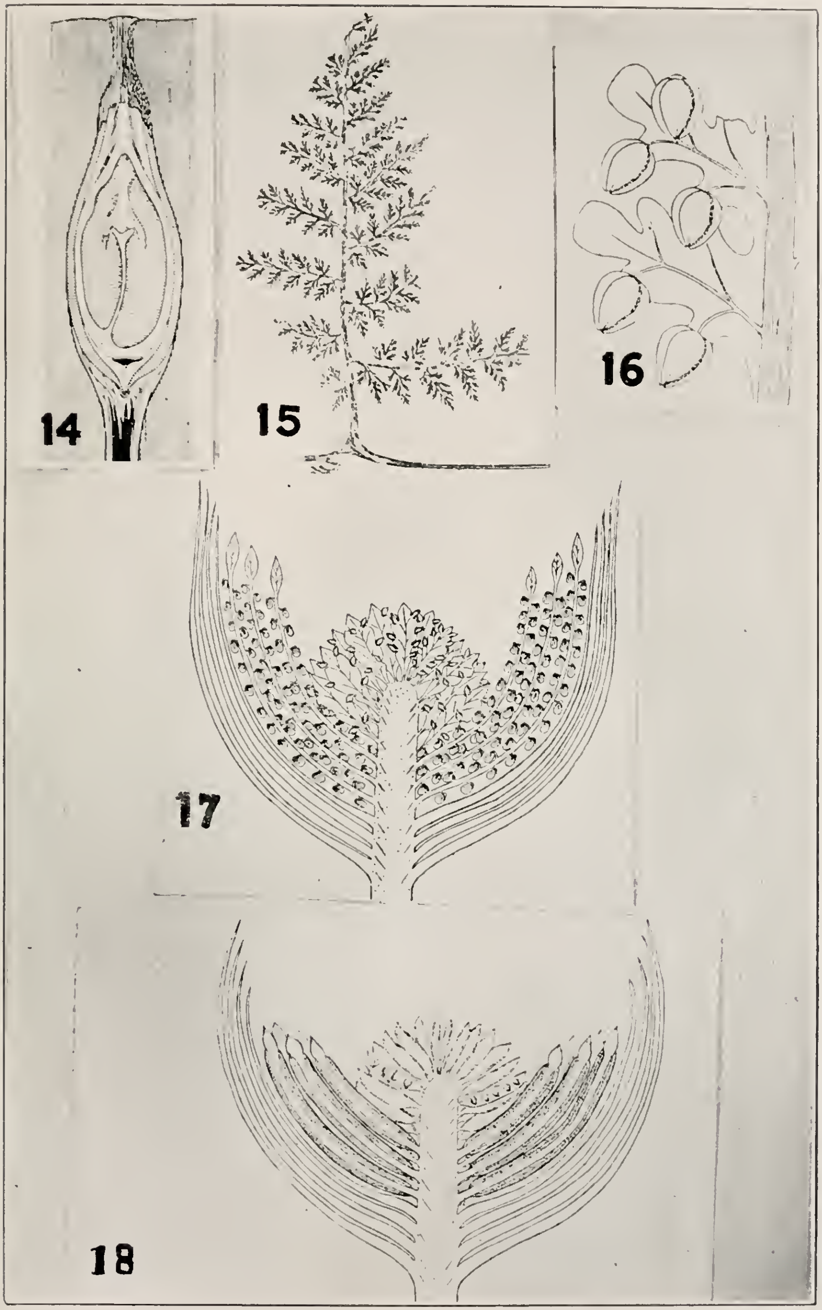
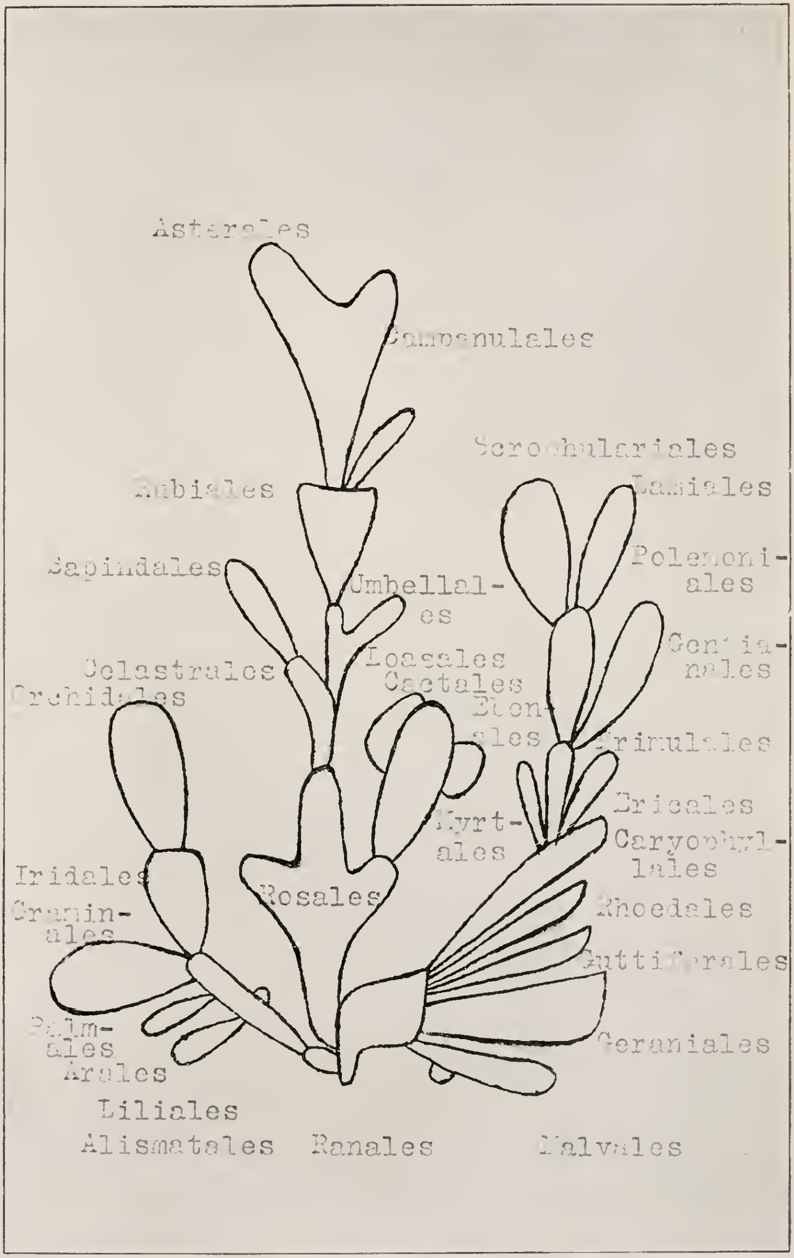


Plate XV.



Diagrammatic scheme of evolution within the Anthophyta. The area of each order is proportional to the known number of species in that order. From C. E. Bessey, Essentials of College Botany, 1914.

Plate XVI. Cunninghamella elegans, Lendner.

Figures 1 and 2. Successive stages in the development of the lateral sporiferous head; obj. 4mm., oc. 10x.

Figure 3. Mature terminal sporiferous head from which the spores have fallen; obj. 4mm., oc. 10x.

Figure 4. Spores; obj. 4mm., oc. 10x.

Figure 6. Upper part of conidiophore; obj. 16mm., oc. 10x.

Figure 7. Detail of conidiophore (one lateral branch of whorl omitted from drawing); obj. 4mm., oc. 10x.

Plate XVI.

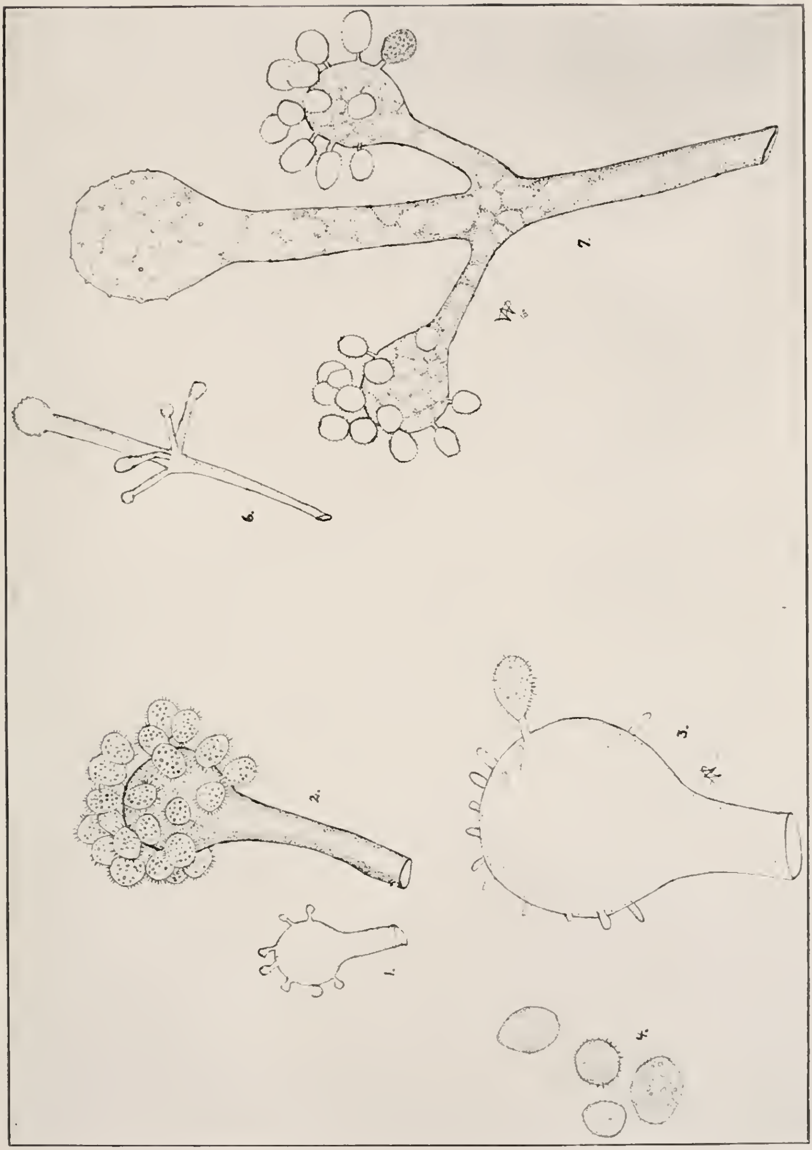


Plate XVII. Helicostylum piriforme Bainier.

Figure 8. Lateral cluster of sporangioles; obj. 8mm., oc. 10x.
Figure 9. Short lateral branch after the three sporangioles have fallen; obj. 8mm., oc. 10x.
Figure 10. Habit sketch; (free-hand drawing).
Figure 11. Single sporangiole; obj. 4mm., oc. 10x.
Figure 12. Median optical section through almost mature sporangium; obj. 16mm., oc. 10x.
Figure 13. Columella of sporangium; obj. 16mm., oc. 10x.
Figure 14. Terminal cluster of sporangioles; obj. 8mm., oc. 10x.
Figure 15. Spores; obj. 4mm., oc. 10x.
Figure 16. Upper part of sporangiophore with branches from which sporangioles have fallen; obj. 8mm., oc. 10x.

The drawings were outlined with the aid of a camera lucida with the combination of Bausch and Lomb lenses noted and reduced about one-half in reproduction.

Plate XVII.