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OF THE

Elisha Mitchell Scientific Society

VOLUME XXXVI
1920-1921

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PLATE 1

AZALEA ATLANTICA. (left)
AZALEA ATLANTICA VAR. LUTEO-ALBA. (right)
½ Natural Size

JOURNAL

OF THE

Elisha Mitchell Scientific Society

Volume XXXVI SEPTEMBER, 1920 Nos. 1 and 2

PROCEEDINGS OF THE ELISHA MITCHELL SCIENTIFIC SOCIETY, DECEMBER, 1916, TO MARCH, 1920.

225TH MEETING—DECEMBER 12, 1916

A. H. PATTERSON—*Shrapnel in the Making.*
J. M. BELL—*Some Recent Work in Crystal Structure.*

226TH MEETING—FEBRUARY 20, 1917

H. H. WILLIAMS—*The Logic of Science.*
COLLIER COBB—*Recent Changes in Currituck Sound* (Illustrated).

227TH MEETING—MARCH 13, 1917

H. R. TOTTEN—*Growing Mushrooms in Pure Culture.*
J. S. HOLMES—*Some Notes on the Occurrence of Landslides.*

BUSINESS MEETING—SEPTEMBER 26, 1917

ELECTION OF OFFICERS:

President—J. G. Beard.
Vice-President—J. M. Bell.
Permanent Secretary—F. P. Venable.
Recording Secretary—W. W. Rankin, Jr.
Editorial Committee—W. C. Coker, chairman; Collier Cobb, M. H. Stacy.

228TH MEETING—OCTOBER 9, 1917

P. H. DAGGETT—*Modern Tendencies in Engineering Education.*
F. P. VENABLE—*The Luminosity of Insects—A Chemical Phenomenon.*

229TH MEETING—NOVEMBER 13, 1917

COLLIER COBB—*Cave Dwellings and their Relation to Geology.*

230TH MEETING—DECEMBER 11, 1917.

W. DEB. MACNIDER—*The Stability of the Acid-Base Equilibrium of the Blood in Animals of Different Ages.*

ARCHIBALD HENDERSON—*The Role of Pascal's Theorem in Modern Geometry.*

231ST MEETING—FEBRUARY 26, 1918

H. V. WILSON—*Contributions of French Scientists as Brought out at the San Francisco Exposition.*

H. W. CHASE—*Some Modern Tendencies in Psychological Thought.*

232D MEETING—MARCH 12, 1918

W. C. COKER—*Corn (Illustrated).*

A. S. WHEELER—*The Production of Toluol.*

233D MEETING—APRIL 9, 1918

J. W. LASLEY—*Some Everyday Problems.*

F. P. VENABLE—*Luminescence and Radioactivity of the Zircons.*

P. H. DAGGETT—*Demonstration of a New Telephone Signaling System.*

BUSINESS MEETING—OCTOBER, 1918

The old officers were re-elected for the year 1918-19, during which period the regular meetings were suspended.

234TH MEETING—APRIL 15, 1919

ARCHIBALD HENDERSON—*Some Points in Gunnery for Heavy Artillery.*

F. P. VENABLE—*The North Carolina Academy of Science.*

235TH MEETING—MAY 13, 1919

W. DEB. MACNIDER—*Influence of the Age of an Organism on Regeneration.*

A. S. WHEELER—*New Napthalene Dyes.*

J. M. BELL—*Investigations on the Nitrotoluenes.*

ELECTION OF OFFICERS:

President—W. C. Coker.

Vice-President—J. M. Bell.

Permanent Secretary—F. P. Venable.

Recording Secretary—A. W. Hobbs.

Editorial Committee—W. C. Coker, chairman; J. M. Bell, Collier Cobb.

236TH MEETING—NOVEMBER 11, 1919.

H. V. WILSON—*Some Crustacea of the North Carolina Coast.*

F. P. VENABLE and D. H. JACKSON—*Reactions of Hydrochloric and Hydrobromic Acids with Potassium Permanganate.*

237TH MEETING—DECEMBER 9, 1919

J. N. COUCH—*A New Species of Water Mold with Observations on Fertilization.*

T. F. HICKERSON—*A New Method For Laying Out Curves in Road Location.*

238TH MEETING—JANUARY 13, 1920.

J. J. WOLFE—*The Plankton of Chesapeake Bay.*

The speaker presented in brief form the results obtained in a plankton survey of these waters, made by the speaker in collaboration with Prof. Bert Cunningham, the object of which was to throw some light on the kind and abundance of organisms that may serve as fish food. The collections on which the work was based were made by the U. S. Bureau of Fisheries.

The details of collection and the methods employed in the study were explained at some length. Charts and tables compiled from the data gathered were presented and the conclusions drawn which may be summarized as follows:

1. The volume of matter suspended in the water bears little or no relation to the number of organisms present.

2. There is a gradual increase in volume with increasing depth due in part to detritus and in part to an increase in organisms.

3. There is a great variation in number of organisms in different parts of the Bay on the same day and at the same depths, the cause of which is not determined. Locations and temperature are ruled out as causes. The data, too meagre as yet, point to the tides as a possible explanation.

4. There are two crests during the year, April-May and September-October, due to a tremendous increase of individuals belonging to only one or two species rather than as might be expected to a general increase in all species represented.

5. There seems to be a definite relation between temperature and number of organisms, the optimum lying between 46° and 55° F.

6. There is a noteworthy absence of *Copepods* certainly due to some error in the method of collection.

7. Neither "count" nor "volume" gives an absolutely true indication of food available. These two in connection with "incineration" would probably give a more correct idea.

239TH MEETING—FEBRUARY 10, 1920

F. P. VENARLE—*The Chemistry of Zirconium.*

This paper will be published in full in this Journal in a later number.

W. F. PROUTY—*Notes on the Geology of a Portion of Clay County, Alabama.*

The fundamental or metamorphic rocks of Clay County, Alabama, have been generally considered of Precambrian age. There is nothing published concerning the age of the associated intrusives. Dr. Smith, of the University of Alabama, has demonstrated the Carboniferous age of a small area in the phyllites of western Clay County. The speaker has recently widely extended, in the phyllite belt, the area of known Carboniferous rocks and has demonstrated the post Carboniferous age of the belt of green schists which everywhere separate the phyllites on the west from the mica schists on the east.

The workable flake graphite ores or the mica schist belt are shown to be of epigenetic origin and the association of the ores with the more quartzitic and coarse-grained, originally sedimentary beds, leads to the conclusion that the graphitic ores resulted from the metamorphism of petroliferous strata.

240TH MEETING—MARCH 9, 1920

J. F. DASHIELL—*Double Habit Formation by Animals, Children, and Adults.*

The problem approached was that as to the relative efficiency of learning two habits by practicing them alternately (the Alternate

Method) or by getting one to some extent fixed before practicing the other (the Complete Method). Data were obtained by the study of the learning of mazes by rats, of mazes by children, and of mazes by adults; then the scope was extended to include the formation of another pair of perceptual-motor habits, card sorting, and further still to include a pair of habits involving very little of the motor element, addition.

The particular technique of the different experiments was intentionally varied considerably: (a) in temporal distribution of trials; (b) in stage at which shift was made from one to the other habit by the Complete Method; (c) in arrangement of controls—division of subject into groups; (d) in methods of scoring; (e) in incentives used, (f) in subjects' previous familiarity with the habits to be learned; (g) in their knowledge of the number and order of the habits to be learned; (h) in their knowledge of the nature of the problem investigated. Thus, the general results found may be considered as independent of particular details of technique and to be of general bearing.

For results, it was found that in all the forms of double habit formation studied, learning by the Complete Method was more economical than learning by the Alternate Method. This was indicated in the different sets of experiments in terms of the different criteria of efficiency respectively applicable. They included: (a) number of trials necessary to fix a habit; (b) degree of regularity in improvement; (c) average amounts of scores on individual trials; (d) rate of acceleration of improvement.

The complete paper will appear in an early number of *The Psychological Review.*

J. B. BULLITT—*Report on Autopsies on 25 Cases of Influenza Pneumonia.*

Extensive cutaneous emphysema was encountered in one case. Firm, fibrous pleural adhesions existed in six cases, in four of which the lungs showed old scars of apparently healed tuberculosis while one showed fibrinous exudate on the pleura, four of these exudates being thick and shaggy. In three of these there was serous effusion; in two, purulent effusion. All cases exhibited the lobular type of pneumonia. In seven there was also distinct lobar consolidation, the lobular process in these being but slightly evident. Numerous bronchiectatic abscesses occurred in four cases, while in four others (three of them associated with labor consolidation) there was massive

necrosis involving the whole or the greater part of a lobe. Meningitis existed in five cases—two due to the meningococcus, one to the meningococcus and pneumococcus together, while in two the organism was not discovered. In all cases of more than one week duration more or less extensive organization has occurred. Two men who lived about five weeks died suddenly during apparent convalescence. The lungs showed little evidence of active inflammation, but organization has obliterated the greater part of the pulmonary tissue. These seem analogous to those cases of nephritis in which the repair process strangles the glomeruli and kills a patient who may have survived the original toxemia.

PROCEEDINGS OF THE NINETEENTH MEETING OF THE NORTH CAROLINA ACADEMY OF SCIENCE, HELD AT STATE COLLEGE, WEST RALEIGH, N. C., APRIL 30-MAY 1, 1920.

The executive committee met in the offices of Prof. Z. P. Metcalf April 30, at 12:00 M., with the following members present: President A. H. Patterson, Secretary R. W. Leiby and member Z. P. Metcalf. The secretary made a preliminary report on finances, membership, etc., following which the policies of the Academy and other questions were discussed. A total of 28 new members were elected as follows:

Josiah S. Babb, Asst. in Geology, U. N. C., Chapel Hill.

Dr. H. P. Barret, Physician, Charlotte.

Wm. Hande Browne, Prof. Elec. Engr., State College, West Raleigh.

Dr. J. B. Bullitt, Prof. Path., U. N. C., Chapel Hill.

J. N. Couch, Asst. in Botany, U. N. C., Chapel Hill.

Dr. J. B. Derieux, Dept. Physics, State College, W. Raleigh.

A. A. Dixon, Dept. Physics, State College, W. Raleigh.

Paul Gross, Ph. D., Chemist, Trinity College, Durham.

Miss Pattie J. Groves, Instr. Science, Durham High School, Durham.

V. R. Haber, Asst. Investigations, Ent., State Dept. Agr., Raleigh.

Dr. J. O. Halverson, Expert Animal Nutrition, State Dept. Agr., Raleigh.

C. M. Heck, Dept. Physics, State College, W. Raleigh.

Miss Alma Holland, Asst. in Botany, U. N. C., Chapel Hill.

J. E. Ivey, Poultry Path., State College, W. Raleigh.

S. G. Lehman, Asst. Plant Path., State College, W. Raleigh.

A. L. Lugn, Prof. Physics and Chemistry, Lenoir College, Hickory.

Dr. Wm. F. Prouty, Stratigraphic Geol., U. N. C., Chapel Hill.

R. F. Revson, Chemist, 210 S. Tryon St., Charlotte.

G. H. Satterfield, Trinity College, Durham.

Prof. M. E. Sherwin, Prof. Soils, State College, W. Raleigh.

I. V. Shunk, Asst. Prof. Botany, State College, W. Raleigh.

M. R. Smith, Extension Ent., State Dept. Agr., Raleigh.

Ira W. Smithey, U. N. C., Chapel Hill.

HAYWOOD M. TAYLOR, U. N. C., Chapel Hill.

DR. WALTER F. TAYLOR, Asso. Prof. Bacter. and Hygiene, W. F. C., Wake Forest.

DR. B. W. WELLS, Prof. Botany, State College, W. Raleigh.

C. B. WILLIAMS, Dean, State College, W. Raleigh.

J. H. WILLIAMS, Instr. Zool. & Ent., State College, W. Raleigh.

The executive committee then adjourned.

At 2:15 P. M. the first session of the annual meeting was called to order by Pres. A. H. Patterson, who made some remarks chiefly concerning the time allowance for presentation of papers. The following committees were then appointed: Auditing—C. S. Brimley, T. F. Hickerson, F. A. Wolf; Nominations—J. J. Wolfe, W. C. Coker, W. A. Withers; Resolutions—C. W. Edwards, H. B. Arbuckle, Miss Mary Petty.

Papers were then called for, the reading and discussion of which was carried on until 5:00 P.M. when the session was adjourned.

The Academy reconvened at 8:15 P. M. to listen to the Presidential address by A. H. Patterson on "The Einstein Theory of Relativity." Previous to the presidential address, the Academy was formally welcomed by Dr. W. C. Riddick, President of the College, the response being made by Professor Patterson.

The Academy was again called to order on Saturday morning at nine o'clock for a business session. The Secretary read the minutes of the previous meeting, which were approved. The Treasurer's report was read and referred to the Auditing Committee. The matter of increasing dues was discussed. Professor Metcalf presented the proposition of the Academy affiliating with the American Association for the Advancement of Science. This was freely discussed and referred by motion to the Executive Committee with power to act. The question of securing State support for the Academy in the sum of $500.00 to $1,000.00 was discussed and motion was adopted to refer to Executive Committee to look into matter and if found practicable to authorize the President to appoint a committee to present the matter to the next Legislature. The committee on Science Instruction in the High Schools as related to the College, was continued with one change in personnel, the substitution of Mr. Bert Cunningham for Dr. J. J. Wolfe. Motion was then adopted, following pro and con discussion, that the Secretary be allowed ten per cent of all moneys collected by him for the Academy, effective next year.

Motion adopted that we accept the invitation of Wake Forest College to meet there next year.

The nominating committee then made its report as follows:

President—Z. P. Metcalf, W. Raleigh.

Vice-President—J. M. Bell, Chapel Hill.

Secretary-Treasurer—R. W. Leiby, Raleigh.

Additional members Executive Committee: H. R. Totten, R. N. Wilson, F. A. Wolfe.

Report was adopted and Secretary authorized to cast the ballot.

Motion was then adopted that the following telegram be sent past President and Secretary, E. W. Gudger:

"The North Carolina Academy of Science in annual session assembled, deeply appreciating the splendid constructive service which you rendered her through so many years, sends you greeting and begs that you accept her thanks for this most devoted service which we well know was a labor of love, and sincerely hopes that events may so shape themselves that you may at an early date again actively share in her work and achievement."

Following the business session the presentation of papers was continued before the joint session of the Academy and Chemists until 12:30.

At 1:30 the Academy reconvened for the further presentation of papers. During this session the report of the Auditing Committee was adopted which found the books correct and suggested the payment of the nominal sum of $5.00 to the Secretary's stenographer for clerical work. The report of the Resolutions Committee was then read and adopted as follows:

Resolved, That we, the members of the North Carolina Academy of Science, sorrow because of the demise of our member and fellow worker, Mrs. Fannie Carr Bivins, head of the Science Department of the Durham City Schools, and express our recognition of her unselfish and enthusiastic work as student and teacher which made her life such a notable contribution to the advancement of science in her community.

That we express our hearty appreciation of the kindness, courtesy, and cooperation of the President and Faculty of the N. C. State College of Agriculture and Engineering on the occasion of the nineteenth annual meeting of the Academy and especially of the generous and hospitable manner in which we have individually been entertained.

Following the completion of the program the Academy adjourned *sine die* at 3:15 P. M.

REPORT OF TREASURER, July 1, 1919-April 28, 1920

RECEIPTS		EXPENDITURES	
From former treasurer	$ 128.67	Rubber stamp	$ 1.00
Dues (back)	5.00	Postage and envelopes	13.72
Dues (current)	56.00	Stationery	5.25
Dues (advanced)	16.00	Multigraph letters (3)	3.00
Initiation fees	28.00	Printing programs	16.50
Savings acct. Int.	3.32	Incidentals	1.20
Total receipts	$ 236.99		$ 40.67
Total expenditures	40.67		
	$ 196.32		

Balance April 28, 1920 ..... $ 196.32

Balance May 31, 1920 (all bills paid) ..... $ 156.09

Following is present membership of the Academy. Those marked with asterisk were in attendance at meeting:

Andrews, W. H. ..... Chapel Hill
*Arbuckle, H. B. ..... Davidson
Babb, Josiah S. ..... Chapel Hill
Bahnson, F. F. ..... Winston-Salem
Balderston, Mark ..... Guilford College
Barret, H. P. ..... Charlotte
Beardslee, H. C. ..... Asheville
*Bell, J. M. ..... Chapel Hill
Binford, Raymond ..... Guilford College
Bonney, Miss F. C. ..... Hartsville, S. C.
Bottum, Miss F. R. ..... Raleigh
Brewer, C. E. ..... Raleigh
*Brimley, C. S. ..... Raleigh
Brimley, H. H. ..... Raleigh
*Browne, Wm. Hande ..... W. Raleigh
Bruner, S. C. ..... Santiago de las Vesgas, Cuba
Bullitt, J. B. ..... Chapel Hill
Bynum, J. C. ..... Chapel Hill
Cain, Wm. ..... Chapel Hill
Clapp, S. C. ..... Swannanoa
*Cobb, Collier ..... Chapel Hill
Cobb, Wm. B. ..... Columbia
*Coker, W. C. ..... Chapel Hill
Collett, R. W. ..... Willard
Coman, J. H. ..... Durham
*Couch, J. N. ..... Chapel Hill

Cunningham, Bert ..... Madison, Wis.
Davis, H. T. ..... Chapel Hill
*Derieux, J. B. ..... W. Raleigh
*Dixon, A. A. ..... W. Raleigh
Dixon, L. F. ..... Weaverville
Dobbins, C. N. ..... Chapel Hill
Downing, J. S. ..... Elsmere, Del.
*Edwards, C. W. ..... Durham
Edgerton, F. N., Jr. ..... Athens, Ga.
Farmer, C. M. ..... Troy, Ala.
*Gross, Paul ..... Durham, N. C.
*Groves, Miss Pattie J. ..... Durham
Gudger, E. W. ..... Greensboro
*Haber, V. R. ..... Raleigh
*Halverson, J. O. ..... Raleigh
Hatley, C. C. ..... Durham
*Heck, C. M. ..... West Raleigh
Henderson, Archibald ..... Chapel Hill
Hewlett, C. W. ..... Greensboro
*Hickerson, T. F. ..... Chapel Hill
Hobbs, A. W. ..... Chapel Hill
Hoffman, S. W. ..... Statesville
*Holland, Miss Alma ..... Chapel Hill
Holmes, J. S. ..... Chapel Hill
Ives, J. D. ..... Charleston, S. C.
*Ivey, J. E. ..... West Raleigh
Johnson, E. D. ..... Asheville
*Kilgore, B. W. ..... Raleigh
*Krausz, H. B. ..... Raleigh
Lake, J. L. ..... Wake Forest
Lanneau, J. F. ..... Wake Forest
*Lehman, S. G. ..... West Raleigh
*Leiby, R. W. ..... Raleigh
Lewis, R. H. ..... Raleigh
Lugn, A. L. ..... Hickory
Lyon, Miss Mary ..... Red Springs
*Marion, S. J. ..... Raleigh
Markham, Blackwell ..... Chapel Hill
Mendenhall, Miss Gertrude W. ..... Greensboro
*Metcalf, Z. P. ..... West Raleigh
Nowell, J. W. ..... Wake Forest
*Patterson, A. H. ..... Chapel Hill
*Pegram, W. H. ..... Durham
Petty, Miss Mary ..... Greensboro
*Pillsbury, J. P. ..... West Raleigh
*Plummer, J. K. ..... Raleigh
Poteat, W. L. ..... Wake Forest

Pratt, J. H. .....Chapel Hill
*Prouty, Wm. F. .....Chapel Hill
Randolph, E. O. .....College Station, Texas
Randolph, Mrs. E. O. .....College Station, Texas
Rankin, W. S. .....Raleigh
*Revson, R. F. .....Charlotte
*Rhodes, L. B. .....Raleigh
*Riddick, W. C. .....West Raleigh
*Robinson, Miss Mary .....Greensboro
*Satterfield, G. H. .....West Raleigh
*Saville, Thorndyke .....Chapel Hill
Seymore, Miss Mary F. .....Greensboro
Shaffer, Miss Blanch E. .....Greensboro
*Sherman, Franklin .....Raleigh
Sherrill, Miss Mary L. .....Greensboro
*Sherwin, M. E. .....West Raleigh
*Shore, C. A. .....Raleigh
*Shunk, I. V. .....West Raleigh
Smith, J. E. .....Ames, Iowa
*Smith, M. R. .....Tallulah, La.
Smithey, Ira W. .....Chapel Hill
*Spencer, Herbert .....West Raleigh
Stiles, C. W. .....Wilmington
Taylor, Haywood M. .....Chapel Hill
Taylor, Walter F. .....Wake Forest
*Totten, H. R. .....Chapel Hill
Vann, Miss Fannie E. .....Durham
Venable, F. P. .....Chapel Hill
*Wells, B. W. .....West Raleigh
*Wheeler, A. S. .....Chapel Hill
*Williams, C. B. .....West Raleigh
*Williams, J. H. .....West Raleigh
*Williams, L. F. .....West Raleigh
*Wilson, H. V. .....Chapel Hill
*Wilson, R. N. .....Durham
*Winters, R. Y. .....West Raleigh
*Withers, W. A. .....West Raleigh
*Wolf, F. A. .....West Raleigh
*Wolfe, J. J. .....Durham, N. C.

Total membership, 113.

The following papers were presented at the meeting:

The Einstein Theory of Relativity. A. H. PATTERSON. (Presidential address).

Appears in full in this issue.

A New Method for Laying out Circular Curves. T. F. HICKERSON.

Appears in full in this issue as a new method for laying out circular curves by deflections from the P. I.

A Remarkable Form of Skeletal Element in the Lithistid Sponges (A Case of Analogical Resemblance. H. V. WILSON.

Appears in full in this issue.

Animal Locomotion. H. H. BRIMLEY.

This paper treats of the means used in moving from place to place by the fishes, amphibians, reptiles, birds and mammals. The species in each class are artificially grouped according to their main locomotion characteristics.

Together with what may be called their normal methods of progression, the paper treats of fish that can walk and mammals that cannot; of mammals that can fly and birds without such powers; of reptiles that possess the power of volplaning through the air; of fish that travel while lying on the side; of mammals that use three or five members in their movements; of others that spend their lives upside down; of fish that possess the power of movement through the air; of birds that swim and dive while young and lose such powers on becoming adult; of mammals possessing exceptional locomotive powers both on land and in the water, and of birds that walk, fly, swim, dive and climb.

Single Spore Cultures of Coprinus radiatus. H. R. TOTTEN.

Reports the growth to maturity of *Coprinus radiatus* Fr. from a single spore. Mycelia from a spore germinated in broth of horse manure, and transferred to the following media, formed mature plants: Horse manure, cow manure, horse manure agar, corn meal agar, and peas. A review was given of Mlle. Bensaude's thesis on "Sexualité chez les Basidomycete," Paris, 1918, in which she proves that *Coprinus fimetarius* is a dioecious fungus. *Coprinus radiatus* was compared with *Coprinus fimetarius* and was shown to be monoecious. The hyphae of *Coprinus radiatus* also lacks the *clamped connections* so commonly seen on hyphae and always seen on the hyphae of *Coprinus fimetarius* before the formation of mature plants.

Genera of Lower Basidiomycetes not Before Reported from North America. W. C. COKER.

Reports the occurrence in Chapel Hill of three Genera; all growing on wood as saprophytes, and forming small pustules or expanded, resupinate layers. They are as follows:

Saccoblastia Möller. A remarkable genus with elongated basidia divided across into four cells as in the rusts; and arising in a peculiar way from the tip of a pendant pear-shaped sac. Three species have been reported, two from South Brazil and one from Poland. Our plant is considered a variety of *S. ovispora* Möller from South Brazil.

Platygloea Schroeter. Two species were found on Crepe Myrtle, both of which seem new. About nine others have been described from Europe and the tropics. Our plants seem nearest *Helicogloea Lagerheimi* Pat. which is usually considered as not generically distinct from Platygloea. Our species have small, crowded basidia borne in corymbs and two-celled by a cross partition.

Sirobasidium Möller. In this genus the basidia are borne in *chains* and are divided into two cells by an oblique wall or into four cells by longitudinal walls. Three species have been described, all from South America (one from Brazil, two from Equador). Our plant agrees well with the one from Brazil, *S. Brefeldianum* Möller.

Attention was also called to the Genus *Septobasidium*, which is well represented in America, but in which the basidia have been misunderstood.

The Turtles of North Carolina. C. S. BRIMLEY.

Appears in full in this issue.

The Life History of a Gall-Making Psyllid (*Pachypsylla mamma* Riley). Lantern. DR. B. W. WELLS.

Oviposition on under side of young hackberry leaf. Nymph migrates to upper side of leaf where galls are initiated near the principal veins. Nymph grows very slowly at first while gall on the other hand grows very rapidly. Usually but one insertion of the mouthparts into the leaf tissue is made, the insect keeping its position for an extended period. The nymph escapes from the gall in the fall, the adults appearing immediately afterward. These overwinter in bark crevices or ground debris.

Dreams and their Causes. C. S. BRIMLEY.

Paper gives concisely the author's opinion as to the causes of dreams, and illustrates the same by examples from his own personal experiences.

A Little-Known Vetch Disease. FREDERICK A. WOLF.

Appears in full in this issue.

Notes on the Mosquito Fauna of North Carolina. FRANKLIN SHERMAN.

Appears in full in this issue.

The Larger Corn Stalk-Borer (*Diatrae zeacolella* Dyar). Lantern. R. W. LEIBY.

Brief references to life-history as determined over a period of 5 years in North Carolina. Discussion of control measures which included late planting of corn and destruction of overwintering larvae by plowing out corn stubble in fall.

An Interesting Fertilizer Problem. H. B. ARBUCKLE.

Appears in full in this issue.

A Phenomenal Shoot. DR. B. W. WELLS.

A shoot found by Mrs. B. W. Wells near Raleigh, N. C., which measures 19 feet, 5 inches in length, was exhibited. It had grown from the stump of a beheaded tree of *Paulownia tomentosa* during the season of 1919. The base is 7.75 inches in circumference 2.50 inches diameter. The shoot possessed 20 internodes, the longest of which measures 19 inches.

A Peculiar Mycorhiza-forming Rhipzopogon on the Roots of Pine. H. R. TOTTEN.

Specimens of a species of Rhizopogon were shown on the roots of *Pinus Taeda* and *Pinus echinata.* This fungus attacks the young rootlets, forming a mycorhizal covering about each rootlet in a cluster. The fungal coats of several rootlets soon coalesce into a light creamy

mass of various forms and sizes. The fungus attacks the pine tissue, completely destroys the mass of enclosed rootlets, and remains lightly attached to the root. Many irregular cavities lined with basidia and spores are formed. The interior becomes a dark jelly mass, and the tougher coat later also breaks down.

Effect of Fertilizers on Germination and Seedling Growth of Corn and Cotton. M. E. SHERWIN.

This paper shows the effect of fertilizers on time required for germination and on rate of seedling growth of corn and cotton grown in galvanized pans 3½ inches each way. These results are in part in confirmation of field observations.

Heavy applications of soluble mineral fertilizers cause the greater delay in germination. Organic fertilizers cause the greater injury to the seedlings. Where germination seems to be poor as determined by the per cent of seeds which have "come up" the trouble will usually be found to be due to root injury where organic fertilizers are used and to inability of the seed to absorb sufficient water where mineral fertilizers are used.

To obviate the difficulty in germination and the root injury from organic fertilizers no fungicidal treatment has availed. Injury is less severe when the fertilizer is well mixed with the soil but to wholly obviate these troubles the fertilizer should be applied to the soil a week in advance of planting the seed. The injury appears to be much less in soil containing abundance of acid organic matter than in ordinary sand clay soils. The injury appears worse at high temperatures than at low temperatures.

The viability of the seed does not seem to have been impaired by contact with the soil solution containing sufficient nitrate of soda to prevent germination in two weeks' time.

Increasing the quantity of nitrate of soda has the same effect on rate of germination as decreasing the amount of soil moisture.

Borax, either alone or in trona-potash, is decidedly harmful to germination. Very small amounts of borax cause almost complete chlorosis of corn seedlings.

Some Investigations on the Compounds Isolated from the Polypores. JOSEPH T. MADDOX and RAYMOND BINFORD.

There has been little or no investigation done on the chemical analysis and isolation of the various compounds present and obtainable from any Polyporus. An investigation was made this past winter towards isolating under various conditions as many compounds as possible. Some eleven different compounds were obtained, which, owing to the lack of proper laboratory equipment, are as yet unidentified. This paper is only intended to give an account of the methods used and a study of the physical properties of each compound isolated.

New Ethers. A. S. WHEELER and S. C. SMITH.

A new group of ethers has been derived from chloral. The addition product obtained by the action of one mole of chloral upon one mole of m-nitroaniline is boiled with an alcohol. A molecule of water splits off and an ether of strong crystallizing power is obtained. These ethers are sensitive to acids but stable towards alkalies. The reaction with p-nitroaniline is best carried out by first making the chloral alcoholate and then treating this with the amine. The series of ethers under preparation include the three nitroanilines and methyl, ethyl, n-propyl, n-butyl and isoamyl alcohols.

p-Cymene, A New Solvent. A. S. WHEELER.

p-Cymene is now produced on a much larger scale than formerly since it is so easily obtained from spruce turpentine. It becomes, therefore, a useful solvent for high temperatures, its boiling point being 176.5°. It is a colorless hydrocarbon of the benzene series and is to be preferred where possible to such colored solvents as aniline and nitrobenzene and ill-smelling ones as pyridin. The solubility of a number of compounds of a wide range of types has been determined.

A Color Reaction for p-Cymene. A. S. WHEELER.

In p-cymene obtained from spruce turpentine are one or more impurities which give a color reaction with p-anisidine. The solid p-anisidine may be used or a solution in pure cymene. In samples where the cymene is still yellowish the coloration is very pronounced and is really not needed. The immediate coloration is pale yellow, deep yellow, brown or red depending on the degree of impurity.

Further in all cases the color deepens very noticeably in succeeding hours. If no coloration occurs in the diffused light of the laboratory within two hours the cymene is pure.

The following papers were read but no copies or abstracts furnished:

Some Biological Aspects of the Tidal Zone Region of the North Carolina Coast. Z. P. METCALF.

Recent Growth and Depletion of Sea-beaches on the North Carolina Coast. COLLIER COBB.

Electro-endosmosis of Clays. THORNDYKE SAVILLE.

Effect of Borax on Plant Growth and Notes on a Method for its Quantitative Determination in Fertilizers. OSCAR J. THEIS, JR., and H. B. ARBUCKLE.

Dyestuff Situation in the United States. R. F. REVSON.

Agricultural Geology (Read by title). JOHN E. SMITH.

The Wing Venation of the Heteroptera. HERBERT SPENCER.

Vitamines—A Review. W. A. WITHERS.

Further Studies on the Melting Points of the Nitrotoluenes. J. M. BELL.

A List of the Cicadellidae Taken at Swannanoa, North Carolina. Z. P. METCALF and HERBERT OSBORN.

The Conductivity of Nonaqueous Solutions. PAUL GROSS.

Behind the Barrier Beaches from Boston to Beaufort. COLLIER COBB.

Some New Types of Distillation Apparatus. PAUL GROSS.

R. W. LEIBY, *Secretary.*

THE THEORY OF RELATIVITY*

By Andrew H. Patterson

The idea of Relativity is not new. It was presented by the old philosophers, and has been a constant part of philosophical doctrine to this day. All of our knowledge is relative. Especially is this true of our knowledge of time and space. We know time only at a certain place; we observe the position of a point only at a certain time. To say that an observation or measurement was made at a given time is useless and meaningless until we have stated the place,—Greenwich or Washington or Tokio,—to which the time is referred. Places of stars in the Nautical Almanac are given only for the epoch, or time, stated at the head of the page, and corrections must be applied for later dates. It is quite true to say that we do not know the exact place of a star unless we know the exact time. Important dates in Assyrian history have been fixed because of the record of a total eclipse of the sun which was seen in the streets of the city of Nineveh at half-past nine on a certain morning of a certain month of a certain year in the reign of Jeroboam the Second. By calculating when this eclipse must have occurred at that particular place at that time of the morning, we at once link up the Assyrian era to our own, and can translate their time into ours. Time without position in space has no more independent existence than the direction "vertically upwards", for example, which changes with every point on the earth's surface.

But to fix the place of a point we need a system of axes to which we can refer its position by means of co-ordinates. The latitude and longitude of a ship are the two co-ordinates which fix its position on the surface of the ocean. If the point is to be fixed in *space,* three co-ordinates are needed, and if we can conceive of a four-dimensional space, four co-ordinates will be necessary to specify the position of any point therein.

It is immaterial whether we choose rectangular axes, or oblique axes, or whether we use polar co-ordinates or some other system, provided that the position of the point arrived at by any system is the same. Again, we can transform the co-ordinates of a point in one system of axes into its co-ordinates in another system of axes by appropriate mathematical operations, and since a line is a series of points,

* Presidential Address, delivered before the North Carolina Academy of Science, at the North Carolina State College of Agriculture and Engineering, Raleigh, April 30, 1920.

we can also transform the equation of a line with reference to one set of axes into another equation representing the same line referred to another set of axes. The only criterion for the validity of such a transformation is that the length, curvature and position of the line as given by the two equations, each referred to its own set of axes, shall be the same. And this point is to be emphasized: while we may not be able to conceive of a four-dimensional space, the mathematicians find no difficulty in getting the appropriate equations referred to four rectangular axes, and of course containing four co-ordinates, and these equations are as mathematically true and consistent as though we habitually used four dimensions in ordinary life.

But in using a set of axes, they must either be fixed, or else their position and motion must in turn be referred to some so-called "frame of reference" that *is* fixed, and the attempt to find such a frame of reference led to the modern theory of Relativity. Of course the earliest use of co-ordinate systems was in connection with Astronomy, and the first frame of reference was the supposedly fixed Earth, which Ptolemy, the Alexandrian astronomer who lived in the second century A. D., believed to be the center of a universe of planets and stars which revolved about it, and he referred their positions and motions to the stationary earth as his frame of reference. It is true that four hundred years earlier Aristotle and Aristarchus pointed out that by the laws of relative motion the movements of the celestial bodies could be equally well explained by a stationary sphere of stars and a revolving earth, but the learned men of the succeeding centuries followed Ptolemy, and it was not until the middle of the sixteenth century that Copernicus put forth again the theory that the starry sky, or "eighth sphere", should be considered at rest, and the sun also as its motionless center, while to this fixed frame of reference should be referred the motions of planets, comets, earth and moon. But since this transformation of axes—this change in the frame of reference—involved the demotion of the earth from its former proud position of center of the universe to a modest place among the minor planets, Copernicus' theory was bitterly opposed by theologians, both Protestant and Roman, on the idea that the new order involved great danger to the teachings of the church. Martin Luther denounced Copernicus roundly as an "upstart astrologer" who showed a lack of "public decency" in maintaining that neither the sun nor the "eighth sphere" revolved about the earth. But the new theory had come to stay, for it explained

clearly and simply the cause of the loops in the paths of the planets, the phases of Venus and the Moon, and the motions of planets, satellites and comets.

It led very soon to the discovery of Kepler's laws and the epoch-making work of Newton, including the development of the Newtonian mechanics and the differential and integral calculus. Two hundred years after Copernicus, Herschel again upset our frame of reference, for he showed that the whole Solar System is moving through space with a velocity of something like fifteen miles a second in the approximate direction of the star Vega, and that in addition the "fixed stars" are anything but fixed. All of them seem to be travelling in different directions through space with enormous velocities. One of them, indeed, No. 1830 in Groombridge's catalogue, has such a large proper motion that it is called the "runaway star."

So our fixed frame of reference again fails us, and in our attempt to find another we adopted the theory of a stationary ether filling all space, and affording the medium in which light waves are propagated. Such a medium seemed necessary to explain the experiments in optics, electrostatics, magnetism and electromagnetism, and since the same kind of medium with the same properties was needed for the explanation of phenomena in each of the branches of physics just named, Maxwell pointed out that this fact constituted strong evidence for the existence of the ether.

Now *if* it does exist, and *if* it is stationary in space, and *if* we can determine the absolute motion of the earth with respect to it, then we shall have found our much-desired frame of reference fixed in space.

The early experiments seemed to show that the ether is really at rest in space. In 1727 Bradley discovered the aberration of light, and the velocity of light as calculated from his formula agreed well with that found fifty years earlier by Roemer from observations of the eclipses of Jupiter's satellites. Now since the fact of aberration seems inexplicable on any other basis than a fixed or stationary ether, because if the ether in the telescope tube travels with it there would be no reason for any aberration, it was considered that the aberration of light clearly indicated that the ether is at rest in space, and that the material composing the earth moves through the ether just as a tennis racquet moves through air, allowing it to flow through the holes in the stringing. But it seemed incredible that any medium could stream

through the interstices in and between molecules in the solid earth at a rate sometimes of more than thirty miles per second without showing the least sign of friction or binding of any kind, and so further experiments were made. Airy tried the aberration experiment with a telescope tube filled with water, and expected to see an increased aberration, because the velocity of light in water is only three-fourths of what it is in air, and according to the aberration formula the less the velocity of light in the telescope tube the greater the angle of aberration should be.

But when Airy measured the angle through which the water-slowed light was deflected, he found it exactly the same as Bradley had found for full-speed light! This was a puzzling thing, to be explained only on the theory that the water dragged the ether along with it, with a velocity sufficient to compensate exactly for the change expected in the angle from the diminished velocity of light. Time is wanting to detail the experiments of Fizeau, Fresnel, and others to settle this point, but they showed apparently that something of the kind does take place, —a sort of entrainment or cling or viscous drag of the ether,—and they strengthened enormously the conviction that the ether does exist, is a substantial medium, and can be affected by matter,—that is, dragged along.

This brings us to the celebrated experiment of Michelson and Morley, which was an attempt made in 1881, and subsequently repeated, to measure the absolute speed of the earth with respect to the stationary ether of space. They certainly had a right to expect success, for they took every precaution to ensure it. The experiment consisted in splitting a ray of light, sending one-half in the direction of the earth's motion through space, then reflecting it by a mirror back to the source, while the other half of the ray is sent at right angles to the line of motion of the earth, and is then similarly reflected back, the two reflected rays interfering to produce interference bands in an interferometer, invented by Michelson.

The distance from the source to each mirror is exactly the same, but the distance the light travels to and fro between the mirrors and the source is *not* the same when the earth is in motion, being greater in the line-of-motion direction than in the direction at right angles to it. The mirrors and other instruments were mounted on a heavy stone slab floated in mercury, and they expected that when the apparatus was turned through a right angle so that what was before the longer

line-of-motion system became the shorter thwartwise system, they would see the interference fringes in the interferometer move to the right or left. But nothing of the kind happened, and the inevitable conclusion was that there is no appreciable relative motion between the earth and the ether,—that is, that the earth drags the ether in its vicinity along with it at full earth-velocity!

But if so, how can we explain the Airy experiment with the water-filled telescope, where the ether seemed to be dragged with a velocity less than half that of the earth? And especially should be asked, how shall we explain the aberration of light, which seemed to show that the ether isn't dragged along at all? Yet undoubtedly the Michelson-Morley experiment seems to indicate that the whole earth is surrounded by an envelope of stagnant ether, at rest with respect to the earth. This is absolutely contradictory, and physicists lost no time in making further tests.

Lodge spun a huge double disk of steel with tremendous velocity, and sent a split ray of light around in a groove between the two disks, half in one direction, half in the other. If the discs dragged the ether in the narrow groove around with them, the two half rays, one going with the dragged ether, the other against it, ought to interfere and produce fringes. Again no effect. Mascart and others devised most beautiful and accurate tests, but all of them gave negative results. In short, as Lodge says: "Interference methods all fail to display any trace of relative motion between earth and ether." Wood sums it up as follows: "Every experiment, with the exception of the one performed by Michelson and Morley, is in accord with the hypothesis of a stationary ether,"—that is, an ether perfectly stationary in space.

But how then can we explain the negative result of the Michelson-Morley experiment? Certainly interference methods are the most accurate and sensitive we have in the science of optics, and if they fail to detect relative motion between the moving earth and the fixed ether how can we believe that it exists? Lorentz and Fitzgerald then came independently to the conclusion that a moving piece of matter contracts in the direction of its motion. While this contraction is small,—less than three inches in the case of the earth's diameter in the direction of its orbital motion,—yet it would account exactly for the negative result of the Michelson-Morley experiment, because the longer path of the light parallel to the line of motion of the earth

might, by contraction of the stone slab, become exactly equal to the thwartwise path, and if so, no displacement of the interference fringes would result. Besides, this contraction is to be expected, anyhow, on the basis of the electron theory of matter, and in just the amount necessary to explain the negative result of the Michelson-Morley experiment. Tests were then made with wood and steel beams, in place of the stone slab, and it was found that they apparently contracted in the same manner and to the same extent, so we conclude that all matter behaves in the same way. But if such a contraction takes place in crystals, it looks as though double refraction should take place in them. This was tried by Lord Rayleigh and by Brace, but again with a negative result.

It seemed as though all the forces of nature were in a conspiracy to defeat our efforts to find a fixed frame of reference, and the determination of the absolute velocity of the earth with reference thereto, so that after all our work and experimentation it must be admitted that we have but the slightest real idea of either the magnitude or direction of our motion through space, though it would be of the first importance to us in astronomy and physics if we could only know it.

Now we come to the Einstein Theory of Relativity, which was at first an attempt simply to explain the negative results of the Michelson-Morley experiment. We must clearly distinguish three steps or stages in the development of this theory: (1) the Special Relativity theory; (2) the General Relativity theory; and (3) the latter theory as applied to gravitation, or the Einstein Theory of Gravitation.

To aid us in understanding the theory of Relativity, let us recall a few of the results attained in the development of Newtonian mechanics, on which we have built confidently the entire structure of modern physical science. (Of course the Newtonian mechanics, in its turn, is founded on Euclidean geometry, with its dozen axioms and postulates and its three-dimensional space.) In our search for the fundamental, bedrock conceptions, we have adopted, following the lead of Newton, those of Length, Mass and Time, as separate and distinct ideas, independent of each other, and perhaps capable of absolute measurement. For these we have adopted as our fundamental units the centimeter for length, the gram for mass, and the second for time, giving us the centimeter-gram-second or c.g.s. system of units. We have attempted to base all other ideas, such as force, work, energy, etc., on these as derived ideas, and we call their units derived units.

For example, the notion of velocity implies that a certain *length* of path is traversed in a certain *time*, and so by dividing the length by the time we get the *rate of motion*, which is the derived quantity we call velocity. Hence the dimensional formula, so-called, of velocity, is L/T. In the same way we can express every physical quantity in terms of a dimensional formula involving L, M, and T, except a few which we have been obliged to express partly in quantities just as fundamental as any others,—namely, temperature, magnetic permeability and specific inductive capacity.

In addition we have grown accustomed to accept without question Newton's laws of motion, and his inverse square law of gravitation, and we never doubted the unchangeable character of mass. We believed that a quantity of matter had the same mass and inertia under any and all conditions of place, time and velocity. We could change its weight, but not its mass, and this is the law of Conservation of Mass.

It is true that in 1881 J. J. Thomson, a rising young physicist, newly appointed head of the Cavendish Laboratory at Cambridge, showed mathematically that an electric charge in motion took on additional mass, but as its velocity had to be very great,—twenty thousand miles per second and upwards,—before this extra mass, or quasi-mass, became appreciable, his work had only a theoretical interest, because up to 1897 the highest velocity ever reached by matter, so far as we knew, was that of the great comet of 1882, and that was only four hundred miles per second at the perihelion point of its orbit. In 1897, however, Thomson's theory of the dependence of mass upon velocity suddenly became of the highest interest, because he not only found a way to measure the enormous velocity of flying electrons in a vacuum tube, but also of measuring their charge and their mass, and by developing this method Kaufmann, Bucherer and others proved by measuring the mass of electrons at various speeds that Thomson was quite right in his theory, and that *mass does depend upon velocity*. It follows, therefore, that the mass of a body in the direction of its motion is different from its mass in a transverse direction, and hence arose the idea of longitudinal and transverse mass. Thus a body may have two values of its mass at the same time, —truly a wide departure from the old Newtonian idea.

The whole mass of any body at rest is now supposed to be due to *the motion and the energy content* of its component parts,—elec-

trons, atoms and molecules,—while if the body itself is in motion an additional mass is given to it in the direction of motion. A shell weighing one ton will have an additional mass of one-millionth of a gram when fired with a muzzle velocity of 2,500 feet per second. For small speeds, therefore, the increase of mass is inappreciable, but for speeds of more than 100,000 miles per second the mass rapidly increases until at the velocity of light, which is 186.000 miles per second, the mass of a body would be infinite. The electrons inside an atom, and the rays fired off from radium, do actually reach prodigious velocities,—more than 100,000 miles per second.

But if mass is a function of velocity it is not a fundamental quantity, and cannot have an independent existence, so it must be given up as one of the pillars of the temple of science. Now comes Relativity and shows that determinations of both length and time also depend upon velocity, so they do not have an independent existence either, and two more pillars of the temple fall, irretrievably, because the determination of absolute velocity is forever beyond our reach.

Thus we have our first experience with the realm of Relativity,—the land of Topsyturvydom. We have our three *fundamental* conceptions of Length, Mass and Time all depending upon a *derived* conception, Velocity, which we formerly held to be dependent upon them! And then, having pointed this out, the relativist quietly states that all such experiments as that of Michelson and Morley are bound to fail, because it is impossible to determine the absolute velocity of the earth through the ether by experiments made on the earth, and besides, there isn't any ether anyhow! To the first statement we reply that we are on the earth, and can't get anywhere else, so if we cannot determine the velocity of the earth by experiments made here we can never know its velocity, and never be able to fix a unit of absolute motion. To which the relativist retorts, "Quite right,—we never can," and this is the First Postulate of Relativity.

To the second statement, that there is no ethereal medium, we can only ask what takes its place, to which the relativist replies, "No medium at all; electromagnetic energy, including light, is propagated through space somewhat as water is thrown from a hose. It is self-existent, and needs no medium." When we examine this remarkable statement, we should have as the background of our thinking the facts concerning the ether theory, which are, briefly, these: When the assumption of the existence of the ether was made, to explain the phe-

nomena of optics, electrostatics, etc., attempts were made to measure its properties. Newton thought its density was something like 700,000 times less than that of water; Lord Kelvin thought the ether so attenuated that it had a density of only one-quintillionth that of water, and many other scientists agreed with them as to the extreme tenuity of the ether. On the other hand, Sir J. J. Thomson says that "all mass is mass of the ether; all momentum, momentum of the ether; and all kinetic energy, kinetic energy of the ether," which shows the confidence of the foremost English physicist in the reality of the ether, but he goes on to say that this view "requires the density of the ether to be immensely greater than that of any known substance." Other leading physicists take this view also, and Sir Oliver Lodge insists that the ether has a mass of one quadrillion grams per cubic centimeter, and that "compared to ether the densest matter, such as lead or gold, is a filmy gossamer structure like a comet's tail"!

Now we all agree, I am sure, that when Kelvin claimed that one cubic centimeter of the ether weighs one-quintillionth of a gram, and Lodge says it weighs one quadrillion grams, (which is one million tons), there is a serious discrepancy, to say the least, in the estimates of physicists as to the properties of the ether, and we are not surprised to learn that there are a multitude of ether theories,—solid, liquid, elastic, labile, irrotational, gyrostatic, adynamic, etc., so no wonder Relativity wants to get rid of the whole thing by turning the ether out of doors.

And yet there comes, in protest, the cool reasoning of one of our very foremost American physicists, Millikan, who says that the ether "was called into being solely for the sake of furnishing a carrier for electromagnetic waves, and it obviously stands or falls with the existence of such waves in vacuo, and this has never been questioned by anyone, so far as I am aware." Other leading physicists protest also against giving up the notion of the ether for what Newton called "the forlorn idea" of empty space, among them being Lorentz, the great Dutch mathematician and physicist.

But Planck, the originator of the Quantum Theory, gives up the ether, and Einstein of course does the same, for his first postulate implies this very thing. But his second postulate states that light in a vacuum is propagated with a constant velocity quite independent of the velocity of its source, and queerly enough, this postulate seems to assume the existence of the ether, which the first postulate denies,

or as Stewart says, "we have the Principle of Relativity destroying a concept which is used in one of its postulates,"—another instance of Topsyturvydom.

Einstein admits this, but cannot get away from the confidence he, and all other physicists, have always had in Maxwell's great theory of electrodynamics, and the equations in which it is expressed, and so Einstein states in his London "Times" article that for this reason he was led to achieve the logical reconciliation of his two postulates by making a change in the doctrine of the physical laws of time and space. In doing so, however, he was obliged to overthrow some of the time-honored ideas of Galileo and Newton, and deal with four-dimensional, instead of three-dimensional space. Of course that also meant using non-Euclidean mathematics, and the difficulties pressing upon him from every side seemed insuperable. But he was immensely helped by the work of Minkowski, who developed a system of four dimensions,—using time for the fourth dimension,—involving four rectangular axes, of which three are for the three space dimensions, and the fourth is the time axis. Space and time are thus bound together, and no mathematical difference is made between them, the axes being interchangeable.

It is of course impossible for us to conceive of four dimensions all at right angles to each other, but let us take this example: When we go to the moving-picture show, we see the screen picture in only two dimensions, of course. But we supply a third dimension in our minds by seeing the perspective of the picture. We see a horseman coming in the distance apparently straight towards us, along the third axis which our mind supplies perpendicular to the screen. But there is another element in the picture, the *time* element. Time is always of the essence in melodrama. The interest centers in the question as to whether the hero, beset with difficulties and dangers, as he always is, will be in time to rescue the fair heroine. This *time* element, measured along an imaginary time axis, is also mentally present, and the picture is not complete without it. And moreover, as stated before, while we cannot visualize this axis at right angles to the others, the mathematician can make his equations behave exactly as though we could.

What Tennyson calls our "bourne of time and place," therefore, Minkowski calls a four-dimensional "space-time continuum," and by using four-dimensional geometry he showed *how events in nature may*

be represented mathematically, and how any equation referred to these four axes could be transformed to any other set of axes provided the second set is at rest or moving *uniformly* with respect to the first. Einstein used many of Minkowski's ideas, and developed what he calls his Special Relativity Theory, which he describes as follows: The Special Relativity theory is the application to any natural process of the following propositions:

1. Every law of nature which holds good with respect to a co-ordinate system K must also hold good for any other system K′ provided that K and K′ are in uniform motion of translation.

2. The second proposition is that light has a constant velocity in a vacuum, quite independent of the velocity of its source.

There is much experimental evidence for the truth of this second postulate, and the special theory, resting only on the two postulates just given, was eagerly studied by physicists.

It was immediately seen that the most important fields of study were those of acceleration and energy. The conception that inert mass is nothing but latent energy was developed, the law of conservation of mass lost its independence and became merged with the law of conservation of energy, and new laws of motion, differing from Newton's, were worked out for masses moving with great velocity. Many startling and unexpected results were found, and Einstein pushed his investigations vigorously. Please remember that his *special* theory dealt only with axes in *uniform* motion, and he next tried to find a more generalized theory dealing with axes in *any* kind of motion. Again the obstacles in his path seemed to defy his highest skill. But he persisted, for he asked himself, why must the independence of physical laws with regard to a system of co-ordinates be limited to a system of co-ordinates in *uniform* motion of translation with regard to one another? What has Nature to do with the co-ordinate systems which *we* propose, or with their motions? We must, of course, use arbitrarily chosen systems to describe Nature's operations, but they ought not to be limited as to their *state of motion.* So he worked on until he found the necessary transformation formulae for *any kind of motion* of the axes, and this is what he calls his General Theory of Relativity, the single postulate of which may be stated as follows: The laws of nature must remain invariant for all transformations of co-ordinates. But he further says that "a generalized theory of

Relativity must include the laws of gravitation, and actual pursuit of the conception has justified the hope.'' So his third achievement is his new theory of gravitation, which differs widely in some respects from that of Newton. To understand it is not easy.

First, let me remind you that gravitation has always been a physical mystery, and numerous theories to account for it have been developed without success. For one thing the speed of gravitation seems to be infinite, the only thing in nature which has a speed greater than light. Again, we say the sun ''attracts'' the earth and holds it in its orbit, but when we find that this so-called attraction is a force sufficient to break a million millon rods of the best tensile steel, each seventeen feet in diameter, we are amazed that any ethereal medium can transmit it. And if we let the ether go, we are still more perplexed. Let us, however, start with the conception that all pulls are really pushes. When lemonade is sucked or pulled through a straw, it is really the pressure of the atmosphere which pushes it through the straw from the other end. Perhaps gravitation is a push, rather than a pull.

When a baseball curves, we do not imagine something pulling it around in a curve, but we think of the bank of air in front and on the side of it, due to its twisting motion, as pushing it around. In like manner a railroad train is pushed by the reaction of the outer rail around the curve in the track. So we may imagine gravitation as pushing the earth around in its curved orbit. From this conception let us proceed to another,—the principle of Least Action. It may be familiarly expressed in this way; every moving body holds to the line of least resistance. That is what the curving baseball does; perhaps that is what the curving earth does. If so, the first thing to ascertain is what the line of least resistance is in space, and why it is so, if we can; at any rate, find out what a body will do, and how it will move under certain conditions.

This Einstein has done, and as he worked he came more and more to the conclusion that the idea of gravitation, like the ideas of time and space, is only part of the mental scaffolding we have erected to explain the phenomena of nature, and has no existence apart from our brains. To understand this let us imagine ourselves in an elevator high up in the Woolworth building. We feel the weight of our bodies pressing the soles of our feet; we feel the weight of the package we are carrying; perhaps a pendulum is swinging in the elevator. Then

suppose the wire rope breaks; the elevator with its contents falls vertically with the gravitational acceleration of thirty-two feet per second per second.

If we could keep our mental equilibrium under the circumstances, we would notice that our weight appeared to vanish; that the package we carried also lost its weight, and if we removed our hand from it, it would remain suspended in mid-air; the pendulum, if at the end of its swing when the rope broke, would remain there motionless and would not swing back. In other words, so far as we are concerned, and so long as the elevator is falling, gravity has been annihilated by giving the appropriate acceleration to the elevator. In reality, an observer inside a closed windowless box could not by any means decide whether the box is in a static gravitational field, or is endowed with accelerated motion in a space free from gravitation. We seem to weigh more while in an elevator *ascending* with accelerated motion, so that acceleration simulates gravitation and may be substituted for it. Now imagine two sets of four-dimensional axes, one set stationary in the Woolworth building, and the other set fixed in the falling elevator. Let x, y, z, and t be the co-ordinates of a point with reference to the second, or falling-elevator set of axes. Then, since we have no gravitation in the elevator to complicate matters, an element of length *ds* with reference to this set would be given by the equation

$$ds^2 = dx^2 + dy^2 + dz^2 + dt^2$$

Now let the same point mentioned above have at the same instant the co-ordinates x′, y′, z′ and t′ with reference to the first, or fixed-in-the-building set of axes. Then the transformation equation for *ds* will be

$$ds^2 = g_{11}dx'2 + g_{22}dy'^2 + g_{33}dz'^2 + g_{44}dt'^2 + 2g_{12}d\,x'dy' + 2g_{13}dx'dz' + \text{etc.}$$

There are ten of these *g* coefficients, and their value depends on the nature of the transformation, *and specifies it.* They can be used, therefore, not only to specify it, but they also define *the original gravitational field, because they specify how it was got rid of.*

Now in Einstein's theory these ten *g*'s, used in ten differential equations, are regarded as ten values of the gravitational potential specifying the field, and one of them, g_{44}, is approximately the same as the Newtonian potential, except for a factor.

Einstein, after long investigation, has so chosen his equations that they remain unaltered by any change of co-ordinates, and these ten are the only ones which do satisfy all conditions. What has just been said illustrates Einstein's famous "Principle of Equivalence," which states that for any particle at any instant it is possible to replace the effect of a gravitational field upon it by a mathematical transformation of axes.

If, therefore, gravitation can be annihilated mathematically by a transformation to an accelerated set of axes, and if its very existence depends upon a choice of axes, which is contrary to the General Relativity Postulate, then gravitation, in the words of deSitter, "becomes almost a property of space."

Of course a first approximation from Einstein's equations, neglecting terms of higher orders, gives the old Newtonian law for comparatively small velocities. Please notice, however, that Einstein's theory only shows how gravitation *acts*, not what causes it to act thus. It is in no sense an explanation of gravitation, which remains as much of a mystery as before. Now a new theory, like a tree, is known by its fruits, and when Einstein was asked to make his theory do things to prove its truth he was at first perplexed to find cases in which the actual differences between his theory and that of Newton could be subjected to observation.

But he was not long at a loss, and presented three cases which would test the correctness of his theory. The first case was the long outstanding discrepancy between theory and observation shown in the displacement of the perihelion point of Mercury's orbit. This point shifts around toward the east at the rate of 574 seconds of arc per century. The Newtonian mechanics, allowing for the effect of the other planets on Mercury's orbit, accounts for a shift of only 532 seconds, thus leaving an unexplained shift of 42 seconds of arc per century. Einstein's theory calls for a difference of 43 seconds,—an almost startling agreement. But of course Einstein might have started with this answer, and worked backwards, as it were, to his equations, so a great deal more interest was taken in his second case: a prediction that at the eclipse of the sun on May 29, 1917, the light of certain stars which just grazed the sun on its way to the earth would be found to have a deviation from a straight path because of the sun's gravitational field which he estimated would amount to 1.75 seconds of arc.

This prediction was made in 1917, two years before the eclipse, and Einstein was a professor in a German university, shut in by the war, and so helpless to test the observation himself, but the English promptly began to make plans for sending out not one but two eclipse expeditions to test the theory. Let us examine the point in question. For years it has been customary to regard light as having mass, for we reasoned as follows: Light is a form of energy; being of the kinetic type it is expressed mathematically in terms of its velocity and its mass, or at least something that takes the place of mass and acts like it. Now if light possesses mass and velocity it must possess momentum, and ought to exert a push when it falls on a body. This light pressure, or radiation pressure, was predicted by Maxwell, and its value calculated by him, but it was only experimentally confirmed forty years later by Nichols and Hull and Lebedew. It is the radiation pressure from the sun which causes a comet's tail to stream behind the comet when approaching the sun, and to stream ahead of the comet when receding from the sun.

The question next arises, does light possess weight? Is the mass of light the kind which is acted on by gravitation? If so, we can consider a beam of light passing near the sun as a comet, and using the regular comet formula we can regard the speed of light as the speed of the comet, and as usual insert the proper value of nearest approach to the sun. From this formula we can find the angle between the asymptotes of the cometary orbit, and hence find the angle of deviation of the ray which we should expect on the basis of Newtonian mechanics. The result is an angle of .82 seconds of arc. Now in the case of ordinary comets we have always found that their speed increases while they are approaching the sun, and decreases after they have swung round it on their long journey back into the depths of space, so Newton's idea was that this acceleration should be expected of any comet moving with any speed, and acted on by the sun's gravitation, because force always produces acceleration in a mass free to move.

And just here is one of the most interesting of Einstein's discoveries. It is shown from his formulas that if a body is approaching the sun with a velocity less than about 100,000 miles a second, it *will* be accelerated in its motion, but if it has a velocity greater than this amount *it will actually be retarded* as it moves toward the sun. Such a thing is inconceivable on the basis of Newtonian mechanics. Incon-

ceivable, yes, but is it true? Einstein worked out his predicted deviation of a ray of light grazing the sun on the idea that it *is* true,—that the ray does really suffer a retardation on its way toward the sun proportional to the increasing gravitational field of the sun. This would of course make the part of the wave front closest to the sun move more slowly than the remoter portion, and hence the ray would be swung round through an angle of 1.75 seconds of arc, as already mentioned, and this is *more than twice* the angle expected from Newton's laws. So here is a clear-cut test;—Newton or Einstein,—a deviation of .82 seconds of arc, or a deviation of 1.75 seconds. Which would it be? The two British eclipse expeditions sent out last summer, one to Sobral, in Brazil, and the other to Prince's Island, west coast of Africa, both detected the deviation, and in the required amount to show the correctness of Einstein's views.

This was the triumph which put Einstein's name on the front page of every newspaper, and made every physicist in the world prick up his mental ears and begin to study Einstein's work more closely.

The third test set by Einstein for his theory was this:—his formulas show that the inside mechanism of an atom moves more slowly in a gravitational field than in free space. Perhaps this is due to the retardation suffered by a particle moving with a prodigious velocity through a gravitational field, as considered above. At any rate, Einstein predicted that light waves coming from a source located in an intense gravitational field would make a spectrum in which the lines would be shifted toward the longer-wave end of the spectrum, which is the red end.

This effect was looked for without success, but Einstein remained serene in his conviction that it would be found, and offered to rest the validity of his entire theory upon it.

Now comes his third triumph, for quite recently two young physicists at Bonn not only detected the shift towards the red end of the spectrum, but also discovered the reasons why previous attempts to find it, at Mt. Wilson and elsewhere, were unsuccessful.

These three triumphant verifications of the Einstein ideas about gravitation have focussed the eyes of the world upon this modest scholar in Berlin. Born a German Jew, he moved to Switzerland during his boyhood, was educated there, became a Swiss citizen and served for some years in the Swiss patent office. During this time he pursued his mathematical studies, and later taught in the Zurich Poly-

technikum, from which he went to the University of Prague. Just before the war he was called to the University of Berlin, at the age of forty. He did not sympathize with the militarists and protested vehemently against the famous, or rather infamous, manifesto of the German professors in 1915. His frank statement expressing his thanks to the English government and to his "English colleagues" for going to so much trouble and expense to verify his predictions, when he was himself helpless to do so, shows a fine spirit, and has gained for him both admiration and respect. It was, in part, as follows: "It was in accordance with the high and proud tradition of English science that English scientific men should have given their time and labor, and that English institutions should have provided the material means, to test a theory that had been completed and published in the country of their enemies in the midst of war."

Some of the more mathematical and theoretical conclusions drawn from his equations may be interesting. If a circle be imagined in empty space, its circumference bears to its diameter the usual ratio of 3.14159 to 1, but if a heavy mass be placed at its center, the ratio of circumference to diameter is changed, because of a "warp in space" produced by the mass. Again, suppose a wheel is rotating in space. The rim of the wheel, because it is at every point moving in the direction of its length, suffers the contraction already explained in connection with the Michelson-Morley experiment, but the *spokes* of the wheel are not moving in the direction of their length, and hence do not suffer contraction. Here again the circumference of the wheel changes length while the diameter does not, so the ratio is again not the usual one. This same contraction in the direction of motion is suffered by electrical, optical and gravitational fields. If a system is moving with respect to us, the unit of time in the moving system seems longer to us than to an observer on that system, and when the system is moving with respect to ours with the velocity of light, their second would seem infinitely long to us. That is, if we could watch a clock face on a system receding from us with the velocity of light, although an observer on the system with the clock would see it running as usual, we would forever see the clock hand at exactly the same point.

This sounds as crazy as anything in "Alice in Wonderland," and in fact the Mad Hatter must have been the originator of Relativity, and to have had this very point in mind when he claimed that 'for

him it was always six o'clock and always tea-time. Einstein goes even farther than this; let me quote his own words: "We could substitute for the clock a living organism enclosed in a box. Were it hurled through space like the clock it would be possible for the organism, after a flight of whatever distance, to return to its starting point practically unchanged, while an exactly similar organism which remained motionless at the starting point might have given place to new generations. For the organism in motion, time was but a moment, if its speed approached the velocity of light." This statement implies that not only does time depend on velocity, but that the rapidity of chemical and biological processes is also a function of velocity.

Rosalind's remark is therefore doubly true, that "Time travels in divers paces with divers persons," and until the velocity of each system is known (that is, the relative velocity, for we can never find the absolute velocity of any system,) we cannot know with whom the swift foot of Time ambles, trots, gallops, or even stands still withal. One observer's *now* may be another observer's *future* and a third observer's *past,* all at the some cosmical moment of time. Two actions quite simultaneous to one observer may not be simultaneous to another observer located in a different system. Again, what to a stationary observer is an electrostatic field is to a moving observer an electromagnetic field.

According to Einstein and Minkowski any point relatively at rest in space really traces a "world-line" or "path of adventure" parallel to the time axis. The locus of a point in relative motion is a line making an angle with the time axis. An observation is the crossing of two or more world-lines, and we know nothing of these world-lines between the points of crossing with other world-lines. The axes of our four-dimensional space-time continuum have been aptly called the to-and-fro axis, the forward-and-backward axis, the up-and-down axis and the sooner-and-later axis, the last, of course, being the time axis. On one side of the origin the time axis represents the past, on the other side the future. Events do not happen,—they are coincidences of world-lines, and are simply there, to be met or happened upon, as it were. A few years ago Anderson's new star burst forth. Whatever caused it is supposed to have occurred about the year of George Washington's birth, but we only happened upon a crossing of its world-lines with ours one hundred and seventy years later. If a change is made in an element of our system, it alters the whole past,

mathematically speaking, as well as the future. This seems absurd, and corresponds to nothing real in our experience, so far as we know, but these equations we are discussing have proved true in so many ways that we eagerly anticipate their further interpretation. New tests for straightness of lines, for simultaneity of events, etc., have been adopted, and everything seems queer and unfamiliar. Straight lines, according to Relativity, appear crooked to us, and vice versa. Spheres in motion become oblate spheroids, and we feel like the prisoner in Gilbert and Sullivan's opera, condemned always to play on a warped table, "on a cloth untrue, with a twisted cue, and elliptical billiard balls."

According to this theory, also, the *greatest possible* velocity in space is that of light,—186,000 miles per second. Even if a shell were fired with a velocity of 100,000 miles per second directly forward from a gun mounted on a car moving with the same velocity of 100,000 miles per second, the resultant velocity of the shell would not be 200,000 miles per second, as we should expect, but only 150,000. No combination of any number of velocities impressed upon a body can exceed the velocity of light. The new definitions of physical terms are equally puzzling, as for example: "Matter does not cause the curvature of space,—it *is* the curvature." Again, Einstein has practically ignored in his theory the idea of *force* as the condition for change of motion, which was possibly the greatest contribution made by Galileo to the science of dynamics, and in spite of the fact that some physicists hold force to be perhaps the most basic of all the ideas of mechanics. As already said, the ether, which Planck calls a "child of sorrow," is, in the eyes of relativists, hopelessly discredited.

The work of Einstein is epoch-making. Just as for sixty years everything in physics has had to square with Maxwell's equations,—even Einstein's theory,—so now there is already seen a tendency to make our thinking square with Einstein's equations. Just what results will come out of the new theory it is impossible to say. The Einstein mechanics have shown at least some power of exploration of intra-atomic space, which Newtonian mechanics could not do, and this may assist us in the development of a rational theory of atomic structure better than any theory we now have.

But we are not to stop here. The English are actively preparing to make even more accurate observations in Australia during the

eclipse of 21st September, 1922, when we may hope to have much additional light thrown upon the whole subject, which now presents, it must be confessed, many difficulties. For example, according to the new quantum theory energy is radiated in a discontinuous fashion in very small amounts called quanta. The value of a quantum has been determined, but according to the Relativity theory, since it travels with the speed of light, every quantum should appear infinite, which it doesn't.

Then, too, by no means all physicists agree with the theory, and Abraham, for instance, has opposed it vigorously, warning us against the "Sirenenklaenge dieser Theorie." Many others, such as Sir Joseph Larmor, while not hostile, are lukewarm. Trouton says that Relativity is merely trying to remove the lion in the path by laying down the general proposition that the existence of lions is an impossibility.

The truth is that the theory is so new, so revolutionary, and so difficult to understand, that the natural conservatism of science forces it to make its way slowly. Then, too, the language in which it is expressed in the articles scattered through the literature of the subject is not easily "understanded of the people." As an example, Larmor complains in one of his articles that a certain expression is only "wrapping up in abstractions the simple statement that when at any place the quadratic characteristic of the spatial extension involves the differential of the co-ordinate specially related to time in its product terms, then there is latent in it a specification of its own mode of change at that place with respect to uniform space-time." You see what a "simple statement" in non-Euclidean Relativity sounds like, and this may throw light on Einstein's reported saying that he did not suppose there were more than twelve men on the earth at present who can understand his theory fully. The surprising thing about this statement is that he should have put the number so high as twelve.

In conclusion, let us sum up the situation: Conservatives in science claim that at best Einstein has merely introduced some refinements in our mathematical weapons of attack; but the radicals claim that he has overthrown much of the older mechanics, has given the coup de grâce to the ether, and has started an entirely new chapter in the development of human thought comparable only to that begun by Galileo and Newton; furthermore, that the Relativity point of

view will color everything in the future, and that we have now two and only two foundations on which we can build with confidence,—the Electromagnetic Theory of Clerk Maxwell and the General Relativity Theory of Albert Einstein.

CHAPEL HILL, N. C.

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A NEW METHOD FOR LAYING OUT CIRCULAR CURVES BY DEFLECTIONS FROM THE P. I.

By T. F. Hickerson

With Three Text Figures

The writer hopes that the tables based upon formulas given below will fill the long-felt need of a simple and time-saving method for laying out circular curves by deflections from the point of intersection of the tangents (the P. I.), thus avoiding the trouble of moving the instrument and resetting the vernier.

Referring to Fig. 1, P is any point on the circular arc CB and A is the point of intersection of the tangents. Also C is the point of curve (P. C.), and B is the point of tangent (P. T.). Lines from points A and O to point P makes angles of Θ and α with the line AO, these angles being plus when measured above AO and minus when below it. PN is drawn perpendicular to AO. The deflection angle is called Δ.

$$\text{Tan } \Theta = \frac{PN}{AN} = \frac{R \sin \alpha}{E + R - R \cos \alpha} = \frac{R \sin \alpha}{R (\sec \tfrac{1}{2}\Delta - 1) + R - R \cos \alpha}$$

$$\text{Hence, } \tan \Theta = \frac{\sin \alpha}{\sec \tfrac{1}{2}\Delta - \cos \alpha} \qquad \text{.....(1).}$$

Formula (1) shows that for a given value of Δ, the angle Θ is independent of the radius of the curve or the length of curve.

Imagine the curve divided into *ten equal parts,* then formula (1) gives the deflections to these points of division as follows:

$$\alpha = \tfrac{1}{10}\Delta, \ \tan \Theta_1 = \frac{\sin \tfrac{1}{10}\Delta}{\sec \tfrac{1}{2}\Delta - \cos \tfrac{1}{10}\Delta},$$

$$\alpha = \tfrac{3}{10}\Delta, \ \tan \Theta_2 = \frac{\sin \tfrac{3}{10}\Delta}{\sec \tfrac{1}{2}\Delta - \cos \tfrac{3}{10}\Delta},$$

$$\alpha = \tfrac{2}{10}\Delta, \ \tan \Theta_3 = \frac{\sin \tfrac{2}{10}\Delta}{\sec \tfrac{1}{2}\Delta - \cos \tfrac{2}{10}\Delta},$$

$$\alpha = \tfrac{1}{10}\Delta, \ \tan \Theta_4 = \frac{\sin \tfrac{1}{10}\Delta}{\sec \tfrac{1}{2}\Delta - \cos \tfrac{1}{10}\Delta},$$

$$\alpha = 0, \ \Theta_5 = 0,$$

$$\alpha = -\tfrac{1}{10}\Delta, \ \Theta_6 = -\Theta_4,$$

$$\alpha = -\tfrac{2}{10}\Delta, \ \Theta_7 = -\Theta_3,$$

$$\alpha = -\tfrac{3}{10}\Delta, \ \Theta_8 = -\Theta_2,$$

$$\alpha = -\tfrac{4}{10}\Delta, \ \Theta_9 = -\Theta_1,$$

$$\alpha = -\tfrac{5}{10}\Delta, \ \Theta_{10} = -\tfrac{1}{2}(180 - \Delta).$$

Values of Θ_1, Θ_2, Θ_3, etc., computed by means of the above formulas for different values of Δ show that they change *uniformly* with Δ; so that interpolation gives results as closely as 1 minute for ranges of 1° in Δ.

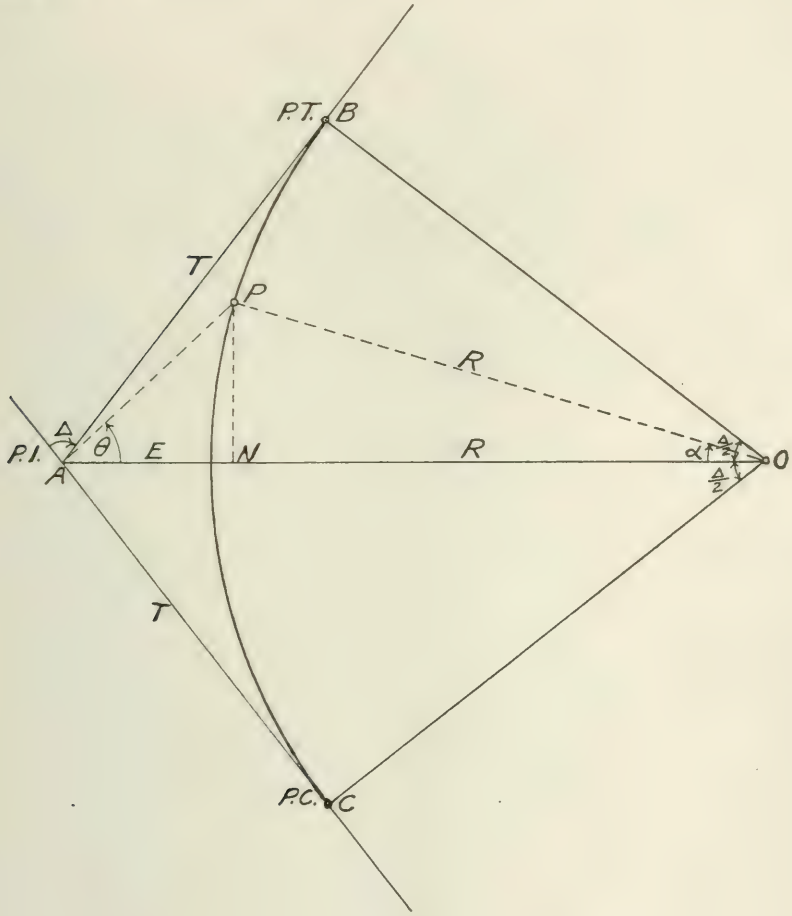


FIG. 1

For convenience in laying out curves without resetting the vernier, these directions to points on the curve are referred to the first tangent, the line CA produced.

Instrument at the P. I., and vernier reading $\Delta°$ on the P. T., we have:

Deflection to point

$$
\begin{aligned}
(1) &= \Delta + \tfrac{1}{2}(180 - \Delta) - \theta_1 = 90^\circ + \tfrac{1}{2}\Delta - \theta_1, \\
(2) &= 90^\circ + \tfrac{1}{2}\Delta - \theta_2, \\
(3) &= 90^\circ + \tfrac{1}{2}\Delta - \theta_3, \\
(4) &= 90^\circ + \tfrac{1}{2}\Delta - \theta_4, \\
(5) &= 90^\circ + \tfrac{1}{2}\Delta \\
(6) &= 90^\circ + \tfrac{1}{2}\Delta + \theta_4, \\
(7) &= 90^\circ + \tfrac{1}{2}\Delta + \theta_3, \\
(8) &= 90^\circ + \tfrac{1}{2}\Delta + \theta_2, \\
(9) &= 90^\circ + \tfrac{1}{2}\Delta + \theta_1, \\
(10) &= 180^\circ.
\end{aligned}
$$

It should be noted that the following pairs of deflections add up to $180^\circ + \Delta^\circ$; (1) + (9), (2) + (8), (3) + (7) and (4) + (6).

Using the above formulas, tables have been computed for all values of the deflection angle Δ varying by 1° from 3° to 128°. This covers all cases that are likely to occur in locating curves for roads and streets.

Fig. 2 is a graphical verification of the fact that for a fixed Δ, the deflections to the points of equal division on a curve remain constant for any length of the curve. This makes the method perfectly general.

The order of procedure in laying out a curve is as follows: (1) set up the instrument at the P. I., backsight on the first tangent with vernier reading O°, transit the telescope, unclamp the vernier and fix the line of sight on the second tangent, the vernier giving the deflection angle Δ°; (2) decide what length of curve to use (determined usually either by the desired external distance E or the tangent length T); (3) compute T and E, using either the well-known table of tangents and externals for a 1° curve, or *preferably* the tangents and externals for a 100-ft. curve (Table II); (4) lay off the tangent length locating the end of the curve (the P. T.); (5) divide the length of curve by 10 and locate each of the ten points, or every other one, or every third one, etc., depending upon how many are needed to properly define the curve, by starting at the P. T., and getting the intersection of the end of the chord with the line of sight from the P. I., according to deflections read directly from the tables (Table I).

The middle point, or the 5th point of the curve, cannot be located very precisely by intersections, since the end of the chord would be moved in an arc tangent to the line of sight. This point can be located exactly by measuring the external distance E from the P. I., and this serves as a check. If only the 2d, 4th, 6th, 8th, and 10th points are located, then it is not necessary to know E.

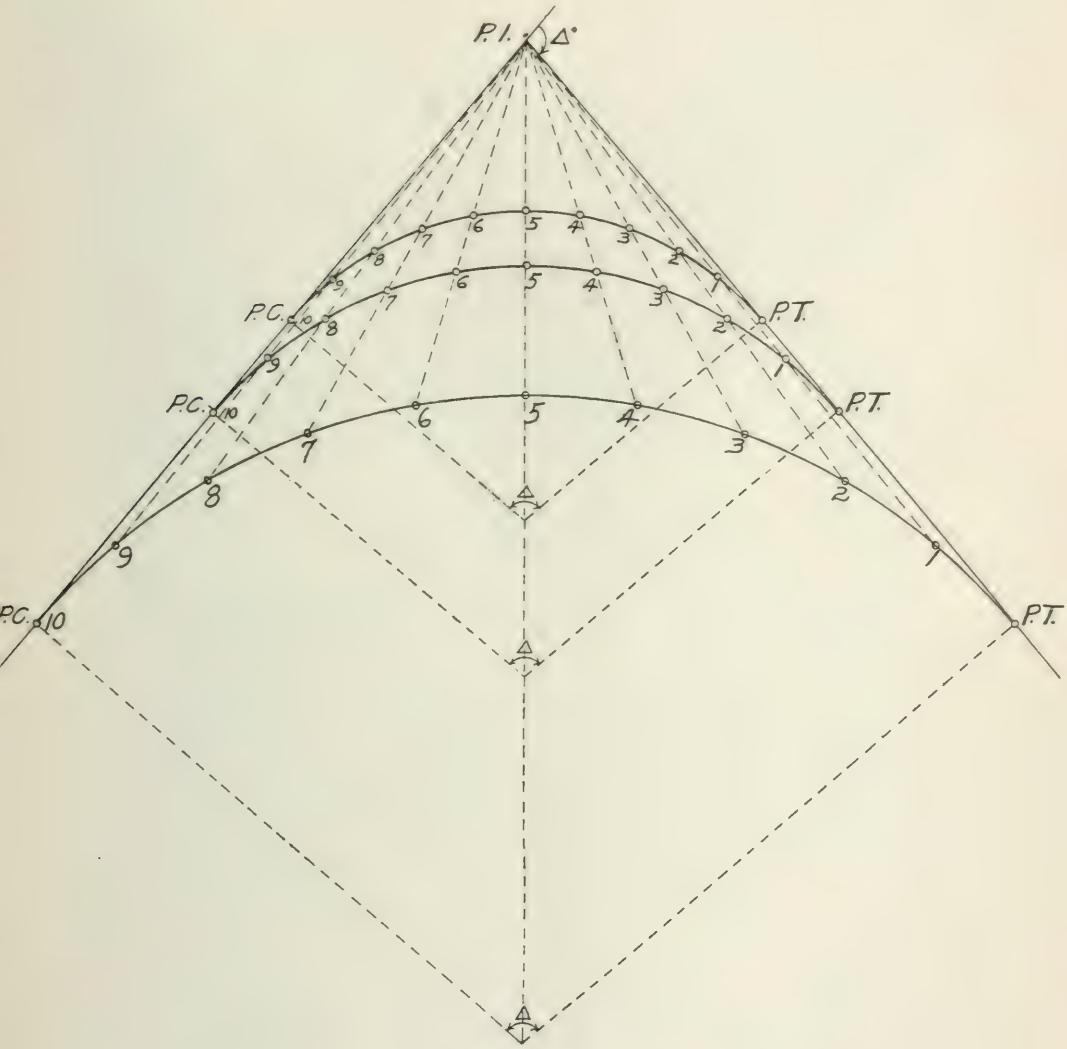


FIG. 2

The beginning of the curve (the P. C.) is located as the 10th point by a deflection which is always 180°. The station number of the P. C. is known, hence its location can be checked by measuring

the plus distance back to the preceding station. This method avoids measuring the tangent distance from the P. I., in order to locate the P. C.

It should be noted that the curve can be located by starting at the P. C. instead of the P. T., the deflection to the first point being the same as that to the 9th point as given by Table 1, etc.

If part of the curve is not visible from the P. I., say that beyond point 6, then the instrument may be moved to point 6 and the remaining points located by deflections from a preceding chord. Suppose a backsight is taken to point 2, vernier reading 0°, then after reversing the telescope the proper deflection to locate point 7 is $\frac{5\Delta^\circ}{2 \times 10} = \frac{\Delta^\circ}{4}$, etc.

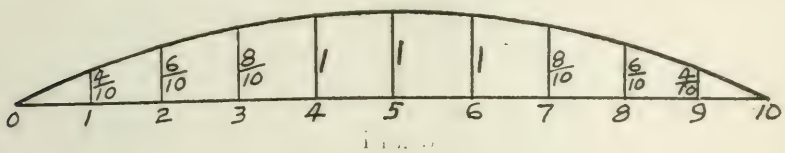
For very long curves in woods and at places where the P. I. is not accessible, the well-known deflection method should be used, that is, the instrument is moved to the P. C., and intermediate points on the curve.

During the past summer the writer was in charge of a party that surveyed 22 miles of federal-aid highways in hilly and mountainous country, and the following facts were observed: (1) not a single case of inaccessible P. I. occurred; (2) along 86 per cent of the curves the P. I. was visible throughout; (3) in only 42 per cent of the curves was the P. T. visible from the P. C. This means that 86 per cent of the curves could have been laid out completely with the instrument set only once (at the P. I.), whereas 58 per cent of them actually required the instrument to be set up three times. The first 11 miles was in fairly open country along the general direction of an old road. Here 96 per cent of the curves were visible throughout from the P. I., but 70 per cent of the P. T. points were not visible from the P. C. The other 11 miles of the survey was partly in a dense forest and not along an old road.

Aside from the time saved in not having to move the instrument, another step in the usual operation of laying out a curve is avoided, and that is, the tangent distance is not measured from the P. I., in order to locate the P. C. Curves laid out by the usual method begin and end with subchords of unequal length. This makes the deflections rather tedious to compute. The errors are cumulative, and the writer has seen the best of transitmen waste time in trying to find the little error that prevented the final check.

The resident engineer can more easily pick up the P. I., than any other point and he would find it convenient to realign the curve by deflections from this position while construction is going on, since it is apt to be beyond the grade stakes and not disturbed.

The points on the curve established by deflections according to the proposed new method are at equal and integral distances apart, but they are not full stations. The writer believes the advantages of full station points are largely imaginative. However, the chainmen can easily locate full station points on their return trip from the P. C. to the P. T., as is explained in Example 1. The middle ordinate of the equal chords can be found in Table III which has been compiled by the writer for the purpose. In this connection, it should be remembered that middle ordinates vary practically as the square of the chords; and for any chord, the ordinates vary practically as those of a parabola. See Fig. 3. Thus if the middle ordinate is 1 ft. the ordinate (or offset) at a point 2/5th of the chord-length from the end of the chord is 0.6 ft. The middle ordinate in practice is usually less than 1 ft. as will be seen later.



Before proceeding with an illustration, Table II will be explained. This table gives the Externals, Tangents, Radii, and Degrees of Curve for circular Arcs of 100 feet in length according to values of the deflection angle ranging from 1° to 128°. It is offered as a substitute for the tables giving the functions of a 1° curve. The following formulas were used in computing the values in Table II:

$$D = \frac{100\,\Delta}{L} = \frac{100\,\Delta}{100} = \Delta.$$

$$R = \frac{5729.578}{D}.$$

$$T = R \tan \tfrac{1}{2}\Delta = \frac{5729.578}{\Delta} \tan \tfrac{1}{2}\Delta.$$

$$E = R \tan \tfrac{1}{2}\Delta = \frac{5729.578}{\Delta} \operatorname{exsec} \tfrac{1}{2}\Delta.$$

For curves longer than 100 feet, the tabular values of the external, tangent, and radius must be multiplied, and the degree of curve divided, by the ratio of the given curve length to 100. For example, suppose Δ is 24° and the length of curve to be used is 400 feet, then

$$E = 5.334 \times 4 = 21.3,\ T = 50.744 \times 4 = 203.0,\ D = \frac{24}{4} = 6°,$$

$R = 238.8 \times 4 = 955.2$. This tables gives conveniently a length of curve that will always be a multiple of ten. The chords therefore will always be an integral number of feet in length.

Example 1.

Given $\Delta = 40°00'$; P. I at Sta. 62 + 11.8
From Table II, L = 100, E = 9.193, T = 52.135, D = 40°.

Suppose local conditions are such that E should equal 46 feet approximately. Hence, ratio $= \frac{46}{9.2} = 5$.

L = 500, E = 46.0, T = 260.7, D = 8°.

$\frac{500}{10} = 50$ = length of each chord to be applied 10 times.

P. I. = 62 + 11.8
T. = 2 + 60.7

P. C. = 59 + 51.1
L. = 5

P. T. = 64 + 51.1

For $\Delta = 40°00'$, the deflections are given directly in Table I as follows:

Points		Deflections
P. T.		Δ
1st		40°29′
2d		42°29′
3d		47°58′
4th		63°41′
5th	(E = 46.0)	110°00′
6th		156°19′
7th		172°02′
8th		177°31′
9th		179°31′
10th	P. C.	180°00′

As a check in taking deflections from the table, it should be noted that the 1st + 9th = 2d + 8th = 3d + 7th = 4th + 6th = 180 + Δ = 220°00′.

The above points on the curve are not at full stations; but the chainmen, on their way back from the P. C., can very easily set stakes at full station and + 50 foot points as follows: the rear chainman holds the + 51.1 division of the tape at the P. C., and aligns the front chainman by sighting to the 9th point of the curve; then a right angle offset on the P. I. side of the curve, at a certain fraction (see Fig. 3) of the middle ordinate for a chord of 50 feet (see Table III), locates Sta. 60 (in this case the middle ordinate is 0.44 ft. and the offset is less than 0.1 ft.); next the rear chainman holds the zero end of the tape at Sta. 60 and aligns the front chainman by sighting from the 9th point to the 8th point, in order to locate Sta. 60 + 50 which is so near the 8th point it does not have to be shifted. The other stations are established in a similar manner.

Example 2.

Given Δ = 20°20′; P. I. at Sta. 37 + 18.2.
T = 50.532, E = 4.5 (Table II).
Suppose T = 100 = approx. desired length of tangent.
Ratio = 2, hence L = 200, T = 101.0, D = 10°10′.

P. I. = 37 + 18.2
T = 1 + 01.0

P. C. = 36 + 17.2
L = 2

P. T. = 38 + 17.2

$\frac{200}{10}$ = 20. Use 40-ft. chords applied five times.

Points	Deflections
P. T.	Δ °
2d	21°40′
4th	35°13′
6th	165°07′
8th	178°40′
10th P. C.	180°00′

2d + 8th = 4th + 6th = 200°20′. Check.

The quantities in Tables II and III are based on the definition that the "degree of curve" is the central angle subtended by an *arc* of 100 feet instead of a *chord* of 100 feet. The radius of a one-degree curve is found by means of the following proportion:

$$1° : 360° = 100 \text{ feet} : 2\pi R \text{ feet, hence } R = \frac{36000}{2\pi} = \frac{36000}{2(3.14159)} = 5729.578$$

feet.

The middle ordinate (M) of an arc whose central angle is $\alpha°$ and whose chord is c feet, is given by the formula:

$$M = R \text{ vers } \tfrac{1}{2}\alpha \quad \text{.....(4).}$$

$$\text{Also } M = \frac{c^2}{8\,R} \text{ approx. .....(5).}$$

Formula (5) shows that for any radius, the middle ordinates vary as the square of the chords. The above formulas were used in computing Table III.

Assuming the arc to be parabolic, we have a convenient relation between ordinates at any point along the chord and the middle ordinate. See Fig. 3. For example, an ordinate at 8/10 of the chord-length from one end of the chord is 6/10 of the middle ordinate.

In practice, the middle ordinate is usually less than 1.0 foot, provided the chords do not exceed the limit where they vary more than .05 ft. from the arc. Table III shows these limits to be as follows:

100 ft.	chords	up	to	6°	curves;	middle	ordinates	up	to	1.31 ft.
50 ft.	"	"	"	16°	"	"	"	"	"	0.87 ft.
40 ft.	"	"	"	25°	"	"	"	"	"	0.87 ft.
30 ft.	"	"	"	37°	"	"	"	"	"	0.72 ft.
25 ft.	"	"	"	47°	"	"	"	"	"	0.64 ft.
20 ft.	"	"	"	67°	"	"	"	"	"	0.58 ft.
15 ft.	"	"	"	100°	"	"	"	"	"	0.49 ft.

TABLE I.

Deflections from the P. I. to Points of Equal Division along Circular Curves.

Pts.	△ = 12°00′	Diff. 1′	△ = 12°30′	Diff. 1′	△ = 13°00′	Diff. 1′	△ = 14°	Diff. 1′	△ = 15°	Diff. 1′	△ = 16°	Diff. 1′	△ = 17°	Diff. 1′	△ = 18°	Diff. 1′	△ = 19°	Diff. 1′
1	12°09′	+1.00	12°39′	+1.00′	13°10′	+1.01′	14°10′	+1.01′	15°11′	+1.01′	16°12′	+1.01′	17°13′	+1.01′	18°13′	+1.01′	19°14′	+1.01
2	12°48′	+1.06′	13°20′	+1.06′	13°51′	+1.06′	14°55′	+1.06′	15°59′	+1.06′	17°03′	+1.06′	18°07′	+1.06′	19°11′	+1.06′	20°15′	+1.06′
3	14°41′	+1.22′	14°17′	+1.22′	15°53′	+1.21′	17°06′	+1.21′	18°19′	+1.21′	19°32′	+1.21′	20°41′	+1.21′	21°57′	+1.21′	23°10′	+1.21′
4	21°18′	+1.73′	22°10′	+1.71′	23°01′	+1.71′	24°44′	+1.69′	26°25′	+1.69′	28°06′	+1.67′	29°46′	+1.65′	31°25′	+1.64′	33°04′	+1.62′
5	96°00′	+0.50′	96°15′	+0.50′	96°30′	+0.50′	97°00′	+0.50′	97°30′	+0.50′	98°00′	+0.50′	98°30′	+0.50′	99°00′	+0.50′	99°30′	+0.50′
6	170°42′	−0.73′	170°20′	−0.71′	169°59′	−0.71′	169°16′	−0.69′	168°35′	−0.69′	167°54′	−0.67′	167°14′	−0.65′	166°35′	−0.64′	165°56′	−0.62′
7	177°19′	−0.22′	177°13′	−0.22′	177°07′	−0.21′	176°54′	−0.21′	176°41′	−0.21′	176°28′	−0.21′	176°16′	−0.21′	176°03′	−0.21′	175°50′	−0.21′
8	179°12′	−0.06′	179°10′	−0.06′	179°09′	−0.06′	179°05′	−0.06′	179°01′	−0.06′	178°57′	−0.06′	178°53′	−0.06′	178°49′	−0.06′	178°45′	−0.06′
9	179°51′	−0.00′	179°51′	−0.00′	179°50′	−0.01′	179°50′	−0.01′	179°49′	−0.01′	179°48′	−0.01′	179°47′	−0.01′	179°47′	−0.01′	179°46′	−0.01′
10	180°00′	0.00′	180°00′	0.00′	180°00′	0.00′	180°00′	0.00′	180°00′	0.00′	180°00′	0.00′	180°00′	0.00′	180°00′	0.00′	180°00′	0.00′

Pts.	△ = 20°	Diff. 1′	△ = 21°	Diff. 1′	△ = 22°	Diff. 1′	△ = 23°	Diff. 1′	△ = 24°	Diff. 1′	△ = 25°	Diff. 1′	△ = 26°	Diff. 1′	△ = 27°	Diff. 1′	△ = 28°	Diff. 1′
1	20°15′	+1.01′	21°16′	+1.01′	22°16′	+1.01′	23°17′	+1.01	24°18′	+1.01′	25°18′	+1.01	26°19′	+1.01′	27°20′	+1.01′	28°20′	+1.01′
2	21°19′	+1.06′	22°22′	+1.06′	23°26′	+1.06′	24°30′	+1.06′	25°33′	+1.06′	26°37′	+1.06′	27°41′	+1.06′	28°45′	+1.06′	29°48′	+1.06′
3	24°22′	+1.20′	25°31′	+1.20′	26°46′	+1.20	27°58′	+1.20′	29°10′	+1.20′	30°22′	+1.19′	31°33′	+1.19′	32°44′	+1.19′	33°56′	+1.19
4	34°41′	+1.60′	36°17′	+1.60′	37°53′	+1.57	39°27′	+1.55′	41°00′	+1.54′	42°33′	+1.52	44°04′	+1.51′	45°35′	+1.48′	47°04′	+1.48
5	100°00′	+0.50′	100°30′	+0.50′	101°00′	+0.50′	101°30′	+0.50′	102°00′	+0.50′	102°30′	+0.50′	103°00′	+0.50′	103°30′	+0.50′	104°00′	+0.50′
6	165°19′	−0.60′	164°43′	−0.60′	164°07′	−0.57′	163°33′	−0.55′	163°00′	−0.54′	162°27′	−0.52′	161°56′	−0.51′	161°25′	−0.48′	160°56′	−0.48′
7	175°38′	−0.20′	175°26′	−0.20′	175°14′	−0.20′	175°02′	−0.20′	174°50′	−0.20′	174°38′	−0.19′	174°27′	−0.19′	174°16′	−0.19′	174°04′	−0.19′
8	178°41′	−0.06′	178°38′	−0.06′	178°34′	−0.06′	178°30′	−0.06′	178°26′	−0.06′	178°23′	−0.06′	178°19′	−0.06′	178°15′	−0.06′	178°12′	−0.06′
9	179°45′	−0.01′	179°44′	−0.01′	179°44′	−0.01′	179°43′	−0.01′	179°42′	−0.01′	179°42′	−0.01′	179°41′	−0.01′	179°40′	−0.01′	179°40′	−0.01′
10	180°00′	0.00′	180°00′	0.00′	180°00′	0.00′	180°00′	0.00′	180°00′	0.00′	180°00′	0.00	180°00′	0.00′	180°00′	0.00′	180°00′	0.00′

TABLE II.

Externals, Tangents, Radii and Degrees of Curve to a 100 Ft. Circular Arc.

Δ	E	Diff. 10′	T	Diff. 10′	R	D	Defl. per Ft.
1°	0.218	.036	50.001	.001	5730	1°	0.3′
2°	0.436	.036	50.005	.001	2865	2°	0.6′
3°	0.655	.036	50.012	.001	1910	3°	0.9′
4°	0.873	.036	50.020	.002	1432	4°	1.2′
5°	1.092	.036	50.032	.002	1146	5°	1.5′
6°	1.310	.036	50.046	.003	955.0	6°	1.8′
7°	1.530	.036	50.062	.003	818.6	7°	2.1′
8°	1.749	.036	50.081	.004	716.2	8°	2.4′
9°	1.969	.036	50.103	.004	636.6	9°	2.7′
10°	2.189	.036	50.127	.005	573.0	10°	3.0′
11°	2.409	.037	50.155	.005	520.9	11°	3.3′
12°	2.630	.037	50.184	.005	477.5	12°	3.6′
13°	2.851	.037	50.216	.006	440.8	13°	3.9′
14°	3.073	.037	50.251	.006	409.3	14°	4.2′
15°	3.296	.037	50.288	.007	382.0	15°	4.5′
16°	3.519	.037	50.328	.007	358.1	16°	4.8′
17°	3.743	.037	50.370	.008	337.0	17°	5.1′
18°	3.968	.037	50.416	.008	318.3	18°	5.4′
19°	4.193	.038	50.463	.009	301.6	19°	5.7′
20°	4.419	.038	50.514	.009	286.5	20°	6.0′
21°	4.646	.038	50.567	.010	272.9	21°	6.3′
22°	4.875	.038	50.624	.010	260.4	22°	6.6′
23°	5.104	.038	50.683	.010	249.1	23°	6.9′
24°	5.334	.039	50.744	.011	238.8	24°	7.2′
25°	5.565	.039	50.809	.011	229.2	25°	7.5′
26°	5.797	.039	50.876	.012	220.4	26°	7.8′
27°	6.030	.039	50.946	.012	212.2	27°	8.1′
28°	6.264	.039	51.020	.013	204.6	28°	8.4′
29°	6.500	.040	51.096	.013	197.6	29°	8.7′
30°	6.737	.040	51.175	.014	191.0	30°	9.0′
31°	6.976	.040	51.257	.014	184.8	31°	9.3′
32°	7.216	.040	51.342	.015	179.1	32°	9.6′
33°	7.457	.040	51.430	.015	173.6	33°	9.9′
34°	7.700	.041	51.521	.016	168.5	34°	10.2′
35°	7.944	.041	51.615	.016	163.7	35°	10.5′
36°	8.190	.041	51.712	.017	159.2	36°	10.8′
37°	8.438	.042	51.813	.017	154.9	37°	11.1′
38°	8.688	.042	51.917	.018	150.8	38°	11.4′
39°	8.939	.042	52.024	.019	146.9	39°	11.7′
40°	9.193	.043	52.135	.019	143.2	40°	12.0′
41°	9.448	.043	52.249	.020	139.8	41°	12.3′
42°	9.706	.043	52.366	.020	136.4	42°	12.6′
43°	9.965	.044	52.487	.021	133.3	43°	12.9′
44°	10.227	.044	52.611	.021	130.2	44°	13.2′
45°	10.491	.044	52.739	.022	127.3	45°	13.5′
46°	10.757	.045	52.871	.023	124.6	46°	13.8′
47°	11.025	.045	53.006	.023	121.9	47°	14.1′
48°	11.296	.046	53.145	.024	119.4	48°	14.4′
49°	11.570	.046	53.288	.025	117.0	49°	14.7′
50°	11.846	.047	53.435	.025	114.6	50°	15.0′
51°	12.125	.047	53.586	.026	112.3	51°	15.3′
52°	12.407	.047	53.740	.027	110.2	52°	15.6′
53°	12.691	.048	53.899	.027	108.1	53°	15.9′
54°	12.979	.049	54.062	.028	106.1	54°	16.2′
55°	13.270	.050	54.230	.029	104.1	55°	16.5′
56°	13.564	.050	54.402	.029	102.1	56°	16.8′
57°	13.861	.050	54.577	.030	100.5	57°	17.1′
58°	14.161	.051	54.758	.031	98.79	58°	17.4′
59°	14.465	.051	54.943	.032	97.11	59°	17.7′
60°	14.773	.052	55.133	.033	95.49	60°	18.0′
61°	15.084	.053	55.328	.033	93.93	61°	18.3′
62°	15.399	.053	55.527	.034	92.41	62°	18.6′
63°	15.718	.054	55.732	.035	90.95	63°	18.9′
64°	16.041	.055	55.941	.036	89.52	64°	19.2′

TABLE III.

Deg. Curve	Radius	MIDDLE ORDINATES					CHORDS				
		For Chords of					For Arcs of				
		100 Ft.	80 Ft.	60 Ft.	50 Ft.	40 Ft.	100 Ft.	80 Ft.	60 Ft.	50 Ft.	40 Ft.
1°	5730	0.2	0.1	0.1	0.0	0.0	100	80	60	50	40
2°	2865	0.4	0.3	0.2	0.1	0.1	100	80	60	50	40
3°	1910	0.6	0.4	0.2	0.2	0.1	100	80	60	50	40
4°	1432	0.9	0.6	0.3	0.2	0.1	100	80	60	50	40
5°	1146	1.1	0.7	0.4	0.3	0.2	100	80	60	50	40
6°	955.0	1.3	0.8	0.5	0.3	0.2	100	80	60	50	40
7°	818.6	1.5	1.0	0.6	0.4	0.3	99.94	80	60	50	40
8°	716.2	1.8	1.1	0.6	0.4	0.3	99.92	80	60	50	40
9°	636.6	2.0	1.2	0.7	0.5	0.3	99.90	79.95	60	50	40
10°	573.0	2.2	1.4	0.8	0.5	0.3	99.88	79.93	60	50	40
		For Chords of					For Arcs of				
		80 Ft.	60 Ft.	50 Ft.	40 Ft.	30 Ft.	80 Ft.	60 Ft.	50 Ft.	40 Ft.	30 Ft.
11°	520.9	1.5	0.9	0.6	0.4	.2	79.92	60	50	40	30
12°	477.5	1.7	0.9	0.7	0.4	.2	79.91	60	50	40	30
13°	440.8	1.8	1.0	0.7	0.4	.2	79.89	60	50	40	30
14°	409.3	2.0	1.1	0.8	0.5	.3	79.87	59.95	50	40	30
15°	382.0	2.1	1.2	0.8	0.5	.3	79.85	59.94	50	40	30
16°	358.1	2.2	1.3	0.9	0.6	.3	79.83	59.93	49.95	40	30
17°	337.0	2.4	1.3	0.9	0.6	.3	79.81	59.92	49.95	40	30
		For Chords of					For Arcs of				
		60 Ft.	50 Ft.	40 Ft.	30 Ft.	25 Ft.	60 Ft.	50 Ft.	40 Ft.	30 Ft.	25 Ft.
18°	318.3	1.4	1.0	0.6	0.3	0.2	59.91	49.94	40	30	25
19°	301.6	1.5	1.0	0.7	0.4	0.3	59.90	49.94	40	30	25
20°	286.5	1.6	1.1	0.7	0.4	0.3	59.89	49.94	40	30	25
21°	272.9	1.7	1.1	0.7	0.4	0.3	59.88	49.93	40	30	25
22°	260.4	1.7	1.2	0.8	0.4	0.3	59.87	49.93	40	30	25
23°	249.1	1.8	1.3	0.8	0.5	0.3	59.84	49.91	40	30	25
24°	238.8	1.9	1.3	0.8	0.5	0.3	59.84	49.91	40	30	25
25°	229.2	2.0	1.4	0.9	0.5	0.3	59.82	49.90	39.95	30	25
26°	220.4	2.0	1.4	0.9	0.5	0.3	59.81	49.90	39.95	30	25
27°	212.2	2.1	1.5	0.9	0.5	0.4	59.79	49.89	39.94	30	25
28°	204.6	2.2	1.5	1.0	0.5	0.4	59.78	49.88	39.94	30	25
29°	197.6	2.3	1.6	1.0	0.6	0.4	59.77	49.87	39.93	30	25
30°	191.0	2.3	1.6	1.0	0.6	0.4	59.76	49.87	39.93	30	25
31°	184.8	2.4	1.7	1.1	0.6	0.4	59.74	49.85	39.92	30	25
32°	179.1	2.5	1.7	1.1	0.6	0.4	59.73	49.84	39.92	30	25
		For Chords of					For Arcs of				
		50 Ft.	30 Ft.	25 Ft.	20 Ft.	10 Ft.	50 Ft.	30 Ft.	25 Ft.	20 Ft.	10 Ft.
33°	173.6	1.8	0.6	0.4	0.3	0.1	49.83	30	25	20	10
34°	168.5	1.8	0.7	0.5	0.3	0.1	49.82	30	25	20	10
35°	163.7	1.9	0.7	0.5	0.3	0.1	49.81	30	25	20	10
36°	159.2	2.0	0.7	0.5	0.3	0.1	49.80	30	25	20	10
37°	154.9	2.0	0.7	0.5	0.3	0.1	49.79	29.95	25	20	10
38°	150.8	2.1	0.7	0.5	0.3	0.1	49.78	29.95	25	20	10
39°	146.9	2.1	0.8	0.5	0.3	0.1	49.77	29.95	25	20	10
40°	143.2	2.2	0.8	0.5	0.3	0.1	49.75	29.94	25	20	10
41°	139.8	2.2	0.8	0.6	0.4	0.1	49.74	29.94	25	20	10
42°	136.4	2.3	0.8	0.6	0.4	0.1	49.73	29.94	25	20	10
43°	133.3	2.3	0.8	0.6	0.4	0.1	49.71	29.93	25	20	10
44°	130.2	2.4	0.9	0.6	0.4	0.1	49.69	29.93	25	20	10
45°	127.3	2.4	0.9	0.6	0.4	0.1	49.67	29.92	25	20	10
46°	124.6	2.5	0.9	0.6	0.4	0.1	49.65	29.92	25	20	10
47°	121.9	2.6	0.9	0.6	0.4	0.1	49.63	29.92	24.95	20	10
48°	119.4	2.6	0.9	0.6	0.4	0.1	49.62	29.92	24.95	20	10
49°	117.0	2.7	1.0	0.7	0.4	0.1	49.60	29.91	24.95	20	10
50°	114.6	2.7	1.0	0.7	0.4	0.1	49.59	29.91	24.94	20	10

NOTE—Tables I, II and III complete for values of Δ up to 128° in convenient form for use in the field may be obtained from the author at a price of 25 cents per copy.

A REMARKABLE FORM OF SKELETAL ELEMENT IN THE LITHISTID SPONGES

(A Case of Analogical Resemblance)

By H. V. Wilson

With Four Text Figures

Sponges, like other groups, are rich in the structural resemblances which are due to common descent, resemblances which involve numerous organs in the individual animal and which are of such a complex intricate character, striking so deeply into the constitutional make-up, that it is impossible to think of them as due to any natural cause save kinship. But as we study these infinitely variable animals, we encounter resemblances which fall in another category, resemblances which involve only some special detail of structure or at most a few features, which in their actual functioning are correlated in physiological-mechanical function. Such resemblances are certainly, in many cases at least, not inheritances from a common ancestor. We group them together as analogical but they fall in two subdivisions: (1) those involving features which are called out in each individual organism by the stimulus of an environment, and which do not appear when that environment is changed; and (2) those involving features which are racial characteristics, viz., characteristics that have arisen and become fixed, in some way, during the course of evolution and which continue to appear under different sets of environmental conditions.

Analogical resemblances of this latter class are due to the independent occurrence of the same variation (or cumulative series of variations), in different idioplasms. How such germinal changes, mutations as we often call them, are brought about physiologically, is a question that is being actively asked by many students of heredity, especially by the experimental evolutionists, of today. Along with the directly experimental attacks, descriptive work has its use in locating facts which at some time it may be worth while to put under the fire of experiment.

Partly, at least, in pursuance of this idea I wish to record a case of resemblance which is certainly analogical, and which, it is practically certain, is racial. It involves the shape of the fundamental spicule on which the characteristic skeletal element, the desma, of the lithistid sponges is built up.

The desma is a silicious body, in most species of a complexly branched shape (Figs. 3, 4), formed by the continued deposition of silicious material on a silicious spicule which we may call the basic spicule, technically *crepis* (Fig. 1). The basic spicules, which are especially present in growing parts of the sponge, are free bodies, that is, they lie in the living tissues of the sponge unconnected with one another or with other skeletal elements. The desmas on the contrary as they assume the final shape, become articulated with one another, and in most species become firmly united to form a coherent skeleton which presents the appearance of a network of silicious beams.

Now the basic spicule of the desma is in some lithistida a four-rayed spicule (tetraxial or tetractinellid spicule), in others a simple rod-shaped spicule (monaxial). Different as are the basic spicules in these two groups of species, the complete desmas are not always easy to distinguish, for in both cases they may become complexly branched bodies. This superficial similarity of the two kinds of desmas, those built on tetraxial, and those built on monaxial spicules, is in itself significant, but when we find, as we do in some species, desmas of the latter class varying toward desmas of the former class, it becomes clear that the desma built on a four-rayed spicule (tetracrepid desma) is the original or ancestral type, while the desma built on a monaxial spicule (monocrepid desma) is a derived type. These interesting and important variations were first described by O. Schmidt in *Discodermia clavatella* (O. Schmidt, 1879, pp. 12, 24). Sollas (1888, p. 341) confirmed the facts and convinced himself "that a complete series of transitional forms connect the monocrepid and the tetracrepid desmas." Topsent (1904, p. 60) has discovered the same state of affairs in another lithistid sponge, *Macandrewia azorica.*

The four-rayed shape may thus be regarded as the original, actual or ancestral, shape of the spicule which is transformed by the deposition of silicious matter into the desma. This spicule in the case of tetracrepid desmas in general is what is called a *calthrops,* viz., a spicule in which the four rays are similar, making the same angle with one another and having the same length. But in at least one species, *Desmanthus incrustans* Topsent, an evolutionary change has occurred, whereby one of the rays of the basic spicule has become longer than the others, the spicule thus being converted from a *calthrops* into a *triaene.* In the triaene, a very common form of spicule in the non-lithistid tetraxial sponges, we distinguish, then, one

long ray, the shaft (technically *rhabdome*), and three shorter rays (the *cladi*, forming together the *cladome*), which are given off from the end of the shaft. In the sponge which I shall now describe, a further evolutionary change has occurred, and rays are given off at both ends of the shaft of the basic spicule, the spicule thus becoming what is called an *amphitriaene* (Fig. 1).

The sponge referred to is a Philippine form, a new species, *Jereopsis fruticosa* mihi, dredged by the U. S. Fisheries Steamer Albatross in 80 fathoms in the region of the Sulu Archipelago, and which will be described in detail in a forthcoming report on Philippine sponges. It is a stony sponge of branching-cylindrical, or shrubby, habitus, 55 mm. high, and with the free spicules of the genus (dichotriaenes, oxeas, and streptasters including amphiasters and spirasters). In the two other recorded species of the genus, *Jereopsis schmidtii* (Sollas) from the tropical Atlantic and *Jereopsis* (*Neosiphonia*) *superstes* (Sollas) from the tropical Pacific (cf. Sollas 1888, Lendenfeld 1903), the desma is, perhaps, the usual type of tetracrepid desma, built up on a calthrops. Schmidt's figure (1879, Taf. II, Fig. 10) suggests however that this is not the case. I hope at some time to have the opportunity of making a critical examination of the desma, from this point of view, in the type specimens of these two species.

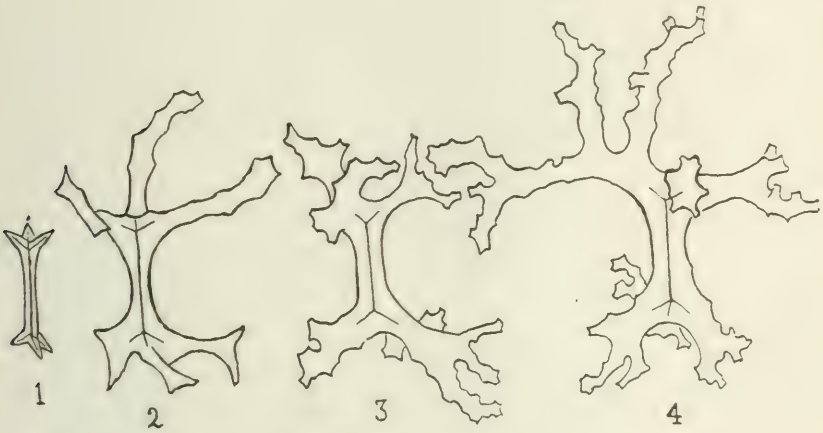
The facts concerning the development and structure of the desma in this sponge (*Jereopsis fruticosa*) are as follows:

Small, perfectly free amphitriaenes (Fig. 1) occur in the superficial (ectosomal) region of the sponge. The spicules are about one-sixth mm. long, and consist of a straight shaft with three rays (cladi) at each end. The streak of peculiar substance, known as the "axial canal," which is found in each of the axes of a tetraxial spicule, here extends, as the figure shows, along the axis of the shaft and to the tip of each ray.

Early stages in the transformation of such spicules into desmas may be found near the surface of the sponge. One is shown in figure 2. Such young desmas are free or only slightly connected with the body of the skeleton. In them the shaft continues to be of about the same length as in the basic spicule (Fig. 1), although it is thicker, but the rays have greatly increased in length. They measure now from one-half to the full length of the shaft or indeed slightly over. They are simple, viz., not branched, and when not corroded their ends bear rounded tubercles for articulation with other desmas. The axial

substance, "axial canal", retains its former size (cf. Figs. 1, 2), thus extending only into the basal part of each ray. This is the characteristic behavior of the axial canal in the growth of the lithistid desma in general.

As such desmas develop their final shape, they become firmly united to the skeletal framework already formed. If one wishes to study accurately their fundamental shape after union, the spicules must be isolated through the application of hydrofluoric acid to rough slices of the framework. When the framework is so treated the desmas fall apart. They are however corroded.



Figs. 1-4. *Jereopsis fruticosa.* Fig. 1, a free and uncorroded amphitriaene from the ectosome. Fig. 2, a young desma, slightly corroded by hydrofluoric acid, from the ectosome. Figs. 3 and 4, adult desmas somewhat corroded by the hydrofluoric acid used to dissociate them from the skeletal framework. All x 150.

Desmas (Figs. 3, 4) obtained in this way show the unchanged axial canal system which indicates the shape of the basic spicule on which the desma has been built up. The shaft is now about three times as thick as in the original spicule but no longer. The rays, better designated now as branches (technically cladi), vary a great deal not only in different spicules but in the same spicule. In some cases they have not advanced over the condition described for the intermediate stage (Fig. 2), either in size or complexity. More often, the branch is itself branched, a condition which is produced, of course, not

by the division of the first branch but by the continued deposition of silicious matter along lines which make angles with the first branch. In this way secondary or even tertiary branches are formed. There is apparently some law of growth which brings it about that no branch shall materially exceed the shaft in length. When or before that point is reached, new branches are formed. The articular tubercles are developed on the ends of the branches, whether the latter be primary, secondary, or tertiary. In many cases, as in Fig. 2, where the branches are about equally developed at the two ends of the shaft, the axial canal system of the basic amphitriaene is conspicuous, but it may be overlooked in cases where, as in Fig. 4, the branches at one end of the shaft are much more extensively developed than at the other end.

The point of importance for this paper is that the basic spicule, on which the adult desma is built, is an amphitriaene, that is a spicule consisting of a shaft and three rays at each end of the shaft. I can find no similar case recorded for the Lithistida.

In the non-lithistid tetraxial sponges, amphitriaenes are recorded only for Samus Gray and Amphitethya Lendenfeld (1906). Samus (one species) is a boring sponge occurring in the South Atlantic, Indian, and South Pacific Oceans. The only megascleres are amphitrianes, which are not all alike. In the larger of these spicules, the shaft, 80μ long, bears at each end three rays, each of which is trifid. In the smaller ones, the shaft, 20μ long, bears at one end three simple rays, and at the other end three trifid rays. While the sponge falls in the Sigmataphora because of its microscleres, which are sigmata (rods curved somewhat in c-shape, but with a spiral twist), its peculiar megascleres give it an isolated position, setting it off as a family (Samidae). The ontogeny of the amphitriaenes is not known, and we have no data on their variation to indicate their origin. It is highly probable however that the spicules have been derived from triaenes, although Sollas (1888, p. 59) has suggested two other conceivable origins.

In Amphitethya (Lendenfeld 1906, p. 126) there is no doubt that the amphitriaenes, which characterize the genus, are derivatives of the triaene. In *Amphitethya microsigma* Lendenfeld, a stalked species with globular body dredged off the west coast of Australia, the facts of variation which demonstrate this are as follows. Triaenes of several kinds occur abundantly in the sponge, those in the more axial

part of the stalk having an especially long shaft, as is often the case in such sponges. In the superficial part of the stalk there are abundant triaenes with short shaft, and mingled with these are the likewise abundant amphitriaenes. The latter spicules, in which the length of the shaft is 160-540μ, are exceedingly variable, scarcely two alike, and they form a close series grading over from amphitriaenes, quite like the spicules I have described above, to the short-shafted triaenes. These observations of the late Professor Lendenfeld securely establish the origin of the amphitriaene. Amphitriaenes were already known in the two other species of the genus, *Amphitethya stipitata* (Carter) and in the sponge from Amboina designated by Topsent *Tetilla merguiensis* Carter (Topsent 1897, p. 437). In the former Sollas noted (1888, p. 49) that "the amphitriaenes sometimes are reduced to simple triaenes." In the latter, the detailed facts, such as similarities in size and precise shape, convinced Topsent that the amphitriaenes are modified triaenes. Amphitethya is a genus with sigmata, and thus falls in the Sigmatophora.

There is still another non-lithistid tetraxonid sponge in which at least a step has been made toward the transformation of the triaene into the amphitriaene. This is *Ancorella paulini* Lendenfeld (Lendenfeld 1906, p. 248) from the Indian Ocean. The spicules referred to consist of a shaft, one millimetre or less in length, which bears at one end three cladi, projecting slightly downward as in an anatriaene, and at the other end a similar single cladus, extending out from the shaft at an angle in the same general direction as the cladi at the opposite end. The sponge is classed in the Astrophora by Lendenfeld, who regards its microscleres (microxeas) as derived from streptasters.

It may be regarded as certain that the presence of the amphitriaene in these several cases is not due to inheritance. The distance of the sponges from one another in the classification, expressing their general dissimilarity, negatives this idea. The comparison of Amphitethya with Jereopsis is especially instructive. Each has plenty of close relatives without amphitriaenes, and the two sponges fall in different suborders of the Tetraxonida. To be sure the Lithistida may not be a natural suborder but a polyphyletic group, some members of which have been derived from non-lithistid tetraxonia with astrose microscleres (Astrophora), and others from non-lithistid tetraxonida with sigmata for microscleres (Sigmatophora). Even in this case

Jereopsis would be related to the Astrophora, Amphitethya to the Sigmatophora.[1]

The only conclusion that is possible is that the triaene has varied and become an amphitriaene, independently, in several groups. The resemblance is analogical, one of 'convergent evolution', a rubric under which we group likenesses that are due to similar responses on the part of related, but not necessarily closely related (witness the similarities between the hydro- and scyphomedusae), organisms to the environment. We classify it, then, as due to a heritable change that may occur in triaenes independently of inheritance, that is, reversion plays no part in its appearance. We would like to know how to evoke it.

If this and similar cases in the sponges should ever be approached experimentally, through the alteration of the external or internal environment, the series of known spicule forms connecting perfect amphitriaenes with perfect triaenes, in *Amphitethya microsigma,* would lead us to expect that the change induced would be more or less cumulative. Also our general knowledge of variation in sponge spicules (cf. Wilson 1904, pp. 9-10) would lead us to expect that the heritable change would probably at first affect comparatively few spicules.

That analogical similarities are common in sponges is generaly recognized, although there is not much that is definite in our knowledge. Nowhere is more emphasis laid on their occurrence than in O. Schmidt's writings. As illustrating Schmidt's standpoint, the following cita-

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[1] The remarkable character of the lithistid desma makes a strong argument for the monophyletic origin of the group, weakened in no degree by the fact that some desmas are built on four-rayed, others on rod-shaped, basic spicules. For (see above) the variation phenomena in several species show that the latter kind of basic spicule is reducible to the former. Sollas (1888, p. CXIX) has laid weight on this argument for the monophyletic origin of the group, which he derives from the Astrophora. The derivation from the Astrophora in particular is based on the fact that the most frequently-occurring type of microsclere in the Lithistida is astrose. The fairly numerous Lithistida without microscleres offer no difficulty to this theory, for comparative study shows that microscleres have been independently lost during the evolution of various sponges. But the few forms with sigmata (Scleritoderma, Taprobane) do offer a difficulty, if we continue to lay such stress, as now, on differences in the matter of microscleres. The whole question (cf. Dendy 1905, p. 99) can only be raised, but not answered until our critical knowledge is much greater. Alternative hypotheses may be formulated as follows: (1) We may assume a monophyletic origin of the group and trace it back along with the Astrophora and Sigmatophora to Tetraxonida with both kinds of microscleres, asters and sigmata, in which case it would certainly be astonishing that the two kinds of microscleres had mutually repelled one another during the evolution of the Astrophora and Sigmatophora, and again within the Lithistida during the evolution of the existing families. (2) If we assume first the evolution of the Astrophora and Sigmatophora from Tetraxonida with both kinds of microscleres, and then the origin of the Lithistida from the former, it is at least conceivable, as Sollas has noted (*loc. cit.* p. CXX) that the occurrence of sigmata in some Lithistida is a case of reversion. Following out this idea, the reversion to sigmata might conceivably occur in Lithistids that had lost their microscleres. If we assume it to have occurred in forms with microscleres (asters), then again we meet the strange conclusion that sigmata and asters repel one another, the reversional variation which brings back sigmata driving out the asters. (3) If we lay stress in the first degree on the difference in microscleres, we are driven to conclude that the Lithistida have had a double origin, some from the Astrophora, some from the Sigmatophora, and that the habit of forming a complex body, the desma, on a free basic spicule, has been twice acquired. Doubtless the number of hypotheses that are logically sustainable, might be increased.

tions from his "Sponges of the Gulf of Mexico" (1879) may be made. "In the Sponge-fauna of the Atlantic Region, I have shown what a great rôle within the sponges is played by the phenomenon of convergence in the production of pseudo-homologies. These fall under the general concept of adaptations in so far as one is justified in speaking of adaptations to general mechanical laws" (*loc. cit.*, p. 4). Schmidt goes on to say that his entire criticism of characters, in the work of comparing organisms with one another, aims at distinguishing what is the result of inheritance and what the effect of the environment, the latter "only drawn into the stock of hereditary characters in the course of a gradual process of fixation" (an abstract statement into which more than one meaning may be read). He continues and notes that in most contributions of the time, especially those dealing with embryology, the possibility that morphological agreement is not always based on common descent and heredity, is far too lightly passed over (a habit of mind which the progress of physiological-mechanical studies has greatly changed since Schmidt's time).

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THE TURTLES OF NORTH CAROLINA; WITH A KEY TO THE TURTLES OF THE EASTERN UNITED STATES

By C. S. Brimley

The animals known as tortoises, turtles or terrapins, no one of which names by the way has an exact application to any particular group of the order, are distinguished from all other living reptiles by having the body enclosed in a bony shell, leaving only the head, neck and limbs free. This shell consists of two portions, an upper more or less arched portion known as the carapace and a lower, smaller, flattened part known as the plastron. These two are united on each side by a bony bridge or cartilaginous suture.

The majority of existing turtles have the shell covered with horny plates, which do not agree, either in size, number or position with the bony plates beneath (though on the carapace the general arrangement of both is similar), but in two small groups the shell is covered with a leathery skin instead.

The classification of turtles seems somewhat unsettled, but we can distinguish without much trouble a few main groups, whatever may be their exact relation to one another.

1. **Athecae.** Marine turtles with the shell composed of a mosaic of small hexagonal plates which are free from the ribs and vertebrae, and covered with a leathery black skin, and with seven longitudinal ridges down the back. This group includes only the leatherback turtles, the largest of all existing forms.

2. **Thecaphora.** In which the shell is composed of a number of bony plates, agreeing in number with and attached to or composed of the expanded ribs and upper processes of the vertebrae. These are attached to a row of marginal bony plates forming the edge of the shell, and these at the sides to another series of plates forming the plastron.

The Thecaphora comprise the majority of existing turtles and divide into:

(A) The soft-shelled turtles (Trionychoidea) in which the shell is flattened, orbicular and imperfectly ossified around the edges, and covered with a leathery skin. The species occur in most parts of the world.

(B) The side-necked turtles (Pleurodira) in which the shell is covered with horny plates and the neck bends sideways (in a horizontal plane) when drawn back. The species are all south tropical.

(C) The S-necked turtles (Cryptodira) in which the shell is covered with horny plates and the neck bends in a vertical plane when drawn back. The majority of existing turtles belong here, including all the marine species except the leatherbacks.

All of these groups except the Pleurodira are represented in this State or off our coasts, so that at present the turtles are known to be represented in our State by four marine and fourteen inland species.

Of the marine turtles, which, however they may differ in structure, all agree in having the limbs developed as flattened paddles for swimming and in having the front limbs much larger than the hind ones, we get the leatherback, green turtle, loggerhead and bastard turtle.

The leatherback is only occasional on our coast, but one caught near Beaufort is now preserved as a mounted specimen in the State Museum at Raleigh and weighed about 800 pounds. The species is sometimes used as a source of oil.

The green turtle used to be common on our coast but has been hunted so much for food, and its eggs collected for the same reason that it is now very scarce.

The loggerhead and bastard turtle are still quite common in summer and the former breeds but the latter does not, its breeding season being reported to be in the winter on the Florida coast.

These marine species all feed on both marine plants and animals.

Of the land and fresh water forms we get species belonging to three families, while members of a fourth, the Trionychidae or soft-shelled turtles should enter our State from either the south or west or both, but as yet we have no satisfactory records of them.

The three families referred to above are the Chelydridae or snapping turtles with a narrow cross-shaped plastron, large head and long tail; the Kinostermidae, or mud turtles, in which the plastron has ten or eleven plates and is divided into three parts, a fixed middle portion and a front and hind portion, both of the latter, or at least the front part being capable of being moved so as to partially close the shell, and the Testudinidae or terrapins, in which the plastron has twelve plates and is either wholly fixed or divided into only two portions, which are movable on a central hinge.

Only one species of snapping turtle occurs in our State, and this usually goes simply by the name of "turtle," all our other species being known as terrapins in this State. The snapper is the largest and the ugliest of our species reaching a weight of 25 pounds, and is also the one most frequently locally eaten, being in fact quite palatable. It is a voracious and vicious reptile, wholly carnivorous, and capable of inflicting a painful wound if carelessly handled. Its eggs are white, soft-shelled and spherical.

The second family includes two of our species, which much resemble the snapping turtles in habits, but differ in the broad plastron and smaller size, neither reaching a length of more than about four inches in the shell. The mud turtle has the head unstriped, and the plastron nearly as large as the shell opening, while the musk turtle has the head with yellow stripes and the plastron considerably smaller than the shell opening. The latter is more of a deep water animal, the former more of a shallow water form, preferring to hunt for its prey with its shell half in, half out of the water. The eggs are elongated, hard-shelled and white.

The balance of our turtles belong to the Testudinidae and all except one are aquatic and have wholly fixed plastrons.

The exception is the Box Turtle, commonly called Highland Terrapin in this State, which is mainly an inhabitant of damp woods, though I have found specimens buried in the wet mud of a swamp in a place where in a wet season they would have been fifty yards from shore. The short high arched shell and the moveable plastron which closes the shell completely when the animal has withdrawn its head and limbs within, distinguishes this from all our other species. Its food consists of fruit, succulent leaves of plants, and living or dead animals of any kind it can capture.

The remainder of our species differ but little in habits, all being aquatic inhabitants of pools and streams seldom leaving the water except to deposit their eggs, which are elongate and soft-shelled.

Roughly speaking, they divide into two groups, the smaller pond turtles with a smooth shell without variegated markings, and the larger terrapins, collectively often known as river terrapins, yellow-bellies, sliders or cooters, which have the shell almost invariably wrinkled or keeled or both. The former rarely attain a length of over five inches, the latter are from eight inches to a foot or more long when adult.

The small pond terrapins include only three of our species, the speckled terrapin in which the head and shell are marked with round, yellow dots, the mountain terrapin with the yellow markings confined to a yellowish patch on each side of the head just behind the eye, and finally the painted turtle in which the shell has red markings around the edges of the shell. The latter is the larger, attaining a length of five inches when adult, the other two not reaching more than four. The first and last are present in the greater part of our State, the mountain terrapin, in or near the mountain region only.

Of the larger terrapins we get five species of sliders proper, the long-necked chicken turtle and the diamond-back terrapin, the last being a salt marsh species.

The sliders are the largest of the group, some of them attaining a length of over a foot in the shell and a weight of ten pounds. The various species inhabit ponds and large streams and are most plentiful in the Mississippi Valley and the southeastern States.

I cannot say much as to the habits of this group, but of the two species which formerly constituted our Raleigh representatives, one (*Pseudemys concinna*) seemed to be more herbivorous in its habits, and the other (*P. scripta*), more omnivorous, eating flesh as well as plants.

The species are keeled when quite young, and the known young of all species with which I am acquainted are beautifully variegated with yellow and brown or green. Older specimens lose the keel and much of the color pattern disappears, so that many species look totally different when young than when adult.

The chicken turtle enters our list on account of its being recorded from Beaufort in Barbour and Stegneger's Cheek List. Of the habits of the animal in nature I know nothing but it differs in some respects from all our other turtles. The neck is very long, awkwardly long in fact, the shell is high and narrow, but rounded above, not keeled and the color pattern is a large meshed net work of narrow yellow lines on a brown ground. On dissecting out a specimen another marked difference appears, the free portion of the ribs (between the vertebrae and the costal plates) is long, slender and rounded instead of being short, broad and flat as in all our other turtles.

The diamond-back terrapin, the terrapin of the restaurants, is a salt marsh species, found only along the coast and may be recognized by the keeled shells and by the concentric lines on each plate from

which it gets its name. While the article of diet known as terrapin should come from this species, yet as a matter of fact the sliders are also to a large extent shipped to market, though, so far I know, not from this State.

One more group of turtles may be alluded to, namely, the soft-shells, which occur in the Mississippi Valley and the Southeastern States, but have not as yet been recorded from North Carolina.

They have flat, orbicular bodies, a long neck, and a long pig-shaped snout, and though the edges of the lips are fleshy, yet within are sharp-cutting edges which can inflict a painful wound. The species grow to a larger size than any of our inland turtles except the snapper, and are wholly carnivorous in diet.

Little has been said about the recorded distribution of our species and actually but little is known.

Raleigh, as usual, furnishes the best records, with 7 species, Beaufort comes next with 4 marine and 7 inland forms, while no other locality (except Lake Ellis with 6 and Greensboro and Chapel Hill with 4 each) gives us records of more than one or two species.

Yet we may reasonably infer that excepting the mountain terrapin, which is confined to the mountains, and the diamond-back, which is a salt-marsh species of the coast, our prevailing forms must range from the edge of the mountains to the coast, though some of the sliders probably are only found in the eastern half of the State and the status of a few is quite problematical.

A key to practically all eastern turtles follows, by eastern, I mean forms that are found east of the Mississippi, excluding the strictly Mississippi Valley species. The key will probably enable a tolerably intelligent person to identify most of the forms included with reasonable accuracy.

Species already recorded from North Carolina are preceded by a serial number, the rest are in italics and unnumbered, and the name is followedby the name of State nearest to North Carolina in which the species has been taken.

KEY TO THE TURTLES OF THE EASTERN UNITED STATES

1. Limbs long, flat and paddle like: front limbs with not more than two claws each. Marine turtles. See 2.

1. Limbs not paddle like, front limbs with three or more claws on each. Land and Freshwater Turtles. See 6.

2. Shell without horny plates, covered with a black leathery skin, and with seven longitudinal ridges down back. (1) Leatherback Sea Turtle (*Dermochelys coriacea*).

2. Shell with horny plates without longitudinal ridges. See 3.

3. Carapace mottled with yellow, and covered with loosely overlapping plates. Hawksbill Sea Turtle (*Eretmochelys imbricata*). Tropical and subtropical seas.

3. Carapace with smooth, not overlapping, plates. See 4.

4. Claws on front limbs one each, carapace mottled with yellow. (2) Green Sea Turtle (*Chelonia mydas*).

4. Claws on front limbs two each, carapace without yellow mottling. See 5.

5. Plates on under side of bridge three. (3) Loggerhead Sea Turtle (*Caretta caretta*).

5. Plates on under side of bridge four. (4) Bastard Turtle (*Caretta kempi*).

6. Shell covered with horny plates. See 7.

6. Shell covered with a leathery skin, form flattened and orbicular. Soft-shelled Turtles (Family Trionychidae). See 37.

7. Plastron narrow, cross-shaped, the plates of its central portion nine. Snapping Turtles (Family Chelydridae). See 8.

7. Plastron not narrow and cross shaped, its plates more than nine. See 9.

8. Under surface of tail with small scales: carapace with three strong keels at all ages. Alligator Snapper (*Macrohelys temminckii*), Georgia.

8. Under surface of tail with rather large plates, carapace without strong keels in adult. (5) Snapping Turtle (*Chelydra serpentina*).

9. Plastron with ten or eleven plates: front and hind portions of plastron hinged on fixed central portion and capable of partially closing the shell. Mud Turtles (Family Kinosternidae). See 10.

9. Plastron with twelve plates: plastron not as in the mud turtles. (Family Testudinidae). See 15.

10. Plastron comparatively small, hind portion capable of little movement, pectoral plate trapezoidal. Musk Turtles. See 11.

10. Plastron comparatively large, both hind and front parts moveable, pectoral plate subtriangular. Mud Turtles proper. See 12.

11. Head without yellow stripes: shell strongly keeled at all ages. Keeled Musk Turtle (*Kinosternon carinatum*), Georgia.

11. Head with yellow stripes, at least when young, shell not keeled in adult. (6) Musk Turtle (*Kinosternon odoratum*).

12. Carapace with three longitudinal yellow stripes: head with yellow stripes. Baur's Mud Turtle (*Kinosternon bauri*), Florida.

12. Carapace without stripes. See 13.

13. Head with yellow stripes. Louisiana Mud Turtle (*Kinosternon subrubrum hippocrepis*), Georgia.

13. Neither carapace nor head with stripes. See 14.

14. Plastron rather small, bridge very narrow, nasal shield deeply notched behind. Florida Mud Turtle (*Kinosternon steindachneri*), Florida.

14. Plastron and bridge of normal size, nasal shield not notched behind. (7) Common Mud Turtle (*Kinosternon subrubrum* [*pensilvanicum*]).

15. Plastron in two pieces, both movable on a transverse hinge, and joined to the carapace by a cartilaginous suture. See 16.

15. Plastron in one solid piece, joined to the carapace by a bony bridge. See 19.

16. Hind feet fully webbed; shell rather long and narrow, carapace with small yellow dots. Blanding's Turtle (*Emys blandingi*), Ohio.

16. Shell short and high, hind feet little or not at all webbed. Terrestrial species, Box Turtles. See 17.

17. Quadratojugal arch present. Shell usually with narrow radiating lines on each plate. Hind feet somewhat webbed. Gulf Box (*Terrapene major*), Georgia.

17. Quadratojugal arch absent. Carapace with large yellow spots, or broad radiating stripes, or unmarked. See 18.

18. Claws on hind feet three each. Three-Toed Box Turtle (*Terrapene carolina triunguis*), Georgia.

18. Claws on hind feet four each. (8) Common Box Turtle (*Terrapene carolina*).

19. Limbs thick and club-shaped, hind limbs the smallest. Shell with concentric striae on the plates, but not keeled. Terrestrial and burrowing in habits. Gopher Turtle (*Gopherus polyphemus*), South Carolina.

19. Limbs not club-shaped, hind limbs usually the largest. See 20.

20. Masticating surface of jaws narrow. See 21.

20. Masticating surface of jaws broad. See 23.

21. Shell with concentric striae on the plates, giving each plate a lumpy appearance. Shell keeled. Terrestrial. Wood Terrapin (*Clemmys insculptus*), New Jersey.

21. Shell smooth without striae or keel. Shell four inches or less. See 22.

22. Head and carapace with small round yellow spots. (9) Spotted Terrapin (*Clemmys guttatus*).

22. Carapace and head without round yellow spots, a yellow patch on each side of neck.

(10) Mountain Terrapin (*Clemmys nuchalis*),
Muhlenberg's Terrapin (*Clemmys muhlenberg*), N. J.

23. Masticating surface of jaws with longitudinal ridge down middle. See 24.

23. Masticating surface of jaws without longitudinal ridge; shell keeled. See 34.

24. Head and neck when extended about two-thirds length of shell, shell high and narrow, with a reticulated pattern of narrow yellow lines in large mesh. (11) Chicken Turtle (*Deirochelys reticularia*).

24. Head and neck not more than half length of shell. See 25.

25. Size comparatively small, usually not more than five inches in length of shell, shell smooth, no variegated markings on large plates of carapace. Shell with red markings around the edge. See 26.

25. Size comparatively large, adults from five inches to a foot or more in length of shell. Large plates of carapace usually with variegated markings. Plates of shell usually with longitudinal wrinkles. See 27.

26. Costal plates in line with the vertebrals so that the plates are in straight rows across the shell. (12) Painted Turtle (*Chrysemys picta*).

26. Costal plates altering with vertebrals. Western Painted Turtle (*Chrysemys cinerea*), New York.

27. Edge of one or both jaws serrated. See 28.

27. Both jaws with smooth edges. Plastron with more or less black. See 32.

28. Both jaws serrated, with a notch at the symphisis of upper jaw and a strong tooth or cusp on each side of it. See 29.

28. Lower jaw only serrated, no notch or tooth at tip of upper jaw. Plastron wholly yellow. See 30.

29. Carapace red and black, plastron red. (13) Redbellied Terrapin (Pseudemys rubriventris).

29. Carapace as above, plastron yellow and brown. Alabama Terrapin (*Pseudemys alabamensis*), Alabama.

30. Carapace smooth, head very small. Hieroglyphic Terrapin (*Pseudemys hieroglyphica*), Tennessee.

30. Carapace with wrinkles on the costal plates. See 31.

31. Shell comparatively short and high, markings on costal plates mainly transverse. (14) Florida Terrapin (*Pseudemys floridanus*).

31. Shell comparatively long and flat, markings on costal plates confused or reticulated. (15) River Terrapin (*Pseudemys concinna*).

31. Shell with an evident keel at all ages. An upright yellow bar behind eye. Black markings of plastron consisting of a roundish black spot on each of the two front plates (sometimes on all or nearly of the plates). (16) Yellow-bellied Terrapin (*Pseudemys scripta*).

32. Shell usually not keeled except in the very young. Black markings of plastron usually more extensive and elongate. See 33.

33. An oval red spot behind eye, and conspicuous yellow lines on head, neck and limbs. Red-Necked Terrapin (*Pseudemys elegans*), Tennessee.

33. No red spot behind eye, markings on head neck and limbs obscure or lacking. (17) Troost's Terrapin (*Pseudemys troosti*).

34. Shell with concentric striae on the plates. Salt marsh species. See 35.

35. Keel of each vertebral plate knobbed at tip. Southern Diamond-Back Terrapin (*Malaclemmys pileata*), and subspecies, Florida.

35. Keels of the vertebrals not knobbed. (18) Diamond-Back Terrapin (*Malaclemmys centrata*) and subspecies.

36. Keel of shell even, not tuberculate. A triangular yellow spot behind each eye. Map Terrapin (*Graptemys geographicus*), Virginia.

36. Keels of vertebrals rising into knobs or tubercles on each plate, an L-shaped yellow spot behind eye. Lesueur's Terrapin (*Graptemys pseudo-geographicus*), Virginia.

37. Shell with tubercles in front in adult. See 38.

37. Shell without tubercles in front in adult. Brown Soft-Shelled Turtle (*Amyda mutica*), Ohio.

38. Pale lines on top of head united just in front of eyes. Southern Soft-Shelled Turtle (*Amyda ferox*), South Carolina.

38. Pale lines on top of head united near tip of snout. Spiny Soft-Shelled Turtle (*Amyda spinifera*), Ohio.

RALEIGH, N. C.

A LITTLE-KNOWN VETCH DISEASE.

By Frederick A. Wolf.

Plates 2-6

Introduction

In the spring of 1918, a diseased condition of vetch was noted to be quite abundantly present upon the several species growing in the vicinity of West Raleigh, N. C., and in the following season, it was so destructive to hairy vetch, Vicia villosa, that the plants were practically all killed before they had reached the flowering stage. Since hairy vetch is the species most widely grown within the State as a winter cover crop and as a feed crop to be utilized either for grazing or for hay, this disease is to be regarded as of considerable economic importance. All parts of the plant above ground were affected in a manner quite characteristically different from any of the several diseases which had previously come under the writer's observation. It soon became apparent, from microscopic examination, however, that the disease was identical with one which had first been collected in the summer of 1907 on the horticultural grounds of Cornell University, Ithaca, N. Y. Since two concise mycological notes[1] containing brief descriptions of the appearance of the disease and of the structure of the casual organism, comprise the only publications dealing with this malady, investigations were forthwith begun. It is the present purpose, therefore, to report upon these studies, which have been conducted during the past three seasons, as a contribution to our knowledge of the distribution, symptomatology and dissemination of this disease and of the life history and structure of the pathogen.

Distribution

It has thus far not been possible to secure any considerable body of data on the distribution of the disease either within the State or within other States where species of vetch are cultivated. It has been collected in North Carolina, however, within the counties of Forsythe, Rowan, Montgomery, Granville, Wayne, and Wake and has been observed[2] by Mr. Roland McKee, Bureau of Plant Industry, Office of

[1] Atkinson, G. F., and Egerton, C. W. Protocoronospora, a new genus of fungi. Jour. Mycol. 13; p. 185-186, 1907. Preliminary note on a new disease of the cultivated vetch. Sci. N. S. 26; No. 664, p. 385-386, 1907.

[2] From a letter to the writer, dated May 23, 1919.

Forage Crop Investigations, Washington, D. C., to occur in South Carolina, Georgia, Alabama, Mississippi, Louisiana and Tennessee. Even though the disease was first collected in New York as long ago as 1907, plant pathologists generally are not familiar with it and specimens have, for this reason, not found their way into the several large herbaria. Since the disease has not received a common name, and has the appearance of an anthracnose, it is, in this account, designated as false anthracnose.

APPEARANCE OF THE DISEASE

False anthracnose can first be noticed during November and December when the plants are still small. A brownish discoloration which completely girdles the stems of the seedlings is at this time manifest. This discoloration begins near the surface of the soil and extends upward. The main stem becomes dwarfed in consequence and is soon surpassed in size by other shoots which develop below the lesions. In other cases, the main stem is so severely involved that it dies or the entire plant may succumb. The disease may be observed at any time during winter but makes little progress until spring. It then spreads rapidly upward upon the stem, producing characteristic, short, dark-brown to blackish streaks, Fig. 25, which may remain isolated or become so abundant as to quite uniformly discolor all of the invaded portions. Young stem lesions are at first grayish in color and their change through light brown to dark brown or black is due to the pigmentation of the mycelium within the cortical cells. Young stems are killed early in the season whereas older woody ones may live to maturity. The leaves, including stipules, petioles and leaflets, are successively involved, beginning with the lowermost. The lesions, except upon the leaflets, are entirely similar in outline to those upon the stems and pass progressively through the same changes in color. Those upon the leaflets may remain minute and circular with a tendency toward being most numerous along the principal veins or may appear as elongated, dark streaks. Affected leaflets are pale green in color, especially when several hundred spots develop upon a single leaflet, and become markedly chlorotic before the lesions attain their mature depth of color, Fig. 24. They eventually become dry and fall off.

The mature spots on the legumes or pods are so strikingly distinctive that there is no difficulty in distinguishing false anthracnose

of vetch from any other of the diseases of this plant. Young lesions are at first manifest as irregular purplish discolorations. The middle line of these discolored areas becomes whitish following the rupture of the epidermis by the acervulus or fruit-body of the fungus, Fig. 27. The mass of spores which comes out may give to the center of the spot a pale pink or salmon color. With age, the whitish portions of the lesions become black and the purplish halo disappears as the pods become dry. Mature lesions appear as black, elliptical or elongated oblique spots, Fig. 28, their direction being no doubt due to the oblique fibrous structure of the pod.

ETIOLOGY

False anthracnose is caused by an organism, Protocoronospora nigricans, which was described, in 1907, by Atkinson and Edgerton as the type of a new genus. Since, during the writer's studies, this fungus was found to possess certain characters, to be described later in this report, which are common to the true anthracnoses, comparison was made with the several species of Gloeosporium occurring on vetch. Specimens of the two American species, *Gloeosporium Davisii* E. et E. and *G. Everhartii* Sacc. et Syd., which occur on the legumes and on the leaves respectively of *Vicia americana* were loaned through the courtesy of Dr. J. J. Davis, Madison, Wisconsin, by whom they were first collected. The latter species was first described as *G. americanum* E. et E[3]., a combination which had been earlier employed for a fungus occurring on *Arauja albens* (described from Argentina by Spegazzini in Fungi Arg. Pug. II,, p. 36). Even though these two species differ in size of conidia, they will probably be found to be identical when submitted to cultural and inoculation tests. Certainly they are distinct from the organism under consideration.

A form which occurs on stems of *Vicia cracca* in France and was described[4] as *G. viciae* Fautrey et Roum. is also very different and beyond doubt is identical with *Myxosporium viciae* Fautrey. There is furthermore no chance of confusing *Protocoronospora nigricans* with *G. tricolor* Lind which produces a "frog-eye" leafspot disease of *Vicia cracca* in Denmark.[5]

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[3] Proc. Acad. Nat. Sci. Phila., 1893, p. 167.
[4] Fungi exsiccati precipue Gallici Centurie LV. Revue Mycologique annee 12, 1890, p. 168.
[5] Annales Mycol. 5: p. 277, 1907.

MORPHOLOGY OF *Protocoronospora nigricans*

As was indicated in the preliminary accounts by Atkinson and Edgerton, this fungus presents some very interesting structural features. They call attention, furthermore, to the fact that the gross appearance of the disease, the character of the fruit body, the pale pink or flesh color of the spores in mass, and their appearance when hastily examined under the microscope suggest the genus Gloesporium. Since, however, they found that the spores are borne at the apices of the conidiophores not singly, but in whorls and that these spores on germination bud in yeast-like fashion, characters not possessed by anthracnoses, they believed that the fungus resembled most nearly, the thelephoraceous genus, Corticium, and consequently placed it there in their provisional diagnosis. They did not find opportunity, however, to make a critical study of its morphology.

Methods—In the present investigation, use was made of cultures, of fresh material and of appropriately fixed and stained microtome sections. For the latter purpose, portions of stems, pods, and leaves were fixed in medium strength chromo-acetic acid solution and stained with Flemming's triple stain according to the shortened method recommended by Harper. The most satisfactory preparations showing the cytological features were secured when safranin was allowed to act 1-2 minutes, gentian violet 10-20 minutes and orange G. 20-30 seconds. Many of the details of the manner of penetration of the host and of the development and structure of the acervuli could be satisfactorily studied by microscopic examination of the epidermis stripped from fresh material.

The germination of the conidia and their development into colonies could be followed by repeated examinations of marked conidia planted upon the surface of hardened agar plate cultures. For this purpose, conidia were transferred from a lesion to a drop of sterile water on a microscpoic slide. A loopful of this suspension of conidia was transferred to one edge of the agar plate and spread over its surface with a zigzag stroke toward the opposite edge. No effort was made to sterilize the surface of the lesion and in consequence mixed cultures containing bacteria were always secured. The bacteria and conidia were sufficiently well separated toward the ultimate end of the stroke, however, to permit the isolation of single spore cultures or their development and study in situ.

Acervulus—The acervuli are either isolated or variously grouped and are always subepidermal in origin, Fig. 21. They open to the surface by the rupture of the epidermis in the form of a slit through which the conidia escape, or by an irregularly lacerate opening.

The stroma upon which the acervulus is seated usually extends 3 to 4 host cell layers in depth and is made up of compact pseudoparanchyma which is at first colorless and becomes with age brown to blackish, Fig. 13. This stroma completely occupies the interior of the host cells without apparent modification of their cell walls. The nourishing mycelium extends radiately from the periphery of the stroma, Fig. 21, and is confined for the most part to the epidermal and hypodermal cells. It has never been observed to be intercellular and cells whose cavities are practically filled with mycelium contain apparently normal intact nuclei. The hyphae composing this mycelium are also hyaline at first, but darken at maturity. Since the mycelium does not penetrate the xylem tissues there is insufficient interference with the conduction of water to prevent the tips of the plant from growing, even when the stems are involved for the greater part of their length.

The conidiophores arise within the epidermal cells and by their elongation rupture the cuticle which persists for a time as a frayed border at the margin of the acervulus. They are compactly arranged and in section appear palisade-like. They are cylindrical to clavate. in shape and quite variable in size, averaging 20-30 x 6-8μ. Those which are more slender are believed to be the structures which were interpreted by Atkinson and Edgerton as conidiophores intermingled with the basidia.

The conidia are borne in a whorl or crown at the apex of the conidiophore, Fig. 1, 6, 9, 10 and 17. They are not formed on sterigmata, but arise as protrusions from the apical wall of the conidiophore. As they are abstricted, others are formed in their places, resulting in the formation of a mass of conidia which may ooze out of the mouth of the acervulus. The conidia are oblong to subelliptical, straight or curved, continuous, hyaline, granular and measure 12-20 x 3-3.5μ, Fig. 2.

The setae are irregularly disposed through the acervuli, Fig. 13. They are very abundantly present on young vetch stems and can readily be distinguished with a hand lens. They are only sparingly present on old stems, however, and one may not be able to determine

their presence without access to serial sections of material embedded in paraffin. Setae on leaf lesions can best be demonstrated by stripping off the epidermis and making examination with the microscope, Fig. 21. Here acervuli will be found which have as few as a single seta or even none, whereas adjacent acervuli bear as many as six to eight. Setae have not been observed on affected pods, although many serial microtome sections of young and mature lesions have been studied. Since the setae do not stand perpendicular to the leaf surface, it would be difficult to get an entire seta in vertical section and they may, for this reason, have escaped detection. Furthermore, their presence in the genus Colletotrichum is known to be so variable that it is entirely possible that they are never formed in pod lesions. These seta are from two to three times the length of the conidiophores, are brown in color, either one-celled or at most, one-septate and gradually taper to a blunt point.

NUCLEAR PHENOMENA

Since Protocoronospora was provisionally placed in the Thelephoraceae, a family in the order Hymenomycetineae whose members possess basidia which are binucleate in the young condition and which arise from binucleate cells in the subhymenium, it was believed that a study of the nuclear conditions in this parasite would be of prime importance in determining its systematic position. Certain hymenomycetes have, of course, been described the cells of whose carpophores, except the hymenial portions, and the nutritive mycelium were either uninucleate or multinucleate.[6]

Accordingly lesions on stems, which were found to be more favorable for study than those on other parts of the plant, were sectioned and stained with Flemming's triple stain in a manner previously stated. The nuclei were found to vary greatly in size, a condition which has been noted in many other fungi. The largest nuclei measure about 3μ in diameter and are most easily observed in the cells at the periphery of the acervulus, either within the epidermis or within the more deeply lying host tissue. Here the hyphal cells are found to contain one to five nuclei (Figs. 14 and 16). The conidiophores and stromatic cells directly beneath them are found to possess considerably smaller, more numerous nuclei, since as many as twelve is not

[6] An excellent review of this situation with a bibliography of all of the important contributions to the subject is contained in a recent paper by Fitzpatrick, H. M. Crytology of Eocronartium musicola. Am. Jour. Bot. 5: No. 8, pp. 399-419, Pls. 30-33, 1918.

an unusual number (Fig. 17). The conidia were likewise multinucleate but none with more than three nuclei have been observed (Fig. 15). Whether the nuclei in conidia containing more than one nucleus had arisen by mitosis following abstriction of the conidium from the conidiophore or had migrated into the conidium before it had become separated, could not be determined. It is entirely likely, however. that multinucleate conidia arise from both conditions.

GERMINATION OF CONIDIA AND GROWTH IN CULTURE.

The organism causing false anthracnose has been isolated several times in each of the three seasons during which it has been studied. It has been cultivated on plain agar, dextrose agar, and vetch decoction agar, on sterilized vetch stems, steamed vetch seed meal, corn meal and tapioca. On each of these media, the isolated colonies remain small and black and are of the type shown in Figs. 22 and 23. When the cultures are heavily seeded with conidia, a compact black mycelial crust is formed over the surface.

The conidia are extremely variable in their method of germination. The most common method is budding in a yeast-like fashion, Figs. 1 and 4, so that the tertiary sporidia may be observed to be still connected seriatim with the parent conidia. These buds arise terminally or more rarely as lateral projections. The conidia may become once septate early in germination (Figs. 3 and 5) and may develop one or more germ tubes similar to the anthracnoses.

The cells of the parent conidium may become enlarged and brown walled within 48 hours and develop a rudimentary mycelium, Figs. 6 and 11. This mycelium may be so reduced that the original parent cells function both as mycelium and conidiophores, Figs. 6 and 9, in which case new conidia are formed as terminal buds. Quite an extensive, thick, closely septate, brown mycelium forms in other cases which may remain sterile, bud sparingly from lateral conidiophores. Fig. 10, or produce masses of conidia, Fig. 9. All the types of germination and growth illustrated in Figs. 3, 4, 5, 6, 9, 10 and 11 have been observed in the *same* vetch decoction agar plate, made by sowing the conidia on the surface of the agar. Conidia taken directly from acervuli have been found to be budding. In old cultures, abnormal conidia of the types shown in Fig. 7 may occur.

When the conidia are sown on the leaves of hairy vetch, they will within 48 hours, have become once septate, formed a slender tube

leading to a brown ovoid appresorium and penetration will have been accomplished, Figs. 18, 19, and 20. The infection tube arises from the lower side of the appresorium and effects entrance into the epidermis by dissolution of the cell wall. This process was observed several times in 1919 and confirmed during the present season. The mycelium then grows rapidly into adjacent cells and forms a new acervulus at the locus of infection. Within three to four days after infection has occurred, new acervuli have matured and are shedding their conidia, Fig. 21.

LIFE HISTORY OF THE CAUSAL ORGANISM

The false anthracnose fungus possesses only one type of reproductive structure which in the vicinity of Raleigh, N. C., may be produced at any time during the life of its host, or from early in November until the first of July. The organism bearing mature acervuli and conidia has been collected during each month of this eight-month period. It is first evident upon the seedling plants and may cause the outer cortical portions of the stems to be blackened to a height of several inches above the surface of the ground, without, however, invading the xylem portions. The disease makes little progress during winter, however, and only develops rapidly with the advent of favorable conditions which appear usually about the middle of April. It then spreads upward and involves all of the above-ground parts including the pods. Here it usually does not extend more deeply than the skeletal or supportive tissue of the pod wall, Fig. 8, but it may penetrate into the young seed. In case of severe infections such as occurred in 1919, the seed are prevented from developing. Lesions on young seeds show as discolored areas which are not noticeable, however, when the seed have matured. If mature seed taken from directly beneath lesions on the pod wall, are soaked in equal parts of alcohol and glycerin for several months to permit them to soften, and are sectioned, the hyphae or Protocoronospora will be found to have permeated all parts of the seed. Such an infected seed is shown in section in Fig. 12. The palisade-like cells of the young seed represented in Fig. 8-d, have become the Malphigian layer, Fig. 12-a, whose outer cell walls are thickened and show a highly refractive "light line."[7] Beneath is the scleroid layer subjacent to which is the

[7] An illuminating account of the structure of legume seeds to which the reader is referred was prepared by Pammel, L. H. Anatomical characters of the seeds of Leguminoseae, chiefly genera of Gray's Manual. Trans. Acad. Sci. St. Louis. 9; No. 6, pp. 91-273, pls. 7-35. 1899.

vestigal nucellar tissue. The hyphae will be noted to be present in all of these tissues which make up the seed coat and to extend into the storage tissues of the cotyledons beneath, Fig. 12-e.

The initiation of the disease in fields not previously seeded to vetch is due to the planting of infected seed. This is supported by field observations during the past two seasons and by an experiment planned to determine this point. Seed from affected pods were collected by the writer in the spring of 1918, and were sown in a new field. By April 15th of the following spring, the plants were abundantly diseased.

The organism can remain alive during summer on old affected parts which undoubtedly serve as a source of infection where vetch is permitted to reseed itself. No evidence has been secured that the organism possesses any other than the conidal stage although repeated examination has been made throughout the entire year of material kept out of doors in wire baskets. Were an ascigerous stage formed, it is not believed that it could have escaped detection. Furthermore, reproduction by conidia alone has occurred in cultures on the various media previously mentioned. Some of these cultures have been maintained for an entire year without transfer but with the addition of sterile water to replace that lost to evaporation.

INFECTION EXPERIMENTS

The organism is such a virulent parasite, as indicated by field observations, that little attention has been given to infection experiments except to study the manner of infection. Three series of inoculations were effected, however, upon plants grown in the greenhouse. Two were made with a crude inoculum consisting of the water in which diseased plants had been washed. This water was atomized upon healthy plants and characteristic lesions developed within ten days. The other was made with pure cultures of the organism grown on agar. A watery suspension of conidia was in this case applied with an atomizer to healthy plants on May 19. The plants were then shaded for 24 hours with a sheet of paper. By May 29 acervuli had matured on the stems and leaves of these inoculated plants.

HOST PLANTS

Protocoronospora nigricans appears to be limited to species of Vicia. It has been observed to be very destructive to *Vicia sativa*

and *V. villosa* although *V. angustifolia* and *V. dasycarpa* are very resistant to attack. This last-named species has been observed, for two seasons, to grow to maturity practically free from disease although it was intertwined with hairy vetch so severely affected that it failed to form pods. The growing of *Vicia dasycarpa*, a species with apparently all of the good characteristics of hairy vetch but which matures a little earlier, instead of *V. villosa*, gives promise, therefore, of being the most satisfactory way of combatting this disease.

GENERAL CONSIDERATIONS

Attention was called, as has been stated, by Atkinson and Edgerton in their preliminary report, to two characters possessed by the vetch organism which inclined them to believe that it was related to Corticium. These characters were the simultaneous formation of several spores from a basidium and the germination of these spores by budding. No special significance was attached by these investigators to the observation that the spores were sessile and that new spores were formed in place of those which had fallen away, although the presence of sterigmata and of a definite number of spores are known to be characters commonly present among the Basidiomycetes. Germination by budding appears to be not uncommon however, in both Hemibasidii and Eubasidii. Whatever may be said of these diagnostic characters, they should not be regarded as of as much importance in determining whether or not the organism is an Hymenomycete as the multinucleate character of the mycelium, conidia and conidiophores, a phenomenon not known among the basidium-bearing fungi. Because of this multinucleate condition, the organism is certainly not to be regarded as a member of the great group of fungi, Basidiomycetes.

Several characters, including the gross appearance of the spots, the pale pink color of the spores in mass, the structure and type of development of the acervulus, the presence of setae, the formation of appresoria when conidia germinate on the host, and germination of the type shown in Figs. 3 and 5, suggest its relationship to the form genus Colletotrichum. The conidia in the anthracnoses are borne singly at the end of the conidiophore whereas the vetch organism forms a number simultaneously. Some of the anthracnoses in culture, because of the more or less glutinous nature of the conidia, are known to give the hyphomycetous appearance shown in Figs. 6, 9, and 10. Furthermore, none of the anthracnoses *normally* bud, as

does the vetch fungus. Viala and Pacottet[8] claim to have observed budding in *Gloeosporium nervisequum* on sycamore but an examination of their figures indicates that they must have been working with contaminated cultures. Such a criticism has, in fact, been offered by several investigators, including Shear.[9] These last two characters are sufficiently distinctive to leave no reason for regarding the vetch fungus as an anthracnose.

In the writer's opinion the genus, Protocoronospora, with its single species, nigricans, should properly be transferred to the Melanconiales. It is realized that the various genera in the Fungi Imperfecti are arranged artificially and not phyllogenetically and that it is, therefore, difficult to properly relate the vetch organism. Under this artificial scheme, Protocoronospora should probably be placed near Colletotrichum. Perhaps some other student of this interesting organism will be able to find an ascigerous stage and thus to know its true relationship.

The following brief Latin description is given and involves the changes necessary in the transfer from the Thelephoraceae to the Melanconiaceae.

Protocoronospora Emend.

Acervulis innato-erumpentibus, in stromate pseudoparenchymatico, ex 2-5 stratis cellularum constituto insidientibus, ramuli mycelici ultimi conidiphora efformatibus; setulis atro brunneis; conidia sessiles, hyalina incolora, continua, leves, plures (plurumque 4-8), ex germinatione conidia conformia efformantes.

Protocoronospora Nigricans Atk. et Edg. Emend.

Plagulis angustis in legumibus foliis caulibusque, 2-5 mm. long., 1-2 mm. latis; primum irregulariter purpurascentibus, centro albicantibus v. purpureo cinctis, deinde nigricantibus; stromate subepidermatico e cellularis 6-9μ diam. constituto; setulis paucis v. numerosis, continuis v. uniseptatis atro-brunneis, 60-90 x 5-7μ; conidiophoris ex clavato subcylindraceis, 20-30 x 5-6μ, plurisporis; conidiis sessilibus ex conidiophoris conidia nova continuo gignentibus; conidiis in massa roseolis, ex oblongo ellipsoideis, granulosis, rectis vel curvulis, 12-20 x 3-5.5μ.

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[8] Viala, P. and Pacottet, P., Levures et Kystes des Gloeosporium. Ann. Inst. Nat. Agron. V. 5: Fasc. 1, p. 31-73, Figs. 32, Paris, 1906.

[9] Shear, C. L. and Wood, Anna K. Studies of fungous parasites belonging to the genus Glomerella. U. S. D. A. Bur. Plant Ind. Bul. 252, pp. 11-110, Figs. 4, Pls. 1-18, 1913.

Hab. parasitice in *Vicia sativa*, *V. villosa*, *V. angustifolia* et *V. dasycarpa*. Amer. bor.

An abundant supply of diseased material has been deposited in the herbaria of the Missouri Botanical Garden and the Office of Mycological Collections, Bureau of Plant Industry.

In conclusion, the writer wishes to express his appreciation and thanks to Dr. C. L. Shear, Bureau of Plant Industry, Washington, D. C., and Dr. E. A. Burt, Missouri Botanical Gardens, St. Louis, Mo., for their opinions and suggestions, given after examination of material, as to the taxonomy of this interesting fungus.

SUMMARY

A vetch disease previously little known has been under investigation during the past three years.

It was first collected at Ithaca, New York, in 1907 and is now known to occur also in North Carolina, South Carolina, Georgia, Alabama, Mississippi, Louisiana and Tennessee.

The disease is caused by *Protocoronospora nigricans* and since its gross appearance suggests an anthracnose, it may be appropriately called false anthracnose.

Dark brown to black, elongated lesions may appear upon any of the above-ground parts of the plant. Pod lesions are especially characteristic since they are oblique to the margin of the pod.

The disease is initiated in new fields by the planting of infected seed. This is demonstrated by the occurrence of hyphae within the seed and by the appearance of the disease on seedling plants in fields not previously seeded to vetch.

The fruit bodies of the parasite are subepidermal in origin and possess setae, and a number of conidia are borne simultaneously at the apices of the conidiophores. As these conidia fall away, new ones form in their places. The conidia germinate in a yeast-like fashion, by septation and the formation of germ tubes, by developing a thickened, short mycelium from which conidia are budded, and by the formation of appresoria from which the infection tubes arise.

It has not been possible to develop an ascigerous stage either in culture or upon affected plant parts kept out of doors.

All parts of the organism are multinucleate and primarily for this reason, it is not believed to be related to Corticium, a thelephoraceous fungus. It is believed to be more nearly like Colletotrichum, one of

the Melanconiceae and is accordingly transferred to this family of imperfect fungi.

Vicia sativa and *V. villosa* become severely affected under conditions in which *V. angustifolia* and *V. dasycarpa* remain practically free from disease.

WEST RALEIGH, N. C.

EXPLANATION OF FIGURES

PLATE 2

Figs 1-7 and 9-11 inclusive, are drawn to the same scale.

FIG. 1. Copy of unpublished camera lucida drawings of *Protocoronospora nigricans*, made by Dr. C. W. Edgerton in 1907. The conidiophores show several stages of conidial formation in whorls at the apex. The formation of yeast-like buds upon germination of conidia is also illustrated.

FIG. 2. Normal conidia of *Protocoronospora nigricans* taken from diseased vetch.

FIG. 3. Germination of conidia in hanging drops of tap water in which vetch stems have been macerated. Septation and the formation of one or more germ tubes is shown.

FIG. 4. The usual type of germination by budding as occurs in tap water, plain agar or various kinds of nutrient agar, 24 to 48 hours old.

FIG. 5. A type of germination not uncommon on a variety of nutrient agar.

FIG. 6. In agar cultures in which certain conidia germinate as in Figs. 4 and 5, others form a thickened, short mycelium which sporulates terminally or from lateral branches.

FIG. 7. Abnormal conidia as appear in old cultures on corn meal.

FIG. 8. Vertical section through a lesion on young vetch pod.

(a) Conidia, conidiophores and fungous stroma;
(b) Hypodermal parenchyma occupied by intracellular mycelium;
(c) Sclerenchyma tissue of pod wall;
(d) Embryonic cells of the younger seed. The palisade-like cells become the Malphigan layer in the mature seed.

FIG. 9. Characteristic short mycelium in agar cultures four days old, showing abundant conidial formation.

FIG. 10. Much branched mycelium with few or no conidia found in the same cultures as the condition represented in Figs. 6 and 9.

FIG. 11. Sterile mycelium from four day old nutrient agar plates.

FIG. 12. Section of mature infected vetch seed, showing the mycelium of Protocoronospora in the various tissues;

(a) Malphigian layer, the outer wall of whose cells is very much thickened and shows the characteristic "light line" so common in seeds of eguminoseae;
(b) Scleroid layer;
(c) Vestigal nucellar tissue;
(d) Epidermis of the cotyledon;
(e) Cotyledonary tissue abundantly filled with starch.

PLATE 2

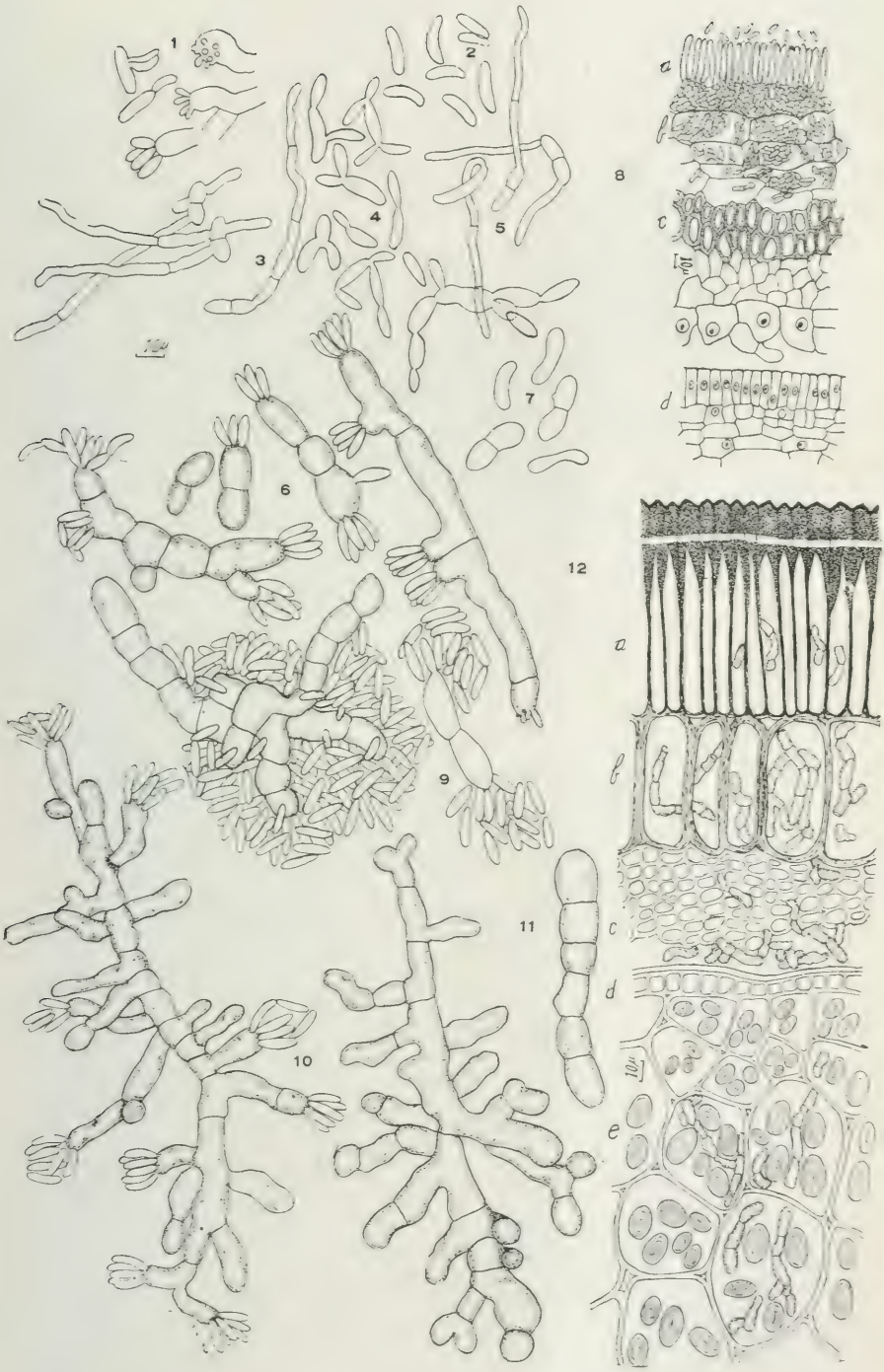


PLATE 3

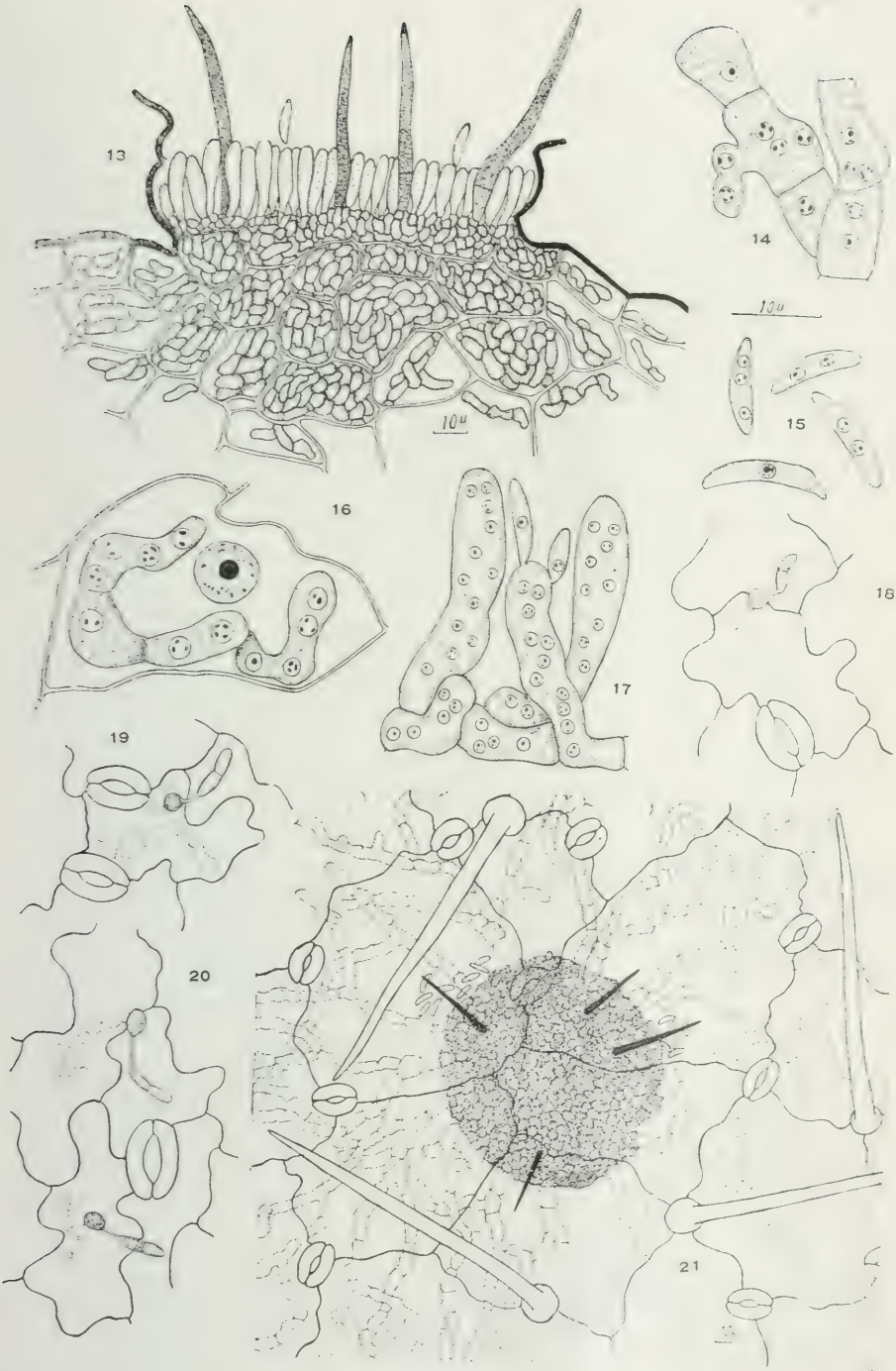
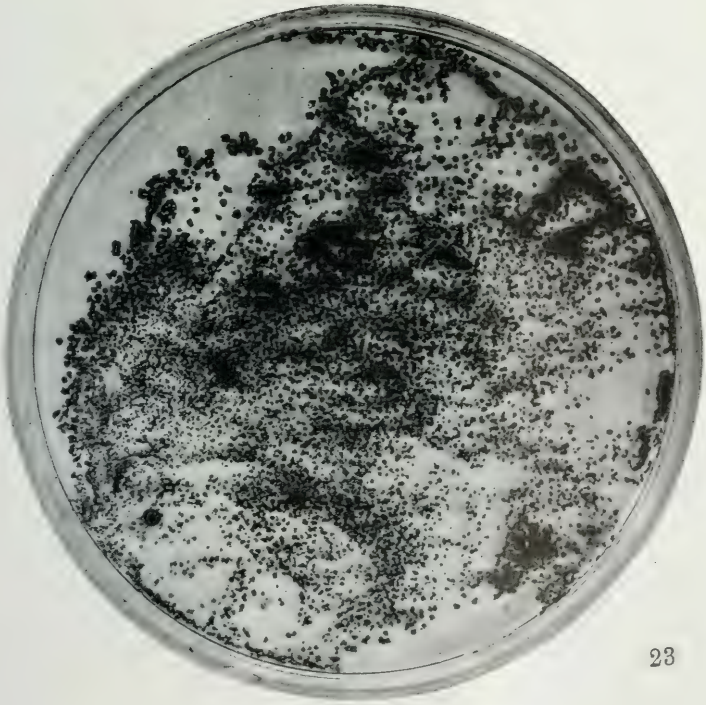


PLATE 4

22



23

PLATE 5

24

25

PLATE 6

26

27

28

PLATE 3

Figs. 13, 18, 19, and 20, are drawn to the same scale; the magnification of Figs. 14-17, inclusive, is alike.

FIG. 13. Acervulus in cross section of Protocoronospora on vetch stem. The stroma extends 3 to 4 host cell layers in depth.

FIG. 14. Multinucleate mycelium taken from the margin of an acervulus.

FIG. 15. Variation in size and shape of conidia and in the number of nuclei.

FIG. 16. Multinucleate cells from beneath the stroma.

FIG. 17. Multinucleate conidiophores and cells of the stroma.

FIG. 18. Germination of conidium on upper leaf surface of hairy vetch. The formation of the appresorium is followed by infection within 36 to 48 hours.

FIG. 19. Infection through the epidermis on the lower surface of the leaf.

FIG. 20. Penetration by conidia lodged on the upper leaf surface.

FIG. 21. A surface view of an acervulus six days after inoculation.

PLATE 4

FIG. 22. Colonies of *Protocoronospora nigricans,* one week old, on vetch decoction agar.

FIG. 23. Two week's old cultures on the same medium.

PLATE 5

FIG. 24. Lesions on leaves of hairy vetch.

FIG. 25. Stones with elongated, dark brown to black lesions.

PLATE 6

FIG. 26. Pods showing the oblique oblong lesions typical of false anthracnose.

FIG. 27. Young lesions with whitish centers on young pods. The pod at the extreme left of the series had purplish discolored areas but fruit bodies of the causal organism have not yet been formed.

FIG. 28. The dark oblique areas are lesions on mature pods.

NOTES ON THE MOSQUITO FAUNA OF NORTH CAROLINA

By Franklin Sherman

For many years the Division of Entomology, State Department of Agriculture at Raleigh, has been accumulating records of the different species of mosquitoes known in the State, the localities where found, the months when present, etc. Recently this subject has been assumed as one of our regular projects of work. The data included in this paper were not gathered by the author alone,—Mr. R. W. Leiby, of our Division, gave a paper on mosquito control before this body a year ago, and is actively contributing to our records,—so also is Mr. C. S. Brimley. Mr. G. M. Bentley, formerly with the Division, contributed a number of records. Dr. Harvey P. Barrett, of Charlotte, has furnished a large number of records based chiefly on rearings from the larvae, and further work with him is contemplated for this year. Mr. Max Kisluik of the U. S. Bureau of Entomology, stationed at Wilmington, has furnished records from that locality. Many of our determinations have been made by authorities at Washington, notably Dr. H. G. Dyar and the late Messrs. Coquillet and Knab.

The interest in mosquito control was accentuated in the State during the recent war by the work done under the Public Health Service, notably around the camps at Charlotte and Raleigh and shipyards at Wilmington. Since hostilities ceased a number of other communities in the State are undertaking control work in co-operation with the Public Health Service.

The importance of mosquitoes as pests of man need be only briefly mentioned:—it has been abundantly proven that malaria and yellow fever are transmitted by them. There are large areas, even in this State, where land values and crop production are lower than should be on account of malaria. We have had yellow fever cases in past years,—the particular species of mosquito which transmits yellow fever is a fully-established member of our fauna. The irritation, vexation and unrest caused by our many species which merely bite, are known to all.

The main outstanding features of mosquito biology may be sketched as follows: The adult female mosquitoes lay their eggs or or near water. The larvae, called "wrigglers", which hatch from these eggs live in the water, coming to the surface for air. As they are frail

little creatures quiet waters not violently agitated by storms and rapid currents, are most favorable to them. This often means stagnant water, but not necessarily so. Completing its larval life within a week or longer, it changes to a pupa, which stage lasts for a day or longer, when it emerges as an adult, winged mosquito. The length of life of the adult is indefinite,—some live over winter, some species have been kept alive in summer for two months or more. Adult mosquitoes usually fly for distances of less than a mile,—but some species are more migratory, and with favorable light winds may travel much longer distances.

The chief features of mosquito control can be briefly outlined as follows: (1) Drainage of stagnant or standing water when practicable; (2) straightening and clearing of drains to secure prompt disposal of the flow; (3) oiling of such waters as may still serve as breeding places; (4) stocking with small insect-eating fishes of such waters as cannot be guarded by other means; (5) screening of houses; (6) use of smudges, lotions, perfumes, etc. Accepting one mile as the general limit of flight, the Public Health Service extends the drainage work for one mile beyond the limits of the camp, yard, town or other particular area to be guarded.

Most rules have exceptions,—and although mosquitoes adhere quite closely to the general principles just laid down, yet there are certain species which are exceptional in certain particulars and unless we know something about these exceptions, and how to allow for them,—we are liable to unpleasant and disappointing surprises,—and the public, often inclined to snap judgment, may criticise and even abandon control work which is really well done, because of the intervention of exceptional circumstances. Thus the control work in vicinity of Wilmington might be ever so well done,—it might almost, it might entirely eliminate malaria,—yet a favoring breeze might bring into that city countless thousands of mosqutoes of the species *Aedes sollicitans* which breed in the salt marshes of the coast ten to twenty miles away, and which is known to migrate for long distances. Such an invasion, temporary though it may be, might arouse much criticism. A house may be "screened," yet small species of mosquitoes may easily crawl through the meshes of an ordinary fly-screen. A pool may be oiled and yet the mosquito *Mansonia perturbans* may breed from it, because the larva of this species does not come to the surface for air but lives in the saturated mud about the roots of aquatic plants.

There are many variations in exact habits,—certain species are especially prone to enter houses for human victims, others seldom or never do this,—the larvae of certain species predominate in rain-barrels or cisterns, while others are seldom found there,—certain species are active chiefly after sundown, others are equally or more active during the day,—certain species are very averse to flying in a breeze, others take advantage of it to cover long distances. The importance of ascertaining which, if any, of the disease-bearing mosquitoes occur in any locality, is self-evident. This cannot be done by disease-records, for we have no yellow-fever records at present, but we do have the yellow--fever mosquito—so far as we know, it would only require the in-coming of a sufferer from this disease, at the opportune season, to start an epidemic. Hence, it requires the study of the mosquitoes themselves, the study of the mosquito-breeding waters, and the recording of all possible data on each separate species before we can claim to have adequate scientific data bearing upon the mosquito problem as a whole. And this phase of the subject, being the strictly entomological part of it, is the one which claims our chief attention in this

The entire list of species for the State, so far as ascertained, includes 32 species, while it is probable that from 10 to 15 more yet await discovery.

It so happens that we have no positive record of any adult mosquito being taken in February, but we have records for every other month of the year.

The localities whose mosquito fauna is best known are: Charlotte, with a list of 23 species; Wilmington, with 15 species; Raleigh, 13 species; Blowing Rock, 5; Henderson County, 5; Havelock (Craven County), 5. Twenty-three other localities have from 1 to 4 species on record.

Let us now adopt the convenient division of the State into three main regions: eastern, central and western.

1. *Eastern.* This we will consider to include all from the coast to Raleigh and Southern Pines but not including either of those two localities. Twenty-one distinct species of mosquitoes have been taken in this region,—of these, five species have not been taken in either of the other regions, so far as our present records indicate, they are exclusively eastern,—nine of the species have been taken in both the eastern and central regions but not in western,—while the remaining seven species have been taken in all three regions.

2. *Central.* We will consider this region to include Raleigh and Southern Pines and westward to the foot of the Blue Ridge, including Tryon. This reckoning places Raleigh and Charlotte (comparatively well-worked localities) in this area, and gives it a predominance, for the present, in the number of species on record. Twenty-seven species of mosquitos have been taken in this Central region,—eight of which have not yet been taken in the other areas,—nine (as before mentioned) have been taken in central and eastern regions but not in the west,—three have been taken in both central and western areas but not in the east,—the remaining seven have been taken in all three regions.

3. *Western.* We will consider this region to include the strictly mountain area of the Blue Ridge and west of it. Ten species of mosquitoes have been taken in this region, none of which are confined to it,—three of them having been taken in the western and central areas only,—the other seven being ones which have been taken in all three regions.

It is probable that further studies will show some of the species which are now known only in our central area to occur in the eastern area also. Dr. Barrett has taken one or more southerly species at Charlotte, which is further north than they were before known to occur, and such species are very likely to occur in our eastern region whose general fauna appears to be more southerly than at Charlotte. Indeed, the general showing would no doubt be considerably altered in its details, if our knowledge of our mosquito fauna, and its distribution, were as complete as we hope eventually to make it.

Already enough is known to indicate that in number of species the central section of the State will compare with the eastern, whatever disparity there may be in numbers of individuals,—even if all of the species now known in the central region are eventually found in the east, and if no more were found in the central region, its present list of twenty-seven species is sufficient to show that it has a mosquito fauna worthy of consideration. Owing to the presence of larger undrained areas it is undoubtedly true that the total mosquito population is the greatest in the east, and for the opposite reason, least in the mountains. As yet the mosquito fauna of the mountains has been least explored. A complete list from that region would probably show a surprising variety, but the areas for breeding are more restricted.

Adult mosquitoes have been found in our State virtually throughout the year. The number of species which have been taken in each of the several months is as follows: January 2; February none, it so happens; March 3; April 5; May 13; June 14; July 13; August 21; September 9; October 10; November 5; December 3. Of the malarial group two species have been taken at all seasons, these wintering in the adult stage,—the third species of the malarial group has been taken from March to September, inclusive. The yellow-fever mosquito has been taken June to November, inclusive. The species which perhaps breeds more abundantly than any other in eaves-troughs, cisterns and rainbarrels and which is our most common house mosquito, has been taken April to November, inclusive. The exceptional species whose larva lives in mud at the roots of water plants and which, therefore, would not be wholly eliminated by the usual means of control, has been taken in all three regions of the State in the months of June, July and August.

With so many species of mosquitoes in every section (and every other State in this part of the country has a comparable list if worked up and put on record), and with many of them presenting exceptions to the usual rules of mosquito life,—the intelligent and informed citizen will not expect perfect, absolute, complete results from any system of control work. There will be occasions when mosquitoes become abundant, by local breeding or by invasion from outside, in the best-protected areas,—they may even develop in unsuspected places inside the house itself.

It has not been our purpose to here discuss the details of control further than already mentioned,—rather it has been our purpose to give an idea of the mosquito life of the State as a whole, so far as now known.

NOTES ON THE SPECIES

Arrangement is alphabetical. Many of the notes are from Smith "Report of Mosquitoes of New Jersey," or Howard, Dyar and Knab "Mosquitoes of North and Central America."

1. *Aedes atlanticus*, Dyar and Knab. An inhabitant of swamps and woods. Not known to invade houses. Taken in east part of State,—May, June and August.

2. *Aedes atropalpus*, (Coq.) D. and K. A small species, rather northern. Taken in central and west parts of State,—no record as to month.

3. *Aedes bimaculatus,* (Coq.) D. and K. A southerly species. Life and habits not fully known. Larvae taken at Charlotte in July.

4. *Aedes calopus,* (Meigen) D. and K. This is the species which transmits yellow fever. Flies and bites in day. Invades houses. Taken in east and central parts of State,—June, July, August, September, October and November.

5. *Aedes canadensis,* (Theobald) D. and K. Larvae in woodland pools. Adults seldom leave woods. Of wide range, but as yet taken only in east and central parts of State,—April, May, June, July and August.

6. *Aedes mitchellae,* (Dyar) D. and K. A southeastern species. Taken at Wilmington in December.

7. *Aedes sollicitans,* (Walker) D. and K. A coastwise species, the larvae living chiefly in salt marshes, but also in brackish or fresh water. Known to fly as much as 40 miles inland. Taken at Wilmington and Beaufort on our coast, and recorded at Charlotte where perhaps carried by train,—June and August.

8. *Aedes sylvestris,* (Theobald) D. and K. One of the species which frequents porches and sometimes enters houses. A common species of wide range. Taken in east and central parts of the State,—May, June, July and August.

9. *Aedes taeniorhynchus,* (Wied) Busck. A coast-wise species of rather small size which migrates, but not so far as *sollicitans.* Bites in daytime. Does not seem to enter houses, but has been taken on porches. Taken at Wilmington and Beaufort on our coast,—May, June and August.

10. *Aedes tormentor,* D. and K. A southern species taken as far north as Arkansas and recorded for Charlotte in our State,—without record as to month.

11. *Aedes triseriatus,* (Say) D. and K. A species whose larvae live chiefly in water caught in holes in trees,—the adult being a ready biter in the woods, but not entering houses. Taken in all three regions (east, central and west) in our State,—May, June, August, September and October.

12. *Anopheles crucians,* Wied. This is one of the malarial group and known to be a carrier of the "aestivo-autumnal" form of malaria, but not of other forms. It bites late in day and early morning as well as at night, and readily enters houses. Taken in east, central and west parts of our State,—March, May, June, August and September. As with others of this group the body is usually tilted at an angle while biting. Wings spotted.

13. *Anopheles quadrimaculatus,* Say. This species is believed to be the most frequent carrier of malaria. Winters as adult. Taken in east and central parts of the State, not yet in the west,—January, April, July, August, September, October, November and December. Body tilted when biting. Wings spotted.

14. *Anopheles punctipennis,* Say. Has been apparently proven to transmit malaria, but not believed to do so as freely as the preceeding. Winters as adult. In our State this seems to be the most common of the three species of the malarial group. Taken in east, central and west parts of State in every month with one exception (Feb.) Body tilted when biting. Wings spotted.

15. *Coelodiazesis barberi,* (Coquillet) D. and K. Breeds in water in holes in trees, and sometimes present in woods when country is so dry than few other kinds are present. A small species. Our only State record is from Tryon at foot of mountains, without mention of the month.

16. *Culex floridanus*, D. and K. A very small southern species, recorded from Charlotte for July and August.

17. *Culex melanurus*, Coquillett. A dark-colored species of wide range which apparently does not bite. Our only record is from White Lake (Bladen County) in May.

18. *Culex peccator*, D. and K. A rather small southern species, recorded from Arkansas, and from Charlotte in our State in August. Apparently a frequenter of caves and tree-holes. Not known whether it bites.

19. *Culex quinquefasciatus*, Say. This is probably our most abundant and universally-present house-frequenting mosquito. Larvae abundant in rainbarrels, cisterns, troughs, temporary pools, sluggish and foul water, etc. Corresponds to the common *C. pipiens* of the northern States. Taken in east, central and west parts of the State,—April, May, June, July, August, September, October and November.

20. *Culex restuans*, Theobald. In general character like the preceeding, but not so abundant, nor breeding in so foul water. Our records are from the central and west parts of the State,—June and October.

21. *Culex salinarius*, Coquillett. A species of wide range, though also occurring close to coast, hence the name. Enters houses. Taken in east and central parts of the State,—May, August, September, October and November.

22. *Culex territans*, Walker. A rather small, dark species which perhaps does not bite persons. Our only records are for Charlotte and Blowing Rock, —August.

23. *Culiseta inornatus*, (Will.) Dyar. A rather large species which freely bites cattle and horses, perhaps in preference to man. Of wide range but our few records are from Wilmington and Charlotte,—March.

24. *Mansonia perturbans*, (Walk.) Dyar. The larva lives in mud at roots of aquatic plants, not coming to surface for air. A species of wide range. Enters houses. A fierce biter. Taken in east, central and west parts of the State,—June, July and August.

25. *Megarhinus septentrionalis*, Dyar and Knab. A very large mosquito with metallic blue lustre, often found on flowers. Taken east, central and west in the State,—July, August, September and October.

26. *Orthopodomyia signifier*, Coquillet. A wide-spread species not positively known to bite. Our only records are from Raleigh and Charlotte,—October.

27. *Psorophora ciliata*, (Fab.) Rob.—Des. A large species with erect scales on the legs giving fringed appearance. Ready biter and goes indoors, but not usually abundant in houses. Taken in eastern and central parts of State,—May, June, August, October.

28. *Psorophora columbae*, Dyar and Knab. A day as well as evening biter. Seldom indoors. East and central parts of State,—May, July, August.

29. *Psorophora discolor*, Coquillett. Our only record is from Charlotte,—July and August.

30. *Psorophora howardi*, Coquillet. A large species, of which our only record is Charlotte,—without indication of month.

31. *Psorophora sayi,* Dyar and Knab. A species of wide range, a severe day biter, but apparently not usual in houses. Our records are from east, central and west parts of the State,—May, June, July, August and September.

32. *Wyeomyia smithii,* (Coq.) Felt. The larva of this species is known to live normally in the water contained in the stems of pitcher-plants. The adult is not known to bite. Our only record is from Boardman (Columbus County)—larvae in pitcher-plant in April.

RALEIGH, N. C.

AN INTERESTING FERTILIZER PROBLEM

By H. B. Arbuckle

Last summer a large number of farmers in Rockingham county suffered almost total loss of their tobacco crop. It so happened that one of these farmers used two bags of fertilizer that he had kept over from the previous year. He observed that the rows of tobacco upon which he used this old fertilizer to the very plant in the row where he changed to the new fertilizer grew off well and produced well. All the rest of his tobacco was stunted and never showed any growth except in very rainy weather.

This was sufficient to fix suspicion upon the new fertilizer. This led to my investigation. The fertilizer was marked "For Tobacco" and the tag showed a guaranteed analysis, 8-2-2. On analysis the fertilizer checked up very well as 8-2-2. The nitrogen was a little low as determined by Kjeldahl, showing approximately 1.5. It is interesting to note that when the nitrogen was determined by Dumas, it ran distinctly higher.

The fertilizer was at once tried out on boxes of clover and rye at the rate of 1,000 lbs. per acre and compared with a fertilizer prepared in the laboratory to yield 8-2-2, the potash being supplied as potassium sulphate and the nitrogen as sodium nitrate. In these experiments the fertilizer under investigation showed up to fine advantage, showing distinct advantage over the prepared fertilizer. Having no tobacco plants at this time, the fertilizer was reported as good, but the farmers insisted that it be tried out on tobacco. After growing a lot of tobacco plants a set of boxes was prepared to test this fertilizer in varying amounts and other fertilizers prepared with potash and nitrogen from different sources. Having discovered that the fertilizer under test contained over 1% of chlorides and knowing that chlorides were not good for tobacco, the chlorine was removed from the fertilizer. It was found that the tobacco plants in the boxes in which 600 lbs. was used in the row or 1,000 lbs. mixed with the soil were nearly all killed. The few plants remaining were pale and sickly and produced no growth in two months time. The plants in those boxes fertilized with 1,000 lbs. of the fertilizer with the chlorine removed grew nicely, comparing favorably with the best fertilizers prepared for tobacco.

Knowing that one per cent of chlorine could not kill tobacco, boxes were prepared in which we used as much as 200 lbs. of sodium chloride per acre. As was expected this did not injure the plants. The chlorides do not affect the growth, but only the burning quality of the tobacco.

We next tried the fertilizer on tomato plants and found that these were injured, but not as much as the tobacco plants. Then we investigated various solutions of the fertilizer. We found it was the water solution alone that injured the tobacco. A small plant in a beaker was killed in twenty-four hours by the application of a solution that represented 2,000 lbs. per acre. Next we removed the organic matter by prolonged heating, taking up the ash with hydrochloric, sulphuric and nitric acids. The plants were injured not at all by the water solution of these salts, but little growth was shown, because the organic matter unquestionably stimulates plant growth, as could be shown in the study of stable manures. It was noted with interest that the nitric acid solution gave after a time a most vigorous growth. This might have been expected. We then tried water solution of the fertilizer under investigation after heating for an hour at 120° for thirty minutes. We found that this solution when applied in quantities representing 1,000 lbs. per acre gave excellent results.

The toxic substance or substances present seemed to be removed or changed by heat. We repeatedly demonstrated the good results with the fertilizer thus treated. We now had the explanation of the puzzling fact about the chlorine. In removing the chlorides with silver sulphate, heat was employed to avoid the loss of the phosphates. The heat had destroyed the toxic substances in this case as in the case of the straight samples.

By accident we discovered that the toxic substances are also removed by leaving the fertilizer exposed to the sunlight in a warm place, as a bottle containing the fertilizer was left for one week in the balance room where it was exposed to strong light from the south. Water solution of this exposed fertilizer had no effect whatsoever on tobacco plants.

Thus it appears that there is an organic substance present in this fertilizer, which is toxic to tobacco plants and tomato plants, while it has no effect upon rye and clover. This toxic substance is made harmless by heating or by exposure to sunlight. What the substance is still remains a puzzle. Thinking it might be a nitrogen compound, prob-

ably an amido compound derived from decomposition of tankage or some form of animal nitrogen, we determined the nitrgen in samples of the fertilizer after it had been rendered harmless. The percentage was higher than in the original sample. This, however, may be due fact that the water content had been changed. Unfortunately, we had not determined this in the original samples. We carried through a set of experiments to see how many organic substances containing nitrogen were toxic to tobacco plants.

These experiments showed several substances that were quite toxic, notably the nitro phenols, pyridine and piperidine. This was but a confirmation of experiments conducted by Cameron. Here is an interesting problem that deserves the attention of the fertilizer manufacturer, especially in this day, when he is ransacking the world to find sources of potash and nitrogen. In the future will it not leave the manufacturer liable if he sells a fertilizer with a guarantee that it will grow a particular crop and it is found to injure it?

In this particular case the tobacco fertilizer did enormous damage.

It can be rendered harmless in a very simple way, but it is the manufacturer's job to discover this and not the farmer's. This should lead to the testing out of samples of every fertilizer sold for a particular crop.

DAVIDSON, N. C.

AZALEA ATLANTICA ASHE AND ITS VARIETY LUTEO-ALBA N. VAR.

By W. C. Coker

Plates 1 and 7

For about eight years I have had under observation a striking species of Azalea, a typical and abundant constituent of low, damp, pine barrens of the coastal plain. My brother, James L. Coker, Jr., first called my attention to the distinction between this species and *A. nudiflora*, which blooms at the same time and with which it is often confused by careless observers. The species is not included in the treatment of the genus in the North American Flora by Dr. Small, but in April, 1917, Mr. W. W. Ashe published in the Bulletin of the Charleston Museum (13: 26. 1917) a new species, *Azalea atlantica*, the description of which agrees well with our plants except that the color was said to be rose-purple or reddish. As our plant has essentially white flowers throughout its range it seemed improbable that they could be the same. However, on talking with Mr. Ashe he admitted that the flowers were nearly pure white when open, thus removing the principal point of difference. I have also now at hand a specimen in flower from the type locality (Georgetown, S. C.) sent me by Mr. T. G. Harbison on April 26, 1918, and find it the same as Hartsville specimens in all essentials. I now have the plant (from Hartsville) in cultivation in the Arboretum of the University of North Carolina, where it flowered this year.

Azalea atlantica Ashe.

The typical form of the species, as I have observed it, may be described as follows:

Shoots low, slender, strict, hairy or glandular when young, smooth later, sparingly branched, about 15-55 cm. (6-18 in.) high, springing from underground runners and thus forming extensive colonies; leaves up to about 4 cm. long and 1.7 cm. broad, elliptic to obovate, the base pointed at the very short petiole, the tip with a short mucro, margin not recurved or slightly so, ciliate with curved tooth-like hairs, upper surface smooth or sparingly pubescent, the lower nearly smooth or moderately pubescent, grayish-green, the midrib not ciliate (or ciliate, at least when young, in the Georgetown plants). Flowers appearing during the whole of April, 3-4.5 cm. long, glandular and sparingly pubescent or only glandular, not hairy, very fragrant, unfolding before the leaves or in part lagging and simultaneous; corolla tube 2-3 cm. long, expanding

into the open throat, the acute petals with a spread of 3-4 cm., color pure white when open except for a blush of pink or purple on outside near base of tube; the buds more pink. Calyx two-thirds to three-fourths as long as the ovary, varying (in the North Carolina plant) to nearly as long, the strap-shaped lobes blunt, unequal, and upright (recurved or revolute on drying at times), separate to near or below the middle, glandular only or both glandular and with the margin hairy; ovary about 4 mm. long and 3 mm. thick, style about 4-6 cm. long, pale pink to greenish white, hairy (not glandular) over lower half or two-thirds, the knob-like stigma greenish brown; stamens well exserted (about 2 cm.), but not nearly so much so as in *A. nudiflora*, whitish or pale green; pedicels about 7-13 mm. long, pink or greenish. Mature pods about 2 cm. long and 6-7 mm. thick, pointed, somewhat curved, nearly glabrous, dark. Floral glands reddish, very short-stalked, present on pedicels, calyx, ovary and on the outside of the corolla tube and along the central keels of the spreading lobes. Odor strong and very pleasant.

Azalea atlantica var. **luteo-alba** n. var.

Flowers smaller, white when open, the buds and opening flowers with a decided yellowish tint; not pinkish. Otherwise as in the type. Occurring in similar habitats as the type but in separate colonies, and not intermixed. We have found it only at Hartsville, S. C.

A well-marked species that is easily distinguished from *A. nudiflora*, which occurs plentifully in the same territory, though rarely intermixed. It differs in the white, very fragrant, and viscid-glandular (not hairy) flowers with longer tubes, more open throats, much larger calyx, shorter and stouter ovary, and less exserted stamens; by the dwarf size and extensive underground runners; and by the absence of cilia on the midrib. The habitat is also not the same, *A. atlantica* being found in low, damp, undrained pine flats of the coastal plain, while *A. nudiflora* prefers the better-drained soil by ditches, branches or bluffs and extends far beyond the range of the former. *Azalea viscosa*, which is really nearest, is, of course easily distinguished by large size, late flowering (late May to July), and different habitat and habit. It is the only other Azalea of the region occupied by *A. atlantica* and *A. nudiflora*, with the possible exception of the next. *Azalea canescens*, which has the leaves whitish-pubescent below, occurs on better-drained soil, is rose-flowered, is not viscid, and has the same size and habit as *A. nudiflora*, which is very near. Compared with specimens of *A. canescens* at the New York Botanical Garden our plants were easily seen to be different. One plant from Orangeburg, S. C., in the New York Botanical Garden Herbarium, labelled *A.*

PLATE 7

AZALEA ATLANTICA

canescens but different from the others, may be our species. *Azalea glauca,* which seems a small form of *A. viscosa* occurs from New England to Virginia and blooms from June to July.

Azalea atlantica is one of the most conspicuous flowers of the damp, flat woods of the low country, often covering acres under old field or long-leaf pine, and scenting the air for a long distance with a fragrance that is far more pleasant than the much less obvious odor of *A. nudiflora.* We have the plant from Georgetown, S. C., Hartsville, S. C., and Brunswick County, N. C., and have seen it in New Hanover County, N. C. It is probably distributed over most of the coastal plain of North Carolina and South Carolina. The plants from Brunswick County are a slightly different form from the South Carolina plants. The calyx is not hairy, the leaves are smooth on both sides, and the flowers are glandular only. In the Georgetown and Hartsville plants the calyx lobes are a little shorter and less fused, and are quite hairy on the margin in addition to being glandular; furthermore, the flowers are slightly tomentose as well as glandular.

Plate I was painted by my niece, Dorothy Coker, from Hartsville plants on April 25, 1915. It is 4/7 natural size. The photograph (Plate 7) was made by me in Brunswick County, N. C., about half way between Wilmington and Southport on April 6, 1918.

CHAPEL HILL, N. C.

A NEW SPECIES OF ACHLYA

By W. C. Coker and J. N. Couch

Achlya Orion n. sp.

Hyphal threads long, reaching a length of 1.5 cms. on house-flies, more slender than in most Achlyas, from 10-40μ thick close to base, rarely up to 85μ thick, often wavy; usually little branched and pointed at tips when young; becoming considerably branched with age. Sporangia abundant, cylindrical, usually borne singly on the tips of the main hyphae in young cultures, renewed by cymose branching, often forming several clusters at regular intervals on the same hypha, irregular and wavy in old cultures, 12-37 x 36-600μ (rarely up to 900μ). Spores 9-10μ thick, emerging as usual in Achlya, but often falling to the bottom in an open group instead of forming a sphere at the sporangium mouth. Oogonia abundant on flies, grubs and vegetable media, spread over the entire culture from bases of hyphae to tips, giving the culture a lacy interwoven or net-work appearance; the diameter 30-60μ, commonly 32-48μ; usually borne singly on long, crooked, recurved stalks which arise racemosely from main hyphae and which vary in length from 2-10 times the diameter of the oogonia; often oogonial stalks may branch bearing two oogonia and rarely oogonia may be borne on a stalk which arises directly from another oogonial wall; very rarely intercalary; oogonial wall usually without pits (except where the antheridial tubes enter) when grown on flies or grubs, but as a rule with pits when grown on boiled corn. Eggs 1-8, usually 1 or 2 in each oogonium; 25-45μ in diameter, most 33-36μ, eccentric when ripe with one large oil drop; usually spherical, but often elliptical from pressure. Antheridial branches almost always androgynous, usually arising from the oogonial stalk itself, less often from the main hyphae; rarely diclinous; antheridia on about 75% of the oogonia, one or two on an oogonium, tuberous; antheridial tubes obvious penetrating the oogonia and reaching the eggs.

The species seems to be quite rare, having been recognized only twice in considerably over a thousand collections, made by the senior author and his students. It was found in some water and trash collected from the west branch above the Meeting of the Waters

(No. 6 of September 26, 1919), and in the same kind of material from the branch in Battle's Park behind Dr. Pratt's residence (No. 4, June 10, 1920). The description has been made from cultures descended from a single spore.

Our plant can be distinguished (with the unaided eye) from most other Chapel Hill Achlyas by the network appearance given it by the oogonia being scattered over the entire culture from the bases of the hyphae to the tips. *Achlya racemosa* approaches this network appearance more than any other species of Achlya but in the latter the oogonia are not nearly so abundant nor do they extend entirely to the tips of the hyphae. In some species, such as *Achlya oblongata*, the oogonia are borne in a definite zone near the substratum and from half to two-thirds of the length of the hyphae from the tips backwards are without oogonia. In the *Prolifera* group the oogonia are scattered more or less over the entire culture but the big hyphae and long sporangia dissipate the net work appearance.

If we ignore the egg structure, the present species seems to be closest to *Achlya polyandra* Hildb. The two plants resemble each other in the long, racemose oogonial branches which are recurved at the tip; in the often branched antheridial stalks which arise chiefly from the oogonial branches; and in the smooth oogonial walls which are normally without pits except where the antheridia touch. The two species are readily distinguished, however, by the difference in the number of eggs in the oogonia, and in the size and structure of the eggs. In *Achlya polyandra* the number of eggs varies from five to twenty-five, the usual number being ten to fifteen, their average diameter is 27μ and they are said to be centric; in *A. orion* the usual number of eggs is one to two, the diameter of most $33\text{-}36\mu$, with an eccentric structure. In *Achlya polyandra* the sporangia are reported as often not abundant, and secondary ones rare; while in our plant both primary and secondary sporangia are abundant. This species is named for the nebula in Orion, which a photograph of the magnified culture somewhat resembles. This photograph, together with drawings by J. N. Couch will appear in a volume by W. C. Coker on the *Saprolegniaceae of the United States* to be published soon.

JAMES JACOB WOLFE
1875–1920

JOURNAL

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Elisha Mitchell Scientific Society

Volume XXXVI FEBRUARY Nos. 3 and 4

PROCEEDINGS OF THE ELISHA MITCHELL SCIENTIFIC SOCIETY, MAY, 1920, TO DECEMBER, 1920

241st Meeting—May 4, 1920

W. deB. MacNider—*On the Relation of the Amount of Stainable Fat in the Renal Epithelium to the Susceptibility of the Kidney to the Toxic Effect of the General Anesthetics.*

Frozen sections were made from fresh kidney tissue and stained for fat with Scharlach R by Herxheimer's method. Such tissue when obtained from puppies and young dogs shows fat as minute dust-like particles in the epithelium of the ascending limb of Henle's loop. Kidney tissue obtained from old and very senile animals shows a marked increase in the amount of fat in the ascending limb of Henle's loop and fine dust-like particles of stainable fat in the convoluted tubule epithelium. Kidney tissue obtained from naturally nephropathic animals shows a large amount of stainable fat not only in the ascending limb of Henle's loop but also in the convoluted tubule epithelium. When such animals of different age periods and naturally nephropathic animals are anesthetized by ether, the relative toxicity of the anesthetic for the kidney is shown in the following manner:

1. The puppies and young dogs continue to form urine during the course of the anesthesia and remain responsive to diuretic solutions.

2. A certain number of the adult and senile normal animals become anuric and fail to respond to diuretic solutions. Other animals in this group remain diuretic for the earlier part of the experiment and later become anuric.

3. All the naturally nephropathic animals become anuric in the early stages of the experiment and remain anuric and non-responsive to diuretic solutions throughout the experiment.

A. W. HOBBS—*Einstein's Special Relativity Theory.*

The laws of Nature must be invariantive, that is they must be so stated as not to depend upon any particular frame of reference. All attempts to discover different values for the velocity of propagation of light in different directions have failed. We then assume the constancy of the velocity of light. This leads to the conclusion that $x^2+y^2+z^2-c^2t^2$ must be changed into the same expression when we refer to another system (i. e.) $x^2+y^2+z^2-c^2t^2 = x'^2+y'^2+z'^2-c^2t'^2$. The Lorentz transformation accomplishes this and is at the same time consistent with experience. It is given by

$$x' = \beta\,(x - vt) \text{ where } \beta = \left(1 - \frac{v^2}{c^2}\right)^{-1/2}$$
$$y' = y$$
$$z' = z$$
$$t' = \beta\left(t - \frac{vx}{c^2}\right)$$

Applying these equations we find that a length $x_2 - x_1$ is shortened in the directions of motion by the factor $\left(1 - \frac{v^2}{c^2}\right)^{1/2}$.

The paralellogram law for the addition of velocities is no longer

$$u + v \text{ but } \frac{u + v}{1 + \frac{uv}{c^2}}$$

These results would have very little interest to most of us if they did no more than add very small corrections to our already complicated system. The interest lies in the fact that they point to an almost organic relation between space and time, so that we must not consider space and time as being distinct concepts.

242ND MEETING—MAY 25, 1920

DR. C. E. MCCLUNG, Professor of Zoology, University of Pennsylvania—*The Material Basis of Heredity.*

The lecturer, covering the chromosome theory of heredity, introduced the principal facts, including the speaker's own well known discoveries showing a correlation between the presence in germ cells of particular chromosome masses and sex. (H. V. W.)

ELECTION OF OFFICERS:

President—A. H. Patterson.
Vice-President—A. W. Hobbs.
Permanent Secretary—J. M. Bell.
Recording Secretary—H. R. Totten.
Editorial Committee—W. C. Coker, chairman; J. M. Bell, Collier Cobb.

243RD MEETING—OCTOBER 19, 1920

H. V. WILSON—*The Mode of Origin of the Nervous System in the Vertebrate Embryo.*

Some recent operative experiments made by Professor Hans Spemann on the salamander embryo were described. These experiments showed that a patch of embryonic tissue might be developed into spinal cord, brain, eye, or ordinary epidermis, according to the locality in which it is placed, and seem to constitute decisive evidence against the view that the organs of the body are represented in the egg by localized peculiar substances.

ELECTION OF MEMBERS:

The following members of the faculty were elected to active membership in the Society: Dr. Otto Stuhlman, Dr. E. A. Abernathy, Capt. Frederick W. Boye, Mr. H. M. Taylor, Mr. H. G. Baity, Mr. W. E. Walke, Mr. Walter B. Jones. The following advanced students and assistants were elected to associate membership: C. P. Savage, Eleanor Hoffmann, P. R. Dawson, T. P. Dawson, R. A. Lineberry, S. C. Smith, A. M. Wolfson, H. L. Cavaness, B. Naiman, R. O. Deitz, S. C. Ogburn, A. B. Owens, F. P. Brooks, J. W. Guard, C. R. Harris, N. W. Taylor, D. M. Carroll, C. B. Ridge, C. J. Bryan, D. St. P. DuBose, W. F. Foote, T. E. Hinson, E. J. Mecum, L. V. Milton, J. D. Morris, P. C. Smith, A. B. Wright, R. M. Casper, M. E. Lake. T. B. Smiley, W. H. Butt, H. S. Boyce, S. B. Lee, J. B. Miller, B. E. Lohr, Roy J. Morton, I. J. Stephenson, Clayton Edwards, S. C. Alston, J. B. Noe, F. R. Bacon, J. B. Broach, S. M. Crisp, A. L. Miner, J. W. Harrell, Jr., J. L. Cobb, M. L. Jacobs, J. M. Alexander, Wm. F. Alston, P. M. Grey, A. H. Merritt, J. G. Tucker, C. D. Beers, H. S. Everett, Ernest Atkins.

244TH MEETING—NOVEMBER 9, 1920

The Society passed the following Resolution:

Whereas, the Elisha Mitchell Scientific Society was organized for the purpose of encouraging scientific investigations in North Carolina; and

Whereas, European Forestry has depended upon and reaped much benefit from the Forest Experiment Stations of the various countries; and

Whereas, several such experiment stations have been established in the western part of the United States and none in the eastern states; and

Whereas, we realize the importance of securing more accurate knowledge concerning methods of management for the perpetuation of the valuable forests of the Southern Appalachian region; therefore be it

Resolved, that we go on record as strongly favoring the establishment of a Forest Experiment Station by the United States in the vicinity of Asheville and do hereby respectfully urge Congress to pass the bill providing for such station.

C. S. Goodwin and C. R. Monroe were elected to associate membership in the society.

J. M. BELL—*Further Studies on the Nitrotoluenes.*

This paper was the result of a continuation of work begun at the request of the National Research Council on the freezing points and thermal properties of the nitrotoluenes. The particular nitrotoluenes investigated are those formed in largest amounts during the nitration of toluene to TNT: viz., orthonitrotoluene (ONT); paranitrotoluene (MNT); 1, 2, 4-nitrotoluene (DNT); and 1, 2, 4, 6-trinitrotoluene (TNT). There are two melting points for ONT, corresponding to the two crystal forms of this compound; the stable form (m. p.–4.5°) and the metastable form (m.p.–10.5°). The following systems were investigated: ONT-DNT and ONT-MNT-DNT (with E. B. Cordon); ONT-MNT and ONT-MNT-TNT (with F. H. Spry); ONT-TNT and ONT-DNT-TNT (with Woodford White). A formal presentation of the results is to be made in early issues of the *Journal of Industrial and Engineering Chemistry.*

A. H. PATTERSON—*Recent Work on Spiral Nebulae.*

A review of the recent work done at Mt. Wilson and elsewhere on the Nebulae, Wolf-Rayet Stars and Stars of Classes B and A; the theory of the origin of Spiral Nebulae was outlined, and lantern slides shown of various types of spiral and quiescent nebulae; the relation between velocity and temperature of the stars and nebulae was touched upon, and the significance of the Spiral Nebulae sometimes occurring in pairs was pointed out.

245TH MEETING—DECEMBER 14, 1920

J. W. LASLEY, JR.—*Some Developments in Modern Geometry.*

Einstein's results resolve the problem of understanding the laws of the universe into the problem of understanding geometry. It was

a contribution of Klein to see in group theory a logical classification of geometry. Classified from the viewpoint of groups of transformations, geometry falls into projective geometry, metric geometry, etc. Some investigations require a knowledge of a geometric figure only in a limited region; others require a knowledge of the figure as a whole. We are thus led to a sub-classification: differential and integral geometry. Four kinds of geometry thus arise: the projective differential geometry of Halphen, Wilczynski and Green, the projective integral (known as projective) geometry of Desargues, the metric differential (known as differential) geometry of Gauss, and the metric integral (known as geometry) geometry of Euclid. The developments in geometry to which this paper calls attention are those in the field of projective differential geometry.

C. S. MANGUM—*A Review of the Public Health Work in North Carolina.*

Progress in health work is indicated by a reduction in death rates. For the whole United States the death rate is 12.9 per thousand of population. In North Carolina it is 12.4. This is lower than the known death rate in any other of the old states from Maine to Texas.

This record is all the more creditable when one considers the fact that North Carolina's birth rate is the highest of all the states in the Union, and is steadily increasing.

The State Board of Health, in conjunction with allied associations, has for years conducted a well organized and energetic campaign which has shown most encouraging results in a number of fields.

In 1914 there were 8,390 cases of typhoid fever and 839 deaths.

In the last twelve months there have been 2,750 cases with 275 deaths. A reduction of two-thirds.

Within the same period the death rate from diphtheria has been cut in half. In 1914: deaths 525. In 1920: deaths 242.

The deaths from tuberculosis have decreased from 3,710 in 1914, to 3,005 in 1920. A gain of 705.

The work of the Board may be classified under three heads:

(1) *Educational.* Through the wide distribution of the "Bulletin" and thousands of special pamphlets, public lectures and publicity campaigns; using the County as a unit.

(2) *Prophylactic.* Supervision of the care of expectant mothers and of infants; Intensive campaigns against preventable diseases, distribution free or at a nominal cost of vaccines and antitoxins,

supervision of public water supply, sewage and sanitation, and the making of water analyses and many other laboratory tests.

(3) *Directly Remedial.* Free clinics for the treatment of venereal diseases; Medical inspection of the public school children followed by free dental clinics and the removal of diseased tonsils and adenoids.

The Public Health Work is under the direction of a general staff, the State Laboratory of Hygiene and eight special bureaus.

1. Laboratory of Hygiene:

Supplies Vaccines, Antitoxins and Pasteur treatments; makes water analyses and Wasserman and other tests.

2. Bureau of Vital Statistics:

Collects information which insures the efficient direction of the work.

3. Bureau of Tuberculosis:

The State Sanatorium treats an average of 135 cases each year, examines and advises over 1000 others, and conducts intensive County Campaigns.

4. Bureau of Medical Inspection of Schools:

In the past two years 150,000 public school children have been examined; 25,587 have been given free dental treatment and 2500 have had diseased tonsils or adenoids removed.

5. Bureau of County Health Work;

Forty counties have full time health officers and 22 have full time public health nurses. Within the past two years 40,000 insanitary privies have been eliminated, principally in rural communities and in small towns.

6. Bureau of Engineering and Inspection:

For supervision of public water supply and sewage disposal.

7. Bureau of Venereal Diseases:

Sixty thousand persons have received treatment in the last 2 years at the free clinics.

Educational campaigns are being conducted in the counties by: (1) A physician who goes into the county to arrange dates and arouse interest. He is followed by: (2) The "educational truck" carrying a physician to lecture to the men, a woman to lecture to the women, a moving picture machine and a negro physician to lecture to the negroes.

8. Bureau of Epidemiology:

Conducts the fight against infectious diseases. In the last 2 years 165,000 people have been given the free protective treatment against typhoid fever.

9. Bureau of Public Health Nursing and Infant Hygiene:

In 2 years has given aid and instruction to 11,000 expectant or new mothers, who needed intelligent care for themselves and their babies, that they were unable to secure.

The economic value of this work is tremendous when computed in terms of the economic value of a human life, which is about $3500.00, but the intangible values based upon better health, greater efficiency and longer life are beyond computation.

JAMES JACOB WOLFE

1875–1920

PLATE 8

The North Carolina Academy of Science has lost in Dr. Wolfe one of its most active, influential and useful members, and desires to put on record a sincere and affectionate appraisal of his character, his personality, his work and his service to the Academy, to Trinity College and to the State.

He was born on September 14, 1875, at Sandy Run, Calhoun County, South Carolina, the son of John Archie Wolfe and Frederica A. (Geiger) Wolfe, was educated at Wofford College, and pursued graduate training at University of Chicago, and at Harvard, receiving the degree of Doctor of Philosophy from the latter University in 1904. He was at once elected Professor of Biology in Trinity College, and filled this position with marked ability and distinction as teacher, investigator and administrator until his death, after only a short illness, on the morning of the College Commencement Day, June 9, 1920.

On June 28, 1904, he was married to Cornelia Wilhelmina Lehrmann, of Montclair, N. J., who survives him. There are no children.

Dr. E. W. Gudger, for many years head of the Biological Department at the State College for Women, and now of the American Museum of Natural History, New York, writes as follows:

"I knew Professor Wolfe for some twelve years, and for ten years of that time intimately. He was an unusual man in every way. Some years after we became friends, he came down to the U. S. Fisheries laboratory at Beaufort to take up the study of certain marine algae, and it was my good fortune to introduce him to the life of a marine biological laboratory. From that time on our friendship grew and our intimacy was terminated only by his all too early death.

"In his scientific work, Professor Wolfe was careful, painstaking, and thorough, testing every observation and phenomenon to the farthest limit before committing his observations and conclusions to writing. In his work on the alternation of generations in one of the marine algae, his observations and results were at variance with those of previous workers. Here, instead of rushing into print with something startling, he patiently reviewed his work year after year until he was absolutely sure of his results. At the time of his death Professor Wolfe was engaged, with the assistance of Mr. Bert Cun-

ningham, in an extensive and far-reaching investigation for the U. S. Bureau of Fisheries on our marine diatoms, and had he been spared to finish this it would have been the authoritative monograph on these plants in our waters.

"As a teacher, Professor Wolfe was one of the most successful instructors in his subject in North Carolina. Under him the department of Biology in Trinity College grew steadily in numbers of students and in influence, and at the time of his death he had plans on foot for a very great enlargement and development of his department.

"In the North Carolina Academy of Science, Professor Wolfe was one of the most influential and valuable members. Never absent from a meeting, he could always be counted on for any needed work. During my eleven years' incumbency as Secretary I called on him scores of times for advice and help, and it was always his pleasure, and, as he put it, his 'privilege,' to serve the Academy. This ready devotion of his was appreciated by all the members, and was signalized in 1914 by his unanimous election to the office of President.

"Professor Wolfe's life was as square and straightforward and honest as was his scientific work. I who knew him intimately knew him always four-square to the world. Generous and whole-souled himself, he always looked for these qualities in others. He was one of the most delightful hosts I have ever known, and no one ever visited him and Mrs. Wolfe in their delightful home at Trinity College without bringing away recollections of the very finest hospitality. He was a man of the most genial and lovable personality.

"Of what Professor Wolfe's death has meant to me personally it is hard for me to speak. For more than ten years I have had in him an intimate friend on whom I could rely to the limit, and his going has made the world much poorer for me."

This impression of fine-souled solidity of character was shared by all who knew him. A co-worker with Dr. Wolfe along certain lines, who saw him often and was able to judge him fairly, is Dr. W. C. Coker, head of the Department of Botany in the University of North Carolina, who bears this testimony:

"I have been asked to give my impression of Dr. Wolfe as a man, as an investigator and as a member of the North Carolina Academy of Science.

"It is significant that as I recall him as a man and as a friend my thoughts have no element of uncertainty or complexity, but rest quietly as though carried on a tranquil stream. Wolfe was a simple man, as all good men are, or rather one might say the impression was that of simplicity, and always the same. It could not be otherwise with one who so fully combined the few great and essential qualities of goodness, to which little need be added, and without

which all additions or embellishments are as naught. A big-hearted humanity, transparent honesty, quiet and sustained industry—these are the immortal three; but let us also add the salt that never loses its savor, the disposition to enjoy life and to get some fun out of it. It is needless to add that he did not know the meaning of the word vanity, as he had no trace of it in himself. While I was at Johns Hopkins one of the strongest and best young professors in that University died. Dr. Brooks, our great teacher of Biology, who loved this man deeply, said to me: 'He was as simple as a child,' as summing up all that was best in his friend. These words return to me as I think of Wolfe. Such is the simplicity of serenity and harmony, the absence of a jarring note.

"Men of this type, and they are not so numerous, remind us of natural phenomena. They are like the pine woods in winter—unshaken and sustaining in their perennial verdure. When others change, their colors do not fade. They are like the hills, from whence cometh our help. There was no uncertainty about Wolfe and no futility. He was radiant with humanity. There was a glow about his friendship and his sympathy that did not admit of question. He was not a casual benefactor, but was full of a sustained generosity. Those who were with him daily in his community will testify to his work as a member of the Board of Directors of Watts Hospital and of his personal service in cases of sickness and distress. He was willing to give himself, and not merely his means, a most rare and excellent thing in a man.

"As a student and investigator, Wolfe was intelligent and faithful. His mind was intensely interested in ideas as well as facts, and he was constantly thinking. I always looked forward to his visits with interest. With his full share of jovial conversation, we were never long together before he started a serious discussion of some interesting biological problem of the day. He liked to talk about evolution and heredity, their new problems and phases. This interest was reflected in his choice of a subject for his presidential address before the North Carolina Academy of Science at its 14th annual meeting at Wake Forest (see this JOURNAL, **31**: 12. 1915). He was not dogmatic and could change with the times. When a cherished position was undercut by new discoveries he could step off at the right moment.

"Among American biologists his position was more than respectable. He stood high as a producer of sound and timely work. He was not wordy, never published for bulk, and was not anxious to appear prolific. His papers were of the kind that required hard and patient labor, and he kept right on until he got the results. His training at Harvard under Farlow and Thaxter gave him a clear conception of what is true scholarship and he never for a moment lowered his standards. True to the best traditions of his profession, he did not loaf his summers away under the plausible pretense of a needed rest, but spent most of them in hard work at the Marine

Biological Laboratory at Woods Hole, Massachusetts (1901–1906), and at Beaufort, North Carolina, in the laboratory of the U. S. Bureau of Fisheries (1909–1916). There he collected and prepared the material for his excellent papers on the biology and reproduction of the seaweeds that brought him his greatest reputation. His work on the algae Nemalion (Annals of Botany **18**: 607. 1904) and Padina (see this JOURNAL **34**: 78. 1918) would alone place him as an investigator of fine abilities. Recently he had been engaged in investigations on the plankton of Chesapeake Bay for the U. S. Fish Commission, a considerable part of this work having been completed at the time of his death. In recognition of the importance of this work the Elisha Mitchell Scientific Society invited him to give an address on the subject at its meeting of January 13, 1920. (For abstract see this JOURNAL **36**: 3, 1920.)

"Wolfe was elected to membership in the North Carolina Academy of Science at its 6th Annual Meeting in 1907 and was an active and enthusiastic member during the whole of its subsequent record. So far as I recall, he never missed a meeting and he nearly always presented a paper—and a good one. As a member of the Executive Committee at various times, as Vice-President (1908–1909) and as President (1914–1915) he gave freely of his time and judgment. In his death the Society has sustained a heavy and irremediable loss. We shall miss him as a friend and as a strong support."

"Below is a list of the published papers and addresses of Dr. Wolfe so far as I have been able to find them:

Cytological Studies in Nemalion. Annals of Botany **18**: 607–630, pls. 40–41, with 1 text fig. 1904.

The Cause of Pellagra: a Preliminary Report. Paper presented before the 9th Annual Meeting of the N. C. Academy of Science. Abstract in Journ. E. M. Scientific Soc. **24**: 53. 1910.

Alternation of Generations in Padina. Paper read before the 12th Annual Meeting of the N. C. Academy of Science. Abstract in Journ. E. M. Scientific Soc. **29**: 8. 1913.

The Locust Tree Carpenter Moth, a Formidable Parasite of the Oak. Paper read at the 13th Annual Meeting of the N. C. Academy of Science. Abstract in Journ. E. M. Sci. Soc. **30**: 65. 1914.

An Outline of Modern Work Bearing on the Theory of Descent. Presidential address before the N. C. Academy of Science. In full in Journ. E. M. Sci. Soc. **31**: 12–26. 1915.

Alternation and Parthenogenesis in Padina. Paper read at 15th Annual Meeting of the N. C. Academy of Science. Abstract in Journ. E. M. Sci. Soc. **32**: 51. 1916.

Some Methods and Results of a Plankton Investigation of Chesapeake Bay. With Bert Cunningham. Paper read at the 17th Annual Meeting of the N. C. Academy of Science. Abstract in Journ. E. M. Sci. Soc. **34**: 70. 1918.

Alternation and Parthenogenesis in Padina. In full in Journ. E. M. S i. Soc. **34**: 78–109, pl. 1. 1918. (Contribution from the Laboratory of the Bureau of Fisheries, Beaufort, N. C. This paper, in somewhat shortened form, was read

before a joint session of the Botanical Society of America and the Botanical Section of the A. A. A. S. at their 1918 meeting in Pittsburgh.)

New and Little-Known Diatoms from Beaufort, N. C. Paper read before 18th Annual Meeting of the N. C. Academy of Science. By title in Journ. E. M. Sci. Soc. **35:** 11. 1919.

The Plankton of Chesapeake Bay. Invitation address before the Elisha Mitchell Scientific Society, January 13, 1920. Abstract in Journ. E. M. Sci. Soc. **36:** 3. 1920."

His younger colleague in the Biological department of Trinity College, Professor Bert Cunningham, is able because of an intimate acquaintance of several years, to render an opinion based upon the sure ground of daily intercourse, and a consequent thorough knowledge of Dr. Wolfe's character as a man, a scholar and a gentleman.

"He was a perfectly frank, straightforward man, always avoiding, if possible, the hurting of another; kind, patient, considering the other man more than himself, and never in any way seeking retaliation for wrongs done him; interested in civic welfare, and especially devoted to the relief of suffering.

"As a teacher, he was exceptionally well-grounded by knowledge much broader than his field; accurate and exacting in the classroom and laboratory; a leader and stimulator of thought on the part of his students; a personal friend and adviser to them.

"As an investigator he was exceedingly accurate and painstaking, endeavoring to get the 'last word' of a subject before laying it down; keen in seeing methods for the attack of problems and in recognizing the relations of a problem to the whole problem of life; and exceptionally careful in his writing that there might be no ambiguity.

"I am incompetent to write a eulogy for this splendid man. Words fail when I try to express my appreciation. To have lived with him and worked with him has been a great opportunity that I shall ever appreciate. To be without his judgment, guidance and friendly counsel is an irreparable loss."

His fellow-members of the Academy of Science, recognizing the justice and truth of the testimony quoted, desire to express their concurrence with it, and to render respectful homage to the fine qualities of mind and heart possessed by Dr. Wolfe, together with a keen and sorrowful regret that his useful life should have been so untimely cut off.

Integer vitae scelerisque purus
Non eget Mauris jaculis neque arcu
Nec venenatis gravida sagittis,
Fusce, pharetra.

W. H. PEGRAM,
R. U. WILSON,
A. H. PATTERSON,
Committee.

THE CHEMICAL BEHAVIOR OF ZIRCONIUM

By F. P. Venable

Any discussion of the chemical relations and behavior of an element forms necessarily an unfinished chapter in the present state of knowledge. This is particularly true of zirconium, which has been so imperfectly studied, where complications are many and their unraveling presents unusual difficulties. It is only by the application of the most modern chemical and physical methods that a solution can be hoped for; hence it is not strange that many of the earlier observations were faulty and misleading, and that only partial knowledge has been attained as yet.

Since there is no positive evidence that the valence of zirconium is ever other than four, there is at least a helpful simplicity in this regard. In the ionization of its compounds two varieties of ions are definitely known, namely, the quadrivalent zirconium Zr and the bivalent zirconium monoxide ZrO, which has no independent existence. It has been reported that the sesquioxide ion (also bivalent), Zr_2O_3, has been found under certain conditions, but this has been brought into question by later work. Recently it has been suggested that both the quadrivalent elementary ion and the bivalent zirconyl ion may be present in the same compound. While this is not impossible, it does not appear to be the only explanation of the results obtained. The complex ions have been found by various investigators to migrate with the negative stream as well as with the positive. This, of course, is to be expected in true chemical compounds where one is dealing with an amphoteric element. Sometimes it is doubtless to be attributed to the colloidal nature of the product under examination.

Zirconium forms binary compounds with a number of the elements. The evidence is against the existence of a hydride ZrH_4. The hydride reported as ZrH_2 may contain only absorbed hydrogen. This hydrogen is lost at a higher temperature. Nitrogen combines with the heated element, forming various compounds. This nitrogen is also driven off below 1000°. Compounds with the halogens are stable up to high temperatures and the oxide is dissociated only at the temperature reached in an electric furnace.

The oxide ZrO_2 forms at least two hydroxides. The normal hydroxide, or zirconium hydroxide $Zr(OH)_4$, is easily hydrolyzed in the

presence of water. When water is excluded normal zirconium salts can be formed from it. When hydrolyzed, zirconyl hydroxide $ZrO(OH)_2$ is formed. This hydroxide is amphoteric, behaving as a base towards strong acids and as an acid towards strong bases. It shows little tendency to form definite compounds with weak acids or bases. As a base it gives zirconyl salts, and these may be hydrolyzed into basic zirconyl salts. As an acid, called zirconic acid H_2ZrO_3, it forms zirconates, chiefly with the alkalies and alkaline earths. These are very slightly soluble in water and are decomposed by mineral acids.

Zirconium shows many and close analogies to the other elements in the fourth group, both as to the compounds formed and their chemical behavior. This analogy is especially close in the cases of titanium and tin when they are quadrivalent. In limitation of valence it is more like carbon and silicon. Its occurrence as the dioxide is also characteristic of the group. The ease of hydrolysis and the amphoteric character of the hydroxide are also group characteristics.

The outstanding characteristics of the compounds in which tetravalent zirconium is directly united with an acid radical is their marked tendency to react with water. Ignorance of this or failure to consider it has led to many mistakes on the part of earlier investigators. Older statements represent such salts as the tetrachloride, the sulphate, the fluoride, and others as crystallizing unchanged from aqueous solutions, but later investigators have shown that none of these salts can exist in water solutions and most of them are unstable in the presence of the slightest moisture.

Hydrolysis takes place not merely with readiness, the water produced in a gas burner hydrolyzing normal zirconium sulphate which is being heated by it, but also to a far-reaching extent. The velocity of the reaction and the extent depend upon the dilution, the temperature, and the time. The content of such a solution then is determined by its previous history. The hydrolysis is progressive and the acid radical may be gradually liberated until very little is left in combination, the small remaining portion being held probably by adsorption. In the case of the chloride, for instance, the amount of chlorine left has been found to be about 3 p.c. of the amount originally present, and this is no longer precipitated by silver nitrate unless first treated with nitric acid. When dialyzed this chlorine is found with the colloidal hydroxide in the hydrogel. This hydrogel consists in the main of zirconyl hydroxide. Experiments with the sulphate yield similar results. The normal hydroxide is unstable in the presence of

water, losing one molecule of water and changing to zirconyl hydroxide. It is more easily soluble in acids than zirconyl hydroxide. At various stages in the hydrolysis the addition of ammonium hydroxide will give precipitates of different composition. These have been considered by some as new hydroxides, but there is little proof that they are not mere mixtures. It has been suggested that there are two hydroxides with the formula $ZrO(OH)_2$, ordinary zirconyl hydroxide, which is amphoteric, and a metazirconic acid. No salts of the latter are definitely known and its existence has been disputed.

While in all cases the hydrolysis is progressive, it is almost certain that all the molecules do not react with water at the same time, and hence at any one time various stages of hydrolysis may be present in a solution. It is common, however, for one of the stages to preponderate. It may therefore be possible to observe definite steps in the progression when there are formed basic zirconyl compounds which either separate by precipitation because of their insolubility or by crystallizing with molecules of water, forming difficultly-soluble salts, or otherwise afford indications of their presence through physical tests such as electrical conductivity, thermo-chemical data, cryoscopic determinations, etc. One of the most frequently occuring of these basic compounds is $Zr_2O_3Cl_2$, known as Endemann's chloride. Its analogues are $Zr_2O_3.SO_4$, $Zr_2O_3(NO_3)_2$, $Zr_2O_3(SCN)_2$, and others. These have always been obtained in the hydrated condition, and it has been observed that the last portion of the water is removed with considerably greater difficulty. This fact, combined with that of leaving the colloidal hydroxide on dialysis, leads to the suggestion that the formulas be written $ZrO(OH)_2.ZrOCl_2$, $ZrO(OH)_2.ZrOSO_4$, etc. These indicate the degree and order of the hydrolysis. Thus the steps are $ZrCl_4+H_2O=ZrOCl_2+2HCl$; $2ZrOCl_2+H_2O=ZrO(OH)_2.ZrOCl_2+2HCl$. In the first stage all of the tetrachloride is hydrolyzed. In the second, one-half of the zirconyl chloride is hydrolyzed and the colloidal hydroxide formed either combines chemically with the zirconyl chloride or forms an adsorption compound with it. It is difficult in this and a number of similar cases to conceive of these substances where the composition is definite and the conditions of formation are accurately known as other than definite chemical compounds. Thus at a temperature of 39.5° between the dilutions 1: 4 and 1: 120 the sulphate $Zr(SO_4)_2$ is hydrolyzed with the production of a crystalline substance having the composition $4ZrO_2.3SO_4.14H_2O$, which may also be written $ZrO(OH)_2.3ZrO$.

$SO_4.13H_2O$. This indicates a hydrolysis in the second stage of one out of four molecules of $ZrO.SO_4$. The velocity of this reaction diminishes with decreasing temperature, and it has been found that only 67 p.c. of the sulphate originally used go to the formation of this product. The condition of the remainder in this case is unknown. The crystalline basic sulphate just mentioned and other compounds of like character show partly colloidal properties and have therefore been classed by Hauser as half-colloids.

Again, the existence of an equilibrium reached in the hydrolysis is indicated sometimes in measuring conductivity changes. Thus in the case of the hydrolysis of a one-fourth normal solution of $ZrOCl_2.8H_2O$ at 18° the change for the first sixty minutes is at an average rate of 67×10^{-5} ohms per cc. per minute. For the next 168 hours it averages only 0.014×10^{-5} ohms per minute, indicating the slow breaking down of a more stable compound or the retarding effect of the liberated acid. This retarding effect of free acid is well known. It can be inhibitory or even cause a reversal of the reaction. Thus the addition of sulphuric acid to a partially hydrolyzed zirconyl sulphate solution when it reaches a certain concentration will bring about the separation as crystals of the original zirconyl sulphate. Normal zirconium sulphate crystallizes unhydrolyzed from sulphuric acid containing only a few per cent of water. This inhibitory and reversal effect is produced also by the presence of the salts of strong bases like the alkalies. Anhydrous zirconium fluoride, for instance, is very slowly and difficultly soluble in water. In solution it is hydrolyzed, $ZrF_4 = ZrOF_2.H_2F_2.3H_2O$. This recrystallizes from water unchanged. If considerably diluted, an amorphous basic zirconyl fluoride is precipitated. This formation of an acid salt with the liberated acid has been noticed in a number of cases. If the water present is in small amount, the hydrolysis is checked. If a salt of a strong base is added (usually in excess) there is formed a double salt or complex which does not hydrolyze. With potassium fluoride three complexes are formed. First, we have $KF.ZrF_4.H_2O$, which can be formed only in the presence of a large excess of zirconium fluoride and is decomposed on re-solution in water. It should probably be written $KF.ZrOF_2.H_2F_2$, lacking enough potassium fluoride to inhibit hydrolysis when much water is added. The second salt, $2KF.ZrF_4$, crystallizes without water of crystallization. It is very stable, giving off hydrofluoric acid only at a red heat, and can be repeatedly recrystallized from water. It is regarded as a salt of fluozirconic acid and, under that

supposition, its formula may be written K_2ZrF_6. It is formed when the potassium fluoride and zirconium fluoride are mixed in equivalent proportions.

Zirconium sulphate also affords a very instructive example of hydrolysis. So complicated are the different directions which this hydrolysis takes and so varied are the products formed that it has been the subject of skilled investigation for the past two decades, and many mistakes have been made from the earliest time up to the present. Some of the problems involved still lack a satisfactory solution. The normal sulphate was long supposed to exist in two crystalline forms—the anhydrous, $Zr(SO_4)_2$, and the tetrahydrated, $Zr(SO_4)_2.4H_2O$. The first crystallized from concentrated sulphuric acid and its formula is correctly given. The second crystallized from aqueous solutions, presumably without change. It has been shown since that the latter is really an hydrolysis product. The hydrolysis proceeds as follows: $Zr(SO_4)_2.4H_2O = Zr(SO_4)_2 + H_2O + 3H_2O = ZrOSO_4.H_2SO_4.3H_2O$. Of course, such hydrolysis would not be revealed by analysis. A solution of this acid compound reacts with certain reagents in a manner different from a freshly-prepared solution of $Zr(SO_4)_2$ and which is only slightly hydrolyzed. If sulphuric acid is added to this fresh solution of zirconium sulphate the same reactions are shown. The mere presence of free acid might serve as an explanation without the assumption of an acid compound but would leave the inhibitory effect upon hydrolysis unexplained. Observations based on physical methods also corroborate the view that an acid compound is present. There seems to be no inherent obstacle to writing this formula as a hydrogen zirconyl sulphate, $ZrO\begin{matrix} H \diagdown SO_4 \\ \diagup SO_4 \\ H \diagdown SO_4 \end{matrix}$. Similar acid complexes are given with the nitrate, perchlorate, and compounds with certain organic acids.

One of the other possible series of hydrolytic changes has also been traced analytically. $Zr(SO_4)_2 + H_2O = ZrO(SO_4)_2H_2$. $2ZrO(SO_4)_2H_2 + H_2O = Zr_2O_3(SO_4)_2H_2 + H_2SO_4$. Electrolytic dissociation yields respectively the anions $ZrO(SO_4)_2$ and $Zr_2O_3(SO_4)_2$. These compounds occur in solution along with strongly hydrolyzed basic zirconyl products, as is evidenced by the composition of the precipitates obtained from these solutions on the addition of alcohol. Such precipitates are usually poorly defined and seemingly amorphous. It

has been found possible, however, to obtain by other means a well-defined, crystalline product whose composition is represented by the formula $8ZrO_2.5SO_3.14H_2O$, and a potassium compound, $4ZrO_2.5SO_3.K_2O$. The following additional scheme of hydrolysis has been proposed:

$$4Zr(SO_4)_2 + 8H_2O = Zr_4(SO_4)_6H_4 + 2H_2SO_4$$
$$Zr_4(SO_4)_6.(OH)_6.H_4 + 2H_2O = Zr_4(SO_4)_5.(OH)_8.H_2 + 2H_2SO_4$$
$$Zr_4(SO_4)_5.(OH)_6.H_2 + 2H_2O = Zr_4(SO_4)_3(OH)_{10} + 2H_2SO_4$$
$$2Zr_4(SO_4)_3(OH)_{10} + 2H_2O = \begin{matrix} Zr_4(SO_4)_2(OH)_{11} \\ Zr_4(SO_4)_2(OH)_{11} \end{matrix} \Big\rangle SO_4 + H_2SO_4$$

The compounds $Zr_4(SO_4)_6(OH)_8.H_4.10H_2O$ and $4H_2O$ have been obtained as crystals, and also the compounds $Zr_4(SO_4)_3(OH)_{10}$ and $(Zr_4(SO_4)_2(OH)_{11})_2SO_4.8H_2O$, but the compound $Zr_4(SO_4)_5(OH)_8.H_2$ only in the form of an alkali salt. In preparing these the colloid is removed by dialysis and these half-colloids crystallized from the concentrated solutions.

The complex and varying products obtained by mixing a solution of zirconyl sulphate with one of potassium sulphate have long been a puzzle. In part, at least, mixtures of hydrolyzed substances are formed. Recently it has been shown that if the mixed solutions are concentrated over sulphuric acid definite compounds crystallize. These show very well the influence of such a salt as potassium sulphate upon a progressing hydrolysis. When potassium sulphate is used micro-crystalline needles with the composition $K_4Zr_4(OH)_8(SO_4)_5.8H_2O$ are obtained. In a solution strongly acid with sulphuric acid the first crystals formed are $K_4Zr(SO_4)_4$; in weakly acid solutions the composition is that of potassium-zirconium hydroxysulphate of varying composition. These products hydrolyze on being treated with water. If boiled with water, they become opalescent with colloidal zirconium hydroxide. Following the crystallizations in detail, the above-mentioned potassium-zirconium hydroxysulphate $K_4Zr_4(OH)_8(SO_4)_5.8H_2O$ forms a crystalline crust of needles. A second crop of prismatic crystals is formed and this has the composition $K_4Zr(SO_4)_4.5H_2O$. The first crystals in hydrolyzing increase the free acid and bring about an equilibrium. The formation of the second then begins and decreases the amount of free acid. The reaction is thereupon reversed and the hydroxysulphate crystals form once more.

In the preparation of certain compounds by precipitation methods it has been found that the precipitate forms sometimes only after a considerable lapse of time or upon heating the solution. This is especially the case where weak acids, such as the organic acids, are concerned. The compounds thus formed are found to be more or less highly basic zirconyl salts or mixtures of such. It seems reasonable to infer that the acid radical of the precipitant used formed only soluble compounds with the less hydrolyzed salts and insoluble ones with the more basic. It is possible also that in some cases these are not true chemical compounds but adsorption compounds in which the acid radical has been absorbed by the colloidal hydroxide. Some of these products are distinctly gelatinous and can be washed and filtered with difficulty. On the other hand, some are granular and some distinctly crystalline. The hypothesis of colloidal compounds is especially probable wherever the acid radical can be practically removed or greatly reduced in amount by repeated washings of the precipitate, as is true with iodic acid and some organic acids. When, however, analysis reveals the same basic compound as being formed under varied conditions of dilution, etc., as is the case with the basic chromate, it may fairly be assumed that a definite chemical compound has been formed.

There has been little system in the assignment of formulas to the basic zirconyl compounds. Some have written them simply in the ratio of the zirconia to the acid anhydride as $2ZrO_2.SO_3$. Others report this basic zirconyl sulphate as $ZrO_2.ZrOSO_4$. Perhaps the most common formula is $Zr_2O_3.SO_4$. Such formulas fail to make clear the known facts. These substances are often gelatinous and, when hydrolysis is far advanced, the solutions become opalescent. On dialyzing the solutions leave zirconyl hydroxide as a hydrogel. Even the crystalline basic salts dialyze with difficulty and show partly colloidal properties. They have been called half-colloids. Electrolytic dissociation shows often a migration of the zirconyl radical as an anion or a partition of the zirconium between the anions and cations. It is well known that the migration of a colloid is largely influenced by the medium. Furthermore, there is practically always water of hydration or crystallization present. Considering these facts, it is suggested that the most suitable formula for these basic salts would have to include the zirconyl hydroxide. Thus $ZrO_2.ZrOSO_4$ becomes $ZrO(OH)_2.ZrOSO_4$ and $Zr_2O_3Cl_2$ becomes $ZrO(OH)_2.ZrOCl_2$. This reveals at a glance the stepwise formation of the

colloid and the liberation of the acid, e. g., $ZrCl_4+H_2O=ZrOCl_2+2HCl$; $2ZrOCl_2+2H_2O=ZrO(OH)_2.ZrOCl_2+2HCl$. Where several molecules of $ZrOCl_2$ are hydrolyzed at one step more complex products will result. This method of writing the formulas has therefore been adopted throughout this text wherever accurate knowledge of the composition of the substance was available.

The tetrahalides of zirconium, especially the tetrachloride, form a number of substitution compounds with organic substances. In these all or half of the chlorine may be substituted. Thus acetic acid and its homologues of the aliphatic series give compounds $Zr(C_2H_3O_2)_4$, or in general, ZrR_4, whereas benzoic acid and its homologues give $ZrCl_2(C_6H_5.CO_2)_2$ or $ZrCl_2R_2$. With the esters, ketones, and aldehydes addition compounds are formed. Thus for the benzoic ethyl ester compound the formula is $ZrCl_4(C_6H_5.CO_2.C_2H_5)_2$. Similar direct addition compounds are formed between $ZrCl_4$ and the amines, the pyridin bases, etc. The tetrachloride has been suggested as a catalyzing agent in organic synthesis by Fridel and Crafts.

CHAPEL HILL, N. C.

A PURE CULTURE METHOD FOR DIATOMS*

By Bert Cunningham

Plate 9

At the suggestion of Dr. G. M. Smith of the Botany Department of the University of Wisconsin the writer undertook the pure culture of Algae. Among others, the Diatoms proved most abundant, and therefore they were selected as the subject of further work.

Beyerinck (1890) seems to have been the first to apply the idea of Koch (1882), i. e., the use of a solid media to the culture of Algae. He succeeded in securing a culture of a protoccoid in a mixture of gelatine and sterile pond water. Miquel (1892) was the first to secure a Diatom in pure culture. He made an artificial nutrient with sterile sea water and inoculated it with a couple of drops of plankton material and then started cultures by fractional subdivision. In 1900 Allen and Nelson used the same method but with a variation of nutrient. West (1916) thought the method of Allen and Nelson to be good but suggested that the materials should be poured into Petrie dishes and, after a few days, the colonies should be pipetted out. Richter (1903–11) secured *Nitzschia palea* and *Navicula minuscula* by the use of synthetic agar plates. His technique will be discussed later. Pringsheim (1912–13) used the agar method for growing and separating of Oscillaria and Nostoc. He mentioned the occurrence of Diatoms but apparently did not follow them up.

Returning now to the technique of Richter. This is given in his *Zur Physiologie der Diatomeen*, published in 1909. In 1906 he started a culture of Diatoms with *Fucus serratus* and placed them in an atmosphere of hydrogen-sulfid. This reagent killed the bacteria but seemed to have no serious effect upon the Diatoms. This had been previously shown by Molisch. The Diatoms secured in this manner were colorless and identified as *Nitzschia putrida* Benecke. Later, in 1906, he secured pure cultures by dipping a tube in raw cultures, holding it for a minute and then dipping it into sterile sea water. The cultures secured in this way were placed on agar plates. At this time he used also another method. A small piece of agar was suspended in sterile sea water which had been inoculated with a few drops of plankton material. In the course of a few days the diatoms had reached the agar and attached themselves to it. Practically

*Presented at the Botany Seminar., Univ. Wis., Feb. 1920.

pure cultures were thus secured. These colonies also were transplanted to Petrie dishes.

Such methods might serve well where the great majority of the Diatoms are of one species and where there is no great contamination of other forms, but would hardly be successful when used with the ordinary fresh water plankton. The method which we propose here is based upon these previous methods but has a number of variations. In the first place we used artificial media. It was made after the formula suggested by Moore (as given by Küster) for the culture of Algae, as follows:

Ammonium Nitrate	.5 gr.
Dipotassium Phosphate	.2 gr.
Calcium Chlorid	.1 gr.
Magnesium Sulfate	.2 gr.
Ferric Sulfate	trace
Distilled water	1000 cc.
(Special low conductivity)	

This differs from the formulae usually given for Diatoms in that it contains no added Silicon compound. Chemical analysis of our agar, however, showed Silicon to be present and an examination of the agar filtered through cotton showed the presence of some marine Diatom shells. A 2% solution was now made up with this nutrient and washed agar. The material was sterilized in test tubes and retained in them until needed. It was then melted and poured into Petrie dishes. When it had cooled somewhat, but not hardened, a drop of pond water was placed on it and washed around. The plate was then hardened and was turned up-side-down upon the cover and placed under a bell jar in the green house. After from three to four weeks, there were colonies of various organisms, large enough to be spaded out. This was accomplished by the use of a platinum needle. The colony thus dissected out was examined under the microscope and if not too badly contaminated, it was stirred up in sterile water and replated on new agar plates. These plates were likewise placed under culture conditions and in a few weeks had well formed colonies. In case all the colonies were not of the same species, colonies were dissected out and replated. Thus far this second plating in all our cases, has given us pure cultures. In this manner we have secured four species of Diatoms.*

* In this manner we secured also a Blue Green, a unicellular Green and Scenedesmus, the latter of which has been thoroughly worked out by the pure culture method by G. M. Smith (1916). The four species of diatoms thus secured have been identified by Dr. J. J. Wolfe as

Navicula atomus Naeg.
Navicula minuscula Grun.
Nitzschia amphioxys (Ehr.) Grun.
Nitzschia palea Wm. Smith.

Diatoms, as well as bacteria, have, in some cases, well defined contour of colony. Each of the species we have cultured shows a decided difference. The first type is that of a spreading form. It soon comes to cover the entire plate with a film of individuals. A plate of this form is shown in fig. 1. A colony of this type is easy to secure since one has but to dip down between the colonies in an old plate and make cultures from this "dip." Another form of colony is shown in fig. 2. Here we find the colony margin to be restricted and the form more or less radiate, with the organisms rather evenly distributed over the area. A third form of colony is somewhat similar to the latter, but differs in that the central area is much more thickly settled than the margin. This thickened area occurs before the gradual spread as is easily seen from fig. 3. Perhaps the more characteristic form is that assumed by the last type which we call the sheaf type. Fig. 4 is of this type.

We are satisfied that we have not in any degree studied all the forms that may be cultured in this manner, since a number of forms were found in the first plates which we did not have time to follow up, and further, our original pond water did not contain a great number of forms.

Diatoms cultured in this manner are easily cleaned and prepared for examination. The various colonies are spaded out, placed in a test tube and the agar dissolved in boiling water. The solution is centrifuged with a small centrifuge and the precipitate is washed several times with hot water, the centrifuge being used each time for concentration. After all the agar has been removed the Diatoms may be either burned upon the cover glass or cleaned with sulfuric acid and bichromate. After thorough washing they are kept in 50% alcohol.

The pure culture methods open up several fields of work. First, the physiology of a species may be studied as was done by Richter. Second, the classification of the groups may be studied. We think this last point one of great interest. It is fairly well known that species have been made upon the description of a single valve. By this method, if the species will grow on agar, both shells would be available for study and any differences could be noted. Rare forms may be secured. Again, there is probably great variation among the Diatoms, as elsewhere, and probably the majority of these variants would show up in these cultures, thus species could be minimized. If there should be any doubt as to the common ancestry of all the

species on a plate, the Barber pipette could be used to isolate a single specimen as the progenitor.

While we do not believe that this method will be available for all species of Diatoms, yet we feel sure that if it is applied to the forms which will grow upon agar, a number of interesting results will follow.

DURHAM, N. C.

EXPLANATION OF PLATE 9.

FIG. 1. Photograph of an agar plate of *Nitzschia amphioxys*. Reduced one-half.

FIG. 2. Photograph of a portion of an agar plate of *Navicula atomus*. ×20.

FIG. 3. Photograph of a portion of a colony on an agar plate of *Navicula minuscula*. ×50.

FIG. 4. Photograph of a portion of an agar plate of *Nitzschia palea* ×20.

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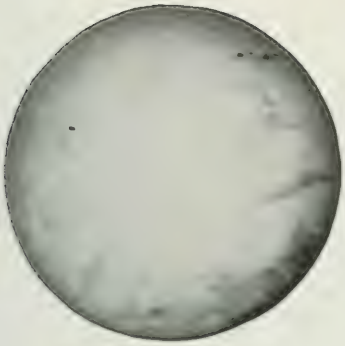
PLATE 9



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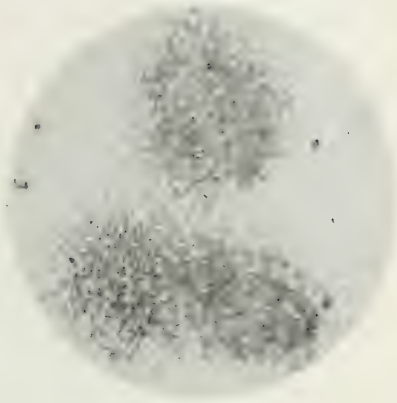

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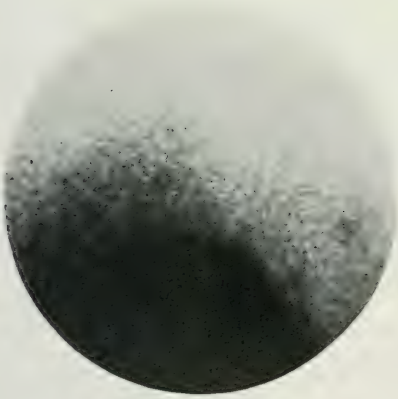


3

4

THE OCCURRENCE OF UNLIKE ENDS OF THE CELLS OF A SINGLE FILAMENT OF SPIROGYRA

By Bert Cunningham

Plate 10

Wolle in his Fresh Water Algae of the United States first divides the genus Spirogyra into two groups, based upon the condition of the ends of the cells. In case they are replicate as represented in figure 5 they are placed in one group, while if they are plane as indicated in figure 6 they are placed in the other. DeToni[1] makes the same distinction. West[2] also uses this character as a means of classification, but adds concerning the former "it (i. e., the replicate ends) is a character which is constant for the species for which it is found, although the ingrowths are not necessarily present at the extremity of every cell in the filament."

Since there are no specific cases cited by West, and since the occurrence is not described by Wolle or DeToni, and since the writer has found such a phenomenon occurring, it was thought to be worth noting.

The material was collected in the spring of 1917 in an intermittent pool along with considerable Vaucheria. The species may be described as follows:

Cell membrane replicate at the ends in at least half of the cases examined; chlorophyll band single, usually about four turns; conjugation scalariform; vegetative cell length about 200 mu, width about 25 mu; zygote cell length about 175 mu, width about 40 mu; zygote somewhat spindle-shaped; length 70 mu, width about 35 mu. This follows so closely the description for *S. spreeiana* Rabh., that the writer places it in this species.

The accompanying figures illustrate more clearly than words the phenomenon. Figure 1 is a diagrammatic drawing (in which no effort has been made to represent the shape of the cell or zygote) of a pair of conjugating filaments. Each cell is indicated as it occurred in the filament. Those marked with double arrows are replicate while the others are plane. Those in which we were unable to determine the nature of the end we have indicated by ?. Cells preparing to conjugate are indicated by a *P*. Figure 2 is a diagrammatic drawing

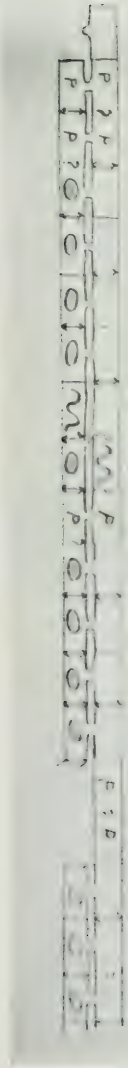
[1] Sylloge Algarum.
[2] British Fresh Water Algae. (1904).

of another pair of conjugating filaments, in which the points are indicated as in figure 1. Figure 3 is a microphotograph of the pair of filaments diagrammed in figure 1. This is a water mount. Figure 4 is a microphotograph showing the differences between the ends of the cells.

The phenomenon occurs freely in the collected material and seems to be natural. The writer has made no attempt at explanation of the cause. However, efforts were made to germinate the spores formed but they were unsuccessful. The failure to germinate was most probably due to laboratory conditions.

DURHAM, N. C.

PLATE 10



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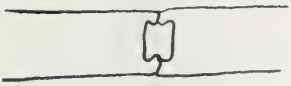

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6

SOME MARINE MOLLUSCAN SHELLS OF BEAUFORT AND VICINITY

By Arthur P. Jacot

Plates 11–13.

While at Beaufort, N. C., during the summers of 1915 and 1916, the writer took the opportunity to collect what marine molluscan shells were procurable by beach picking. A study of the material thus gathered and of the fragmentary and scattered condition of the literature on the mollusca of this region have led me to present this summary for what possible short cuts it might give future workers on this subject.

Four papers on the shells of this region have come to my notice. In 1860 W. Stimpson published a paper, *Mollusca of Beaufort, N. C.*, in the Am. Jour. Sci., ser. II, vol. XXIX, p. 442. When reading his article it should be born in mind that he confounds Cape Lookout with Cape Hatteras. Eleven years later E. Coues included in his *Notes on the Natural History of Fort Macon and Vicinity* in the Proc. Phil. Acad. Sci., vol. XXIII, p. 120 (131), 1871, a list of the shells of this region. Again eleven years later H. L. Osburn published in the Studies from Biol. Lab. John Hopkins Uni., vol. IV, p. 64, 1887, some interesting *Notes on Mollusca Observed at Beaufort, N. C.* Then in 1912, H. D. Aller's *Notes on Distribution of the More Common Bivalves of Beaufort, N. C.* appeared in this Journal, vol. XXVIII, p. 76. Kurtz, *Catalogue of the Shells of N. & S. Carolina*, 1860, is a list without localities. Thus this locality is no new field and promises to be one of importance.

Beaufort is the mid-most of North Carolina's harbors or outlets to the sea. Situated 10 miles northwest of Cape Lookout and 95 miles northeast of Cape Fear, it is the only outlet for the waters of the extensive sounds lying back of and between these two Capes. Thus two distinct faunal areas are brought in direct contact and an outside or deep-water silt fauna added.

The Molluscan fauna of this region is typical of the east coast of the United States and yet is so situated as to receive West Indian as well as northern species. Two distinct faunas are represented, that of the outer beach or sea and that of the sounds or quiet water. The sea fauna is one characteristic of the whole coast of the state, i. e., a hard sand bottom with mud opposite the inlets. The only

exception to this is the rock breakwaters at the inlet and at Cape Lookout. The sound fauna may be much divided and classified as to depth, salinity, character of bottom, plant association and current. This would form an interesting study once the shell fauna is better known. See also Coues.

The following list is a composite of the above mentioned lists and my collecting. The initials (S C O A J) following the name of the species refer to the names of those reporting the presence of that species. The reference below the name of the species is to a good illustration or description. Some of the material collected may be fossil, as indicated. Some of these fossil looking shells are greenish to bluish-black and of a dead to chalky appearance. This may be due to having lived in mud of that color. Shells are similarly discolored from Massachusetts southward, especially such species as *Anomia simplex, Pecten gibbus, Ostrea virginica,* etc. The smaller Gastropods recorded as fossil (not discolored) were thrown on the beaches by a channel dredge which dumped excavated material on the sand bars and grassy flats.

AMPHINEURA

Chaetopleura apiculata Say. S C O J
Dall, U. S. Nat. Mus. Bull. 37, pl. 51, fig. 10.
Uncommon, inside, about break-waters.

PELECYPODA

Solemya velum Say. S C O A J
Dall, U. S. Nat. Mus. Bull. 37, pl. 37, fig. 3.
Locally abundant, sand flats, Town Marsh behind draw. (See Aller.)

Nucula proxima proxima Say. S C A J
Md. Geo. Sur., Plio.-Pleistocene, pl. 65, figs. 1–4.
Fairly common, in the channels.

Leda acuta (Conrad). S C J
Md. Geo. Sur., Plio.-Pleistocene, pl. 65, figs. 5–8.
Fairly common, sand flats, Bird Island.

Yoldia limatula (Say). S C J
Dall, U. S. Nat. Mus. Bull. 37, pl. 49, fig. 5 and pl. 56, fig. 1.
Uncommon, sand, dredged (Coues); only fragments found.

Glycymeris americana (Defrance). S? J
Outline regular, ribs radially striate.
Occasional outside, much worn.

Glycymeris pectinata (Gmelin). S C J
Figure 45.
Uncommon to rare, outside, my specimens all fossil-looking.

Arca occidentalis Philippi. S C J
Figures 48 and 17646.

Less common than the next (Coues), *vice versa* J, outer beach.
This is the American variety of Linné's *A. noae.*
Three or four smaller ribs between the large ones.

Arca umbonata Lamarck. C J
Figure 56.
Occasional, outer beach.
This is the American variety of the European *A. imbricata.*
Large and small ribs alternating, somewhat reticulate.

Arca (Barbatia) reticulata Gmelin. J
Figure 13.
Two fragments of posterior portion of valve; inside.

Arca (Noetia) ponderosa Say. S C A J
Md. Geo. Sur., Plio.-Pleistocene, pl. 64, figs. 1–6, and figures 51 and 1019.
Common, inside and out (see Aller).
Specimens very much elongated posteriorly are rarely met. They approach the ancestral form *A. limaula* Conrad. I have figured one of these specimens, figure 54. (See also Coues.)

Arca (Scapharca) secticostata Reeve. S C J
Figures 55 and 119.
Occasional, outer beach.
My specimens are worn but do not look fossil.

Arca (Scapharca) incongrua Say. S C J
Figures 52, 53 and 1021.
The most abundant of the genus, outside.

Arca (Scapharca) transversa Say. C O A J
Dall, U. S. Nat. Mus. Bull. 37, pl. 56, fig. 2; and figs. 50 and 076a.
Fairly common inside.
Could some of Coues' *A. lienosa* have been this species? The name has often been applied to *A. secticostata.*

Arca (Scapharca) campechiensis Dillwyn. S C A J
Dall, U. S. Nat. Mus. Bull. 37, pl. 56, fig. 16; and figs. 49 and 181.
Common, inside.
Specimens approaching the elongate South Carolina variety *A. americana* (with 35 ribs), are seldom found.

Atrina rigida (Dillwyn). S A J
Arnold, Sea-beach at Ebb-tide, p. 432, fig. 1.
Uncommon outside, occasional inside. (See also Aller.)
This is the long-spined form.

Atrina serrata (Sowerby). S C? J
Rogers, Shell Book, p. 410, fig. 1.
Fairly common on mud flats, commoner outside.

Pteria radiata Leach.
Reeve, Conch. Icon., Avicula, pl. 6, fig. 10; and pl. 7, fig. 14.
One pair of attached valves, 11 mm. along hinge line.

Pteria eximia Reeve.
Reeve, Conch. Icon., Avicula, pl. 16, fig. 62, and figures 7 and 8.
Common on sea fan (*Leptogorgia virgulata*) in shallow water. Found on parts of the sea-fan which are black and bare of zooids, with the long wing di-

rected upward and outward so that they look like a dead stump or part of the fan.

Although Stimpson and Coues report *Pteria colymbus* (Dillwyn), I was unable to find a trace of it. The material which I have called *P. eximia* agrees perfectly with Reeve's *A. eximia* and the specimens were quite common on the fans. I have been unable to find any mention of this form. If Reeve's name should be preoccupied or subsequently taken, I would call the species *P. eximioides*. Some of my material has been deposited in the American Museum under Cat. No. 4998.

Ostrea virginica Gmelin. S C O A J

Md. Geo. Sur., Plio.-Pleistocene, pls. 61–63.

Abundant inside, mostly on mud flats, forming extensive banks locally called "rocks."

Ostrea equestris Say. S C

See Coues.

"Abundant; adhering to rocks with *Modiola* and *Mytilus*."

Pecten (*Plagioctenium*) *gibbus irradians* Lamarck. S C J

Rogers, Shell Book, p. 411, fig. 1.

Abundant, outside, inside on sand in the deeper water.

Normal number of ribs is 18–20, most common number is 19; rarely brilliant as *P. gibbus;* prefers open, clear water, and usually a greater depth than *P. gibbus*.

Pecten (*Plagioctenium*) *gibbus gibbus* Linné. S C O A J

Common, inside on quiet mud flats, west of Piver's Island.

Normal number of ribs is 19–22, most common number is 20, usually brightly colored, shows preference to quiet water.

Pecten nodosus Linné. S C J

Rogers, Shell Book, p. 418, fig. 1.

Coues reports a beach worn valve; half a fresh valve was picked up on Shackleford Bank in August, 1916.

Plicatula gibbosa Lamarck. S C J

Figures 85.

Occasional inside.

Lima inflata Lamarck. S C J

Rare, inside, largest have a vertical height of 14 mm., the riblets are obsolete through the center of the disc. Live specimens found by Dr. Hyman differ in being relatively stouter, more inflated, broader, and in being covered by rounded, unequal, radial wrinkles. Vertical height, 13 mm.

Anomia simplex Orbigny. S C O A J

Rogers, Shell Book, p. 419, figs. 4 and 6.

Abundant inside.

Mytilus (*Hormomya*) *exustus* Linné. A J

Figures 1, 2 and 3.

Common, on breakwaters.

Stimpson and Coues report *Mytilus cubitus* Say (*Modiolus citrinus* Bolten) probably for this species.

They also report *Mytilus edulis*.

Mytilus recurvus Rafinesque. C J

PLATE 11


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Rogers, Shell Book, p. 388, fig. 2.
Occasional inside.

Modiolus (*Brachydontes*) *demissus demissus* (Dillwyn). S C O A J
Dall, U. S. Nat. Mus. Bull. 37, pl. 54, fig. 1.
Abundant, inside on the grassy tidal flats.

Modiolus tulipus Lamarck. S C A J
Dall, U. S. Nat. Mus. Bull. 37, pl. 54, fig. 4.
Rogers, Shell Book, p. 396, fig. 6.
Fragments (rarely entire valves) occasional on outer beach. (See Aller.)
Coues also reports a live specimen of *Modiola castanea* Say from the channel.

Modiolaria lateralis (Say). S J
Dall, U. S. Nat. Mus. Bull. 37, pl. 6, figs. 7 and 8.
One young pair of valves from Piver's Island has been referred to this species.

Lithophaga bisulcata (Orbigny). A
"Railroad pier at Morehead City, burrowing into pieces of coral and soft rock. Maximum length is 46 mm."
Osborn records *Lithodomus lithophagus* Linné, stating that: "Numerous specimens are found boring into the surface of wharf-piles beneath the bark."

Rocellaria stimpsoni Tryon. S C O
"Shells of *Venus mercenaria* riddled with holes" of this species.

Pandora trilineata Say. S C J
Dall, U. S. Nat. Mus. Proc., vol. 24, pl. 31, fig. 4, *cf.* pl. 32, fig. 7.
Uncommon, inside, mud flats.
Some of my material approaches *P. trilineata gouldiana* Dall. Stimpson and Coues report *Lyonsia hyalina* (Conrad).

Crassatellites mactracea (Linsley). S C J
Dall, U. S. Nat. Mus. Bull. 37, pl. 58, figs. 11 and 13.
Occasional, inside.
Unworn individuals are well striated.

Venericardia (*Pleuromeris*) *tridentata* Say. S C J
Figures 9 and 10.
Occasional, inside.

Chama congregata Conrad.
Md. Geo. Sur., Miocene, pl. 41, figs. 1–3.
Occasional, upper valve fairly common, inside.

Chama macerophylla Gmelin. S C O
Reeve, Conch. Icon., vol. 4, pl. 2, fig. 6; and pl. 8, fig. 6b.
Reported abundant by Coues and rare by Osborn, I was unable to find anything that I would refer to this species. The largest of my Chamas s. s. have a greatest length of 24 mm. and have no foliaceous scales.

Echinochama arcinella (Linné). S C J
Rogers, Shell Book, pl. 357, fig. 3.
Uncommon (two specimens), outer beach.

Lucina chrysostoma Philippi. S C O J
Arnold, Sea-beach at Ebb-tide, p. 444, fig. 5.
Common, outer beach.

Phacoides (*Callucina*) *radians* (Conrad).
Dall, U. S. Nat. Mus. Proc., vol. 23, pp. 809 and 824, pl. 42, fig. 8.

One worn right valve.

Phacoides (*Parvilucina*) *multilineatus* (Tuomey & Holmes). A J
Dall, U. S. Nat. Mus. Proc., vol. 23, p. 825, pl. 39, fig. 2.
Common, inside.

Divaricella quadrisulcata (Orbigny). S C O A J
Dall, U. S. Nat. Mus. Bull. 37, pl. 58, fig. 6.
Common, both inside and out.
Called *Lucina strigillia* by Stimpson and Coues.
No specimens of *D. dentata* were found, ditto Aller.

Diplodonta soror (C. B. Adams). S C J
Figure 172.
Five valves, inside.
"This well-characterized species is notable for its microscopic shagreening on the posterior slope and the compression of that part of the valve" (Dall).

Aligena elevata (Stimpson).
Dall, U. S. Nat. Mus. Bull. 37, pl. 68, fig. 6.
Two left valves, inside.

Montacuta (*Orobitella*) *floridana* Dall.
Dall, U. S. Nat. Mus. Proc., vol. 21, pl. 87, fig. 10.
Two right valves, inside.

Cardium (*Trachycardium*) *isocardia* Linné. S C A J
Arnold, Sea-beach at Ebb-tide, p. 454, fig. 2.
Occasional, both inside and out.

Cardium (*Trachycardium*) *muricatum* Linné. S C A J
Rogers, Shell Book, p. 356, fig. 3.
Occasional, inside and out. (See Aller.)

Cardium (*Cerastoderma*) *robustum* Solander. S C O A J
Rogers, Shell Book, p. 356, fig. 2.
Very abundant on outer beach.

Cardium (*Laevicardium*) *serratum* Linné. S C J
Arnold, Sea-beach at Ebb-tide, p. 454, fig. 3.
Occasional, mostly inside.

Cardium (*Laevicardium*) *mortoni* Conrad. S C A J
Dall, U. S. Nat. Mus. Bull. 37, pl. 58, fig. 8.
Fairly common, inside.

Dosinia (*Dosinidia*) *discus* (Reeve). S C O A J
Dall, U. S. Nat. Mus. Proc., vol. 26, pl. 12, fig. 1; and pl. 13, fig. 1.
Common, inside and out. (See Aller.)
D. elegans Conrad is undoubtedly present but I am unable to report it.

Macrocallista nimbosa (Solander). S C O A J
Arnold, Sea-beach at Ebb-tide, p. 450, fig. 2.
Common on the sandy beaches a few inches deep between tide lines. (See Coues for general notes.)

Macrocallista (*Chionella*) *maculata* (Linné). S J
Arnold, Sea-beach at Ebb-tide, p. 450, fig. 3.
One valve, inside.

Callocardia (*Agriopoma*) *morrhuana* (Linsley). C J

Dall, U. S. Nat. Mus. Bull. 37, pl. 56, fig. 15.
Abundant on outer beach, generally discolored as mentioned by Coues. If the habitat of this species is the mud opposite the inlet the coloration would be accounted for, as the valves do not look fossil and have the color of the fine, blue mud just outside the inlet.

Chione cancellata (Linné). S C O A J
Arnold, Sea-beach at Ebb-tide, p. 450, fig. 1.
Abundant, inside on mud at low water. (See Aller.)
Osborn uses Dillwyn's name *C. cingenda.*

Chione (*Lirophora*) *latilirata* (Conrad). S J
Dall, Trans. Wagner Free Inst., vol. 3, pl. 42, fig. 3.
One valve on outer beach.

Chione (*Timoclea*) *grus* (Holmes). S J
Figures 4, 5 and 6.
Fairly common, inside.
Called *C. pygmaea* by Stimpson.

Venus mercenaria Linné. S C O A J
Rogers, Shell Book, p. 322, figs. 4 and 6.
Abundant, inside in mud near surface between tides.

Venus mercenaria notata Say.
Dall, U. S. Nat. Mus. Bull. 37, pl. 57, fig. 1.
Recorded by Coues.

Venus campechiensis Gmelin. S C J
Dall, U. S. Nat. Mus. Proc., vol. 26, p. 377.
Common inside. (See Coues.)

Venus campechiensis quadrata Dall.
Dall, U. S. Nat. Mus. Proc., vol. 26, p. 377.
One specimen, inside.

Gemma gemma purpurea (H. C. Lea). C J
Dall, Trans. Wagner Free Inst., vol. 3, pl. 24, figs. 2, 4 and 4b.
Occasional, at least inside.

Petricola (*Petricolaria*) *pholadiformis* Lamarck. S C A J
Dall, U. S. Nat. Mus. Bull. 37, pl. 59, fig. 15.
Rogers, Shell Book, p. 322, fig. 3.
Fairly common, inside. (See Aller.)

Petricola (*Petricolaria*) *dactylus* Sowerby. A
Figures 42 and 306.
"Railroad pier at Morehead City."

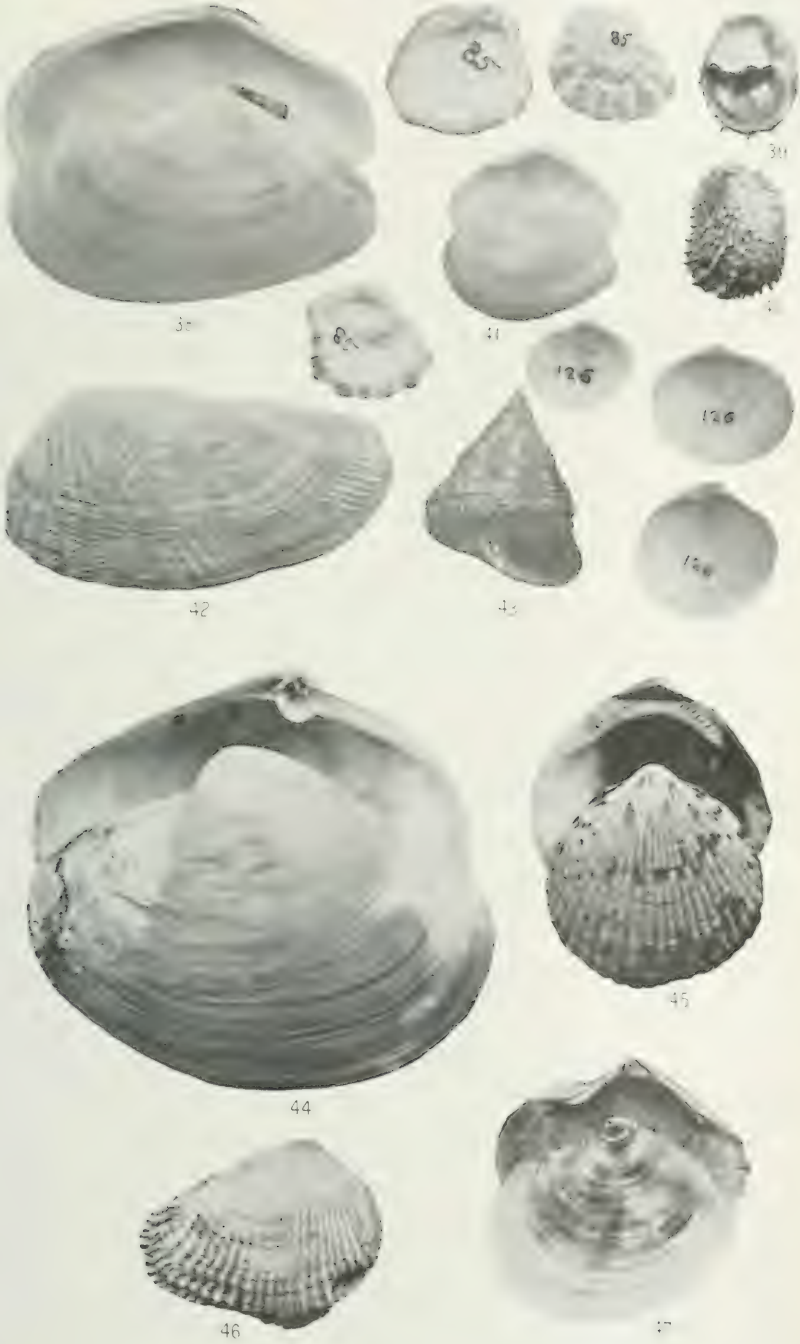
Petricola (*Rupellaria*) *typica* (Jonas). A
Figure 46.
"Railroad pier at Morehead City."

Tellina (*Merisca*) *lintea* Conrad.
Figure 41.
Fairly common, inside.

Tellina (*Eurytellina*) *alternata* Say. S C O A J
Figure 38.
Fairly common, inside. (See Osborn.)

Tellina (*Angulus*) *tenera* Say. S C J
Dall, U. S. Nat. Mus. Bull. 37, pl. 56, fig. 13.
Occasional, inside.
Tellina (*Angulus*) *versicolor* DeKay. S J
Shape as *T. tenera* but rayed with pink.
Less common than preceding, inside.
Tellina (*Angulus*) *sayi* Deshayes. S C J
Thick; with a raised rib running from under the beaks inside.
The commonest *Tellina*, inside.
Called *T. polita* by Stimpson and Coues.
Tellina (*Scissula*) *iris* Say. S C O
Surface obliquely grooved; with radiating pink rays.
Rare, inside, sand.
Tellidora cristata Récluz. S J
Figure 47.
Three valves, inside.
Strigilla flexuosa (Say). S C J
Dall, U. S. Bur. Fish. Bull., vol. 20, pt. 1, p. 482, 1901.
Occasional, inside.
Macoma tenta (Say). S C A J
Dall, U. S. Nat. Mus. Bull. 37, pl. 56, fig. 10.
Two right valves, uncommon, inside.
Macoma (*Psammacoma*) *brevifrons* (Say).
Dall, U. S. Bur. Fish. Bull., vol. 20, pt. 1, p. 481, pl. 55, figs. 3, 12 and 13.
One right valve, inside.
Semele bellastriata (Conrad). S? J
Dall, U. S. Bur. Fish. Bull., vol. 20, pt. 1, p. 477, 1901.
One worn right valve, inside.
Stimpson's record is *S. reticulata*.
Semele proficua (Pulteney). S C A J
Figure 126.
Fairly common, inside.
Called *S. orbiculata* by Stimpson and Coues.
Abra aequalis (Say). S C A J
Figure 127.
Fairly common, inside.
Abra lioica Dall.
Figure 650.
Five valves, inside.
Cumingia tellinoides Conrad. S C J
Md. Geo. Surv., Plio.-Pleisto., pl. 56, figs. 1–5.
Uncommon, inside.
Tagelus gibbus (Spengler). S C O A J
Md. Geo. Surv., Plio.-Pleisto., pl. 57, figs. 1–4.
Fairly common, inside. (See Aller.)
The young have no median ray, short nymphs and a longer pallial sinus than *T. divisus*.

PLATE 12



Tagelus (*Mesopleura*) *divisus* (Spengler). S C A J
Dall, U. S. Nat. Mus. Bull. 37, pl. 56, fig. 5.
Common, inside. (See Aller.)

Donax fossor Say.
Figures 16 and 17 (figure 16 is from Long Island, N. Y.).
Occasional, inside.
Osborn's record, though under this name, is for the other species.

Donax variabilis Say. S C O A J
Figures 14 and 15 (figure 15 is from Long Island, N. Y.).
Abundant on sandy outer beaches, especially where somewhat protected. (See Aller and Coues.)

Ensis directus (Conrad). S C O A J
Dall, U. S. Nat. Mus. Bull. 37, pl. 53, fig. 4.
Occasional, inside. (See Aller.)

Ensis minor Dall.
Common on sandy shallow flats, inside.
Differs constantly from the previous in being smaller and more slender and in having a tendency to be wider at posterior than anterior end.

Spisula (*Hemimactra*) *solidissima* (Dillwyn). S C O J
Dall, U. S. Nat. Mus. Bull. 37, pl. 57, fig. 2.
Common on outer beach.

Spisula (*Hemimactra*) *solidissima raveneli* Conrad.
Short, high form.
Coues' record under this name undoubtedly refers to the previous.

Spisula (*Hemimactra*) *solidissima similis* (Say). S C A J
Smaller, thinner, finer form.
Fairly common, inside.

Mulinia lateralis (Say). S C A J
Figure 12.
Abundant, inside.

Mulinia lateralis corbuloides (Deshayes).
Figure 11 (144).
Fairly common to occasional.

Labiosa lineata (Say). S C J
Figure 44.
Uncommon, on ends of the banks. (See Coues.)

Labiosa (*Raeta*) *canaliculata* (Say). S C O J
Rogers, Shell Book, p. 337, fig. 3.
Common, outside.

Mya arenaria Linné. S C J
Dall, U. S. Nat. Mus. Bull. 37, pl. 69, fig. 2.
Rogers, Shell Book, p. 323, fig. 7.
Uncommon, inside. I found three broken valves, one 2½″ long, the others under one inch, all fresh.

Paramya subovata Conrad. S C J
Md. Geo. Sur., Miocene, pl. 68, figs. 7 and 8.
Uncommon, inside, four valves.

Corbula (*Cuneocorbula*) *contracta* Say. S C J
Md. Geo. Surv., Plio.-Pleisto., pl. 53, figs. 1–4.
Uncommon, inside.
The largest and commonest *Corbula*.
Corbula (*Cuneocorbula*) *dietziana* C. B. Adams.
Dall, U. S. Nat. Mus. Bull. 37, pl. 2, figs. 7a–c.
Four young valves, inside.
Corbula (*Cuneocorbula*) *swiftiana* C. B. Adams.
Dall, U. S. Nat. Mus. Bull. 37, pl. 2, figs. 5a and 5b.
A few valves, inside.
Panopea floridana Heilprin. S C J
Dall, Trans. Wagner Free Inst., vol. 3, pl. 10, fig. 21.
Rare, outside, one right valve.
Barnea (*Scobina*) *costata* Linné. S C O J
Dall, U. S. Nat. Mus. Bull. 37, pl. 68, fig. 9.
Fairly common, outside.
Barnea truncata Say. S C J
Dall, U. S. Nat. Mus. Bull. 37, pl. 59, fig. 12.
Uncommon, inside.
Martesia cuneiformis Say. S O J
Johnson, Nautilus, vol. 18, p. 102, fig. 2.
"Found in dead shells of *Venus*." One valve on Piver's Island.
Martesia (*Diplothyra*) *smithii* (Tryon). A J
Johnson, Nautilus, vol. 18, p. 102, fig. 3.
"Abundant, railroad pier at Morehead City." Several in oyster shells.
Xylotrya gouldi Bartsch. O? A J
Sigerfoos, U. S. Bur. Fish. Bull., vol. 27, pl. 11.
Abundant, boring in submerged wood.

GASTROPODA

Fissuridea alternata Say. S C O J
Rogers, Shell Book, p. 227, fig. 2.
Occasional, inside. (See Osborn.)
Diadora sp.?
Probably new.
Two specimens.
Turbo castaneus Gmelin. S C J
Arnold, Sea-beach at Ebb-tide, pl. 67, fig. 4.
Rare, inside; two specimens.
Calliostoma comtum (Philippi). S C? O? J
Figure 43.
Occasional on jetties, especially of Shakleford Banks.
Cochliolepis striata Stimpson.
Dall, Trans. Wagner Free Inst., vol. 3, pl. 23, figs. 16 and 17.
Two specimens (8.5 mm. and 10.5 mm. long), inside.
Molleria costulata Möller.
Dall, U. S. Nat. Mus. Bull. 37, pl. 72, fig. 9.
Three specimens, inside.

Teinostoma floridana Dall.
Dall, Trans. Wagner Free Inst., vol. 3, p. 922, pl. 27, figs. 5, 6 and 9.
Two specimens, inside.

Teinostoma bartschi Vanatta.
Proc. Acad. Nat. Sci. Phila., vol. 65, pl. 2, figs. 9 and 11, 1913.
One specimen, inside.

Circulus trilix (Bush).
Dall, U. S. Nat. Mus. Bull. 37, pl. 41, figs. 7 and 7a.
One specimen, inside.

Eulima conoidea Kurtz and Stimpson.
Dall, Trans. Wagner Free Inst., vol. 3, pl. 5, fig. 11.
Occasional, inside; three specimens.

Pyramidella crenulata Holmes. S C J
Dall, U. S. Nat. Mus. Bull. 60, pl. 13, fig. 4.
Common, inside, on eel-grass beds.

Pyramidella candida Mörch.
"*P. crenulata* is larger, wider, with less sharply cut and less distinctly crenulated suture; it is rarely light colored, the brown columella and anterior plaits remaining dark even in pale specimens which are usually pinkish and delicately maculated with brown. *P. candida* is pure white, sometimes with an opaque white spiral line on middle of whorl, and generally one fewer lirae on throat than preceding species." Dall.

Turbonillas are common on the eel-grass beds. Among the commoner species recognized are:

Turbonilla (*Pyrgiscus*) *areolata* Verrill.
" " *interrupta* (Totten).
" " *powhatani* Henderson & Bartsch.
" " *pseudointerrupta* Bush, and varieties.
" " *punicea* Dall.
" " *vineae* Bartsch.

For further information see Bartsch, forthcoming monograph.

Odostomia (*Odostomia*) *modesta* (Stimpson).
Bartsch, Proc. Boston Soc. Nat. Hist., vol. 34, pl. 13, fig. 50.
One specimen, inside.

Odostomia (*Menestho*) *trifida* (Totten).
Dall, U. S. Nat. Mus. Bull. 37, pl. 52, fig. 8.
Three or four specimens, inside.

Odostomia (*Menestho*) *impressa* (Say). S C J
Dall, U. S. Nat. Mus. Bull. 37, pl. 52, fig. 11.
Abundant, inside, on eel-grass beds.

Odostomia (*Menestho*) *beauforti* n. sp.
Similar to *O. seminuda* but averaging longer and more slender, with five raised spiral bands, the fourth and fifth being more closely spaced than the other three, the sutural band as prominent as the others on the last three whorls, giving the whorls the appearance of having six raised spiral bands on the last three whorls, translucent, bluish-white. Type No. 15728, Am. Mus. Nat. Hist.

One specimen found on Piver's Island. The writer suspects that this is a mutation of *O. seminuda* but must suspend judgment until more extensive collecting has been done in this region.

Odostomia (*Chrysallida*) *seminuda* C. B. Adams. S C J

Bartsch, Proc. Boston Soc. Nat. Hist., vol. 34, pl. 13, fig. 48.

Common, inside, eel-grass beds.

Odostomia (*Chrysallida*) *toyatani* Henderson & Bartsch.

Henderson & Bartsch, U. S. Nat. Mus. Proc., vol. 47, pl. 13, fig. 2.

Several specimens, inside, eel-grass beds.

Odostomia (*Chrysallida*) sp.?

Two specimens of what seems to be an undescribed species were found with the others of this group. They are stouter than the last, and have eight spiral cords which are alternately larger and smaller, and joined by very prominent raised threads tending to give the base a reticulated appearance. In the other species of this group these connecting radial threads are rather inconspicuous.

Odostomia engonia teres Bush?

Dall, U. S. Nat. Mus. Bull. 37, pl. 41, fig. 9.

Three specimens have been provisionally referred to this form.

Peristichia toreta Dall.

Dall, U. S. Nat. Mus. Bull. 37, pl. 42, fig. 10.

Several, inside.

Epitoneum novemcostata (Mörch).

Figure 22.

One specimen, inside.

Epitoneum humphreysii (Kiener).

Figures 23 and 24.

Four specimens (two with 8 varices, one with 7, and one with 8 except last whorl which has 10 varices), inside. (See Coues.)

Epitoneum angulata (Say). S J

Dall, U. S. Nat. Mus. Bull. 37, pl. 50, fig. 10.

Two specimens, inside.

Epitoneum multistriatum (Say). S J

Dall, U. S. Nat. Mus. Bull. 37, pl. 50, fig. 5, and figure 28.

One specimen, inside.

Epitoneum novangliae (Couthouy). S

Like above but slightly umbilicate.

Epitoneum lineata (Say). S C J

Figures 26 and 27.

Occasional, inside. One specimen perforate.

Polynices (*Neverita*) *duplicata* (Say). S C O J

Dall, U. S. Nat. Mus. Bull. 37, pl. 51, fig. 12.

Fairly common, sand flats, inside. (See Osborn.)

Polynices (*Neverita*) *duplicata campechiensis* (Reeve).

Shell very depressed, umbilicus open.

Two typical individuals out of eleven and three intermediate ones.

Polynices (*Euspira*) *heros* (Say).

Dall, U. S. Nat. Mus. Bull. 37, pl. 51, fig. 11.

Fragment of a four-inch specimen.

Natica (*Cryptonatica*) *pusilla* Say. C
Dall, U. S. Nat. Mus. Bull. 37, pl. 50, fig. 21.
"Not common. Two or three specimens dredged."
Sigaretus perspectivus Say. S C O J
Arnold, Sea-beach at Ebb-tide, pl. 68, figs. 4 and 5.
Fairly common, inside and out. (See Coues or Osborn.)
Calyptraea centralis (Conrad).
Dall, Trans. Wagner Free Inst., vol. 3, p. 353.
One specimen, inside.
Crepidula fornicata Say. S C O J
Dall, U. S. Nat. Mus. Bull. 37, pl. 50, fig. 23.
Common, inside (see Osborn). Occasionally heavily ribbed by *Pecten.*
Crepidula glauca Say.
Gould, Invertebrata of Massachusetts, fig. 535, 1870.
Three specimens, inside.
Crepidula glauca convexa Say. S C O J
Dall, U. S. Nat. Mus. Bull. 37, pl. 50, fig. 25.
Fairly common, inside.
Crepidula aculeata Gmelin.
Figures 39 and 40.
One specimen, inside, bluish and broken, possibly fossil.
Crepidula plana Say. S C O J
Gould, Invertebrata of Massachusetts, fig. 533, 1870.
Fairly common. (See Osborn.)
Litiopa bombix Kiener.
Adams, Genera of Recent Shells, pl. 34, fig. 5a.
The protoconch is decussated with minute riblets.
One specimen among a lot of Sargasum weed.
Litorina irrorata Say. S C O J
Dall, U. S. Nat. Mus. Bull. 37, pl. 69, fig. 6.
Abundant on culms of marsh grass that is partially submerged at high tide.
Serpulorbis (*Vermicularia*) *spirata* (Philippi). S C O J
Dall, U. S. Nat. Mus. Bull. 37, pl. 51, fig. 4.
Two specimens, inside.
Caecum pulchellum Stimpson.
Dall, U. S. Nat. Mus. Bull. 37, pl. 50, fig. 22.
Fairly common in sand.
Triphoris perversum nigrocinctum C. B. Adams. S C J
Gould, Invertebrata of Massachusetts, fig. 522, 1870.
Occasional inside.
The apex is not smooth in unworn specimens of this species but finely cancellated by radial riblets which cross two spiral threads.
Cerithiopsis (*Eumeta*) *subulata* Montagu.
Dall, U. S. Nat. Mus. Bull. 37, pl. 52, fig. 1; and pl. 20, fig. 4.
Uncommon, inside.
For other species of this and the preceding, see forthcoming paper by Bartsch.
Seila adamsii H. C. Lea. S C O J
Dall, U. S. Nat. Mus. Bull. 37, pl. 52, fig. 5.
Common inside. (See Osborn.)

Cerithium floridanum Mörch.
Dall, Trans. Wagner Free Inst., vol. 3, pl. 14, fig. 10.
Arnold, Sea-beach at Ebb-tide, p. 326, fig. 4.
Four specimens.

Bittium (*Diastoma*) *virginicum* Henderson and Bartsch. S C O J
Henderson and Bartsch, U. S. Nat. Mus. Proc., vol. 47, p. 419, pl. 14, fig. 3.
Common, inside, on eel-grass beds.

Strombus pugilis Linné. S C O J
Rogers, Shell Book, p. 118, fig. 3.
Occasional outside, common in Lookout bight. (See Osborn.)
Called *S. alatus* by Stimpson and Osborn, none of this form was found by me.

Cypraea exanthema Linné. C J
Arnold, Sea-beach at Ebb-tide, pl. 70, fig. 2.
Rare, outside; one only, ditto Coues.

Ovulum uniplicata Sowerby. S O J
Rogers, Shell Book, p. 135, fig. 2.
Fairly common on sea fans (*Leptogorgia virgulata*). I have found both the yellow and orange *Leptogorgias* under one wharf, each with *Ovulum* of its own color. In company with them were *Pteria eximia*.

Dolium galea Linné. S C O J
Rogers, Shell Book, p. 139, fig. 1.
Occasional on outer beach.

Cassis inflata Shaw. S C J
Arnold, Sea-beach at Ebb-tide, pl. 71, fig. 5.
Common on outer beach.

Cassis tuberosa Linné.
Rogers, Shell Book, p. 138, fig. 1; and p. 139, fig. 4.
Common on outer beach.

Eupleura caudata Say. S C O J
Dall, U. S. Nat. Mus. Bull. 37, pl. 50, fig. 11.
Md. Geo. Sur., Plio.-Pleisto., pl. 49, figs. 7 and 8.
Occasional, inside and out.

Urosalpinx cinereus Say. C O J
Dall, U. S. Nat. Mus. Bull. 37, pl. 50, fig. 6.
Md. Geo. Surv., Plio.-Pleisto., pl. 49, figs. 9 and 10.
Common, inside and out. (See Osborn.)

Purpura haemastoma Linné. S C O J
Dall, U. S. Nat. Mus. Bull. 37, pl. 46, figs. 2a and 2b.
Common on the jetties.

Columbella (*Anachis*) *avara* Say. S C O J
Figures 33 and 34.
Fairly common, inside and out. Out of 22 one has 10 ribs, eight have 11 ribs, six have 12 ribs, five have 13 ribs, one has 14 ribs, and one has 15 ribs.

Columbella (*Anachis*) *translirata* Ravenel.
Figures 35 and 36.
Fairly common, inside and out.

Columbella (*Anachis*) *translirata similis* Ravenel.
Figure 32. Same as *C. translirata* but about half its size when adult.
One specimen, inside.

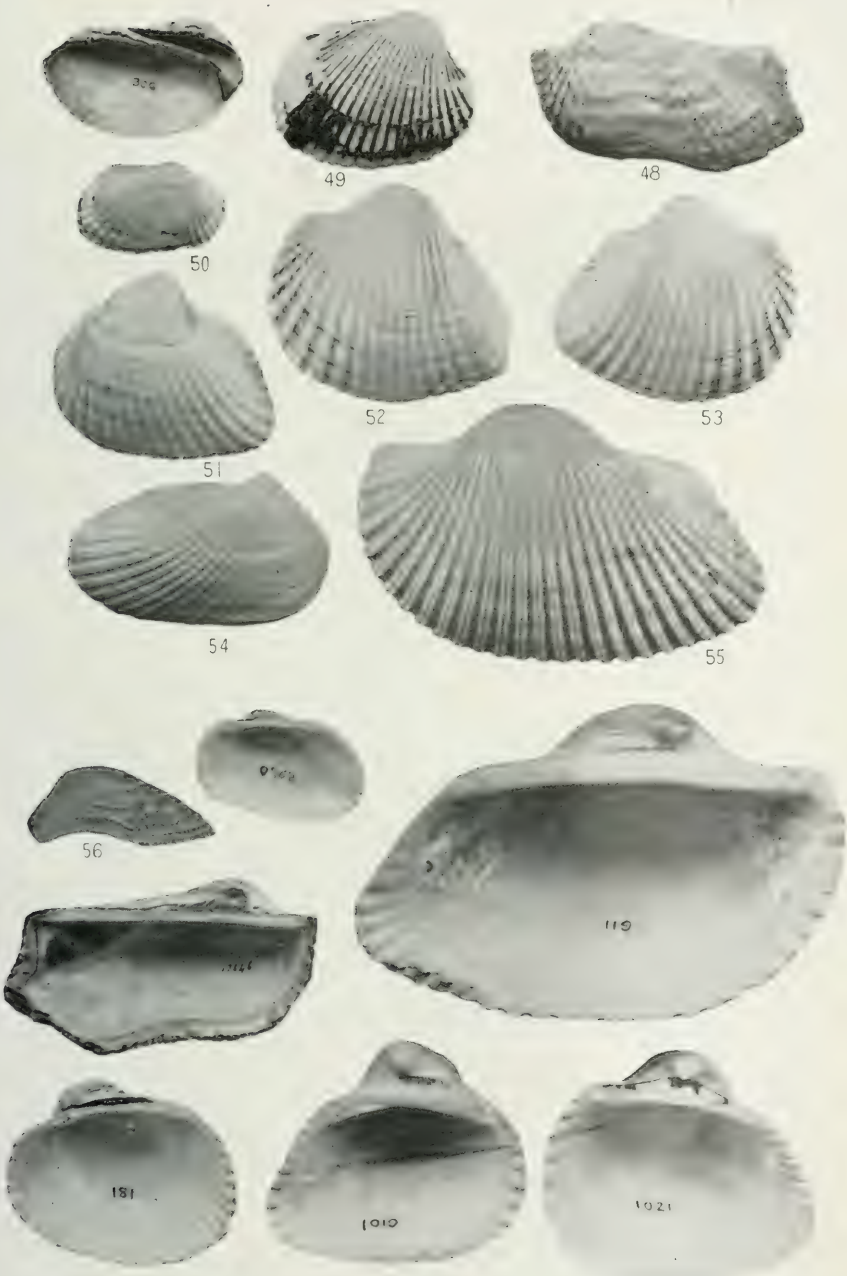
Columbella (*Anachis*) *obesa* C. B. Adams. S C J
Dall, U. S. Bur. Fish. Bull., vol. 20, pt. 1, p. 404, 1900.
Occasional, inside.
Columbella (*Astyris*) *lunata* Say. S C J
Dall, U. S. Nat. Mus. Bull. 37, pl. 50, fig. 16.
Common, inside.
Alectrion acuta Say.
Figures 30 and 31.
Two specimens, inside.
Alectrion (*Hima*) *ambigua* (Montagu). S J
Figures 18, 19 and 20.
Three specimens, inside. These specimens differ from Haitian specimens by having nine instead of thirteen or fourteen ribs and in being slightly less shouldered.
Alectrion (*Hima*) *vibex* (Say). S C O J
Dall, U. S. Nat. Mus. Bull. 37, pl. 50, fig. 8.
Abundant, "on the grassy sand-flats at the edges of the salt marshes, where it replaces *A. obsoleta*, found also, but less frequently, upon exposed mud-flats." Osborn.
Alectrion (*Ilyanassa*) *obsoleta* (Say). S C O J
Dall, U. S. Nat. Mus. Bull. 37, pl. 50, fig. 9.
Md. Geo. Surv., Plio.-Pleisto., pl. 49, figs. 3 and 4.
Very abundant, inside. (See Coues and Osborn.)
Figure 37 is a carinated form of this species.
Alectrion (*Tritia*) *trivittata* (Say). S C J
Dall, U. S. Nat. Mus. Bull. 37, pl. 48, fig. 13; and pl. 50, fig. 7.
Uncommon, inside.
Busycon carica (Gmelin). S C O J
Rogers, Shell Book, p. 70, fig. 2.
Common, especially inside on sand flats. (See Coues and Osborn.)
Busycon perversum (Linné). S C J
Rogers, Shell Book, p. 71, fig. 1.
Occasional, chiefly outside. (See Coues.)
Busycon (*Sycotypus*) *canaliculatum* (Linné). S C O J
Dall, U. S. Nat. Mus. Bull. 37, pl. 13, fig. 1.
Occasional, inside.
Stimpson also records *Busycon pyrum*.
Fasciolaria distans Lam. S C O J
Arnold, Sea-beach at Ebb-tide, p. 86, fig. 3.
Fairly common, inside on mud flats. (See Osborn.)
Fasciolaria tulipa Linné. S C
Arnold, Sea-beach at Ebb-tide, p. 86, fig. 2.
"One mutilated specimen." Coues.
Fasciolaria gigantea Kiener. S C J
Arnold, Sea-beach at Ebb-tide, p. 86, fig. 1.
Occasional, outer beach, rarely entire.
Marginella apicina Menke.
Figure 21.
Several, inside, bluish and fossil-looking.

Oliva sayana Ravenel. S C O J
Arnold, Sea-beach at Ebb-tide, p. 400, fig. 2.
Common, especially outside.
Olivella mutica Say. S C O J
Dall, U. S. Nat. Mus. Bull. 37, pl. 34, fig. 1.
Common, inside.
Olivella mutica nitidula Dillwyn.
Larger and less slender.
One specimen, inside.
Mangilia (*Kurtziella*) *cerina* Kurtz & Stimpson. S C J
Dall, U. S. Nat. Mus. Bull. 37, pl. 44, fig. 16.
Occasional, inside and out.
Mangilia plicosa C. B. Adams. S C J
Dall, U. S. Nat. Mus. Bull. 37, pl. 50, fig. 14.
Fairly common, inside and out.
Terebra (*Acus*) *dislocata* Say. S C O J
Dall, U. S. Nat. Mus. Bull. 90, pl. 5, fig. 2.
Abundant, inside.
Terebra (*Acus*) *concava* Say. S J
Dall, Trans. Wagner Free Inst., vol. 3, p. 24.
Fairly common, inside.
Tornatina canaliculata Say. S C J
Md. Geo. Surv., Plio.-Pleisto., pl. 42, figs. 5 and 6.
Abundant, inside.
Bulla amygdala Dillwyn. S C J
Arnold, Sea-beach at Ebb-tide, p. 350, fig. 1.
One small specimen, inside, fossil-looking.
Stimpson and Coues also record *B. solitaria*.
Cavolina tridentata Forskäl.
Dall, U. S. Nat. Mus. Bull. 37, pl. 66, fig. 113.
One specimen, inside in tow.
Melampus lineatus Say. S C J
Dall, U. S. Nat. Mus. Bull. 37, pl. 47, figs. 9 and 12.
Abundant, especially in brackish water.

SCAPHAPODA

Cadulus (*Polyschides*) *tetraschistus quadridentatus* (Dall).
Dall, U. S. Nat. Mus. Bull. 37, pl. 27, fig. 5.
One specimen, inside.
Cadulus (*Polyschides*) *carolinensis* Bush.
Dall, U. S. Nat. Mus. Bull. 37, pl. 41, fig. 19.
Two specimens, inside.
Dentalium gouldi Dall.
Dall, U. S. Bur. Fish. Bull., vol. 20, pt. 1, p. 455, 1901.
Five specimens, inside.
Besides these five specimens, I have four which have six longitudinal ribs throughout, with no finer threads between them. They are too small for identification and look fossil. Still four other specimens have seven

PLATE 13



longitudinal ribs throughout with no finer threads between them. The largest has a diameter of 1.25 mm. They are very thick, and look fossil. They may be *D. disparile* Orbigny.

Dentalium agile M. Sars.?

Sars, Remarkable Forms of Animal Life, p. 34, pl. 3, figs. 4 and 5.

Occasional, inside.

Dentalium matara Dall.

Smooth, very slightly arched, slightly notched above and below with a short, wide notch, on convex side prolonged as a wide slit.

Occasional, inside.

Dentalium eboreum Conrad.

Conrad, Proc. Acad. Nat. Sci. Phila., vol. 3, p. 27, 1846.

Fairly common, inside.

Dentalium leptum Bush.

Slender, with fine posterior striations.

Occasional, inside.

Dentalium filum Sowerby.

Straightish and slender, sculptured by regular anulations.

Occasional, inside.

The following also are reported by Stimpson:

Arca adamsi, *Lucina crenulatus* Conrad (known as a fossil), *Lepton lepidum*, *Tellina fausta* (a West Indian species), *Macoma constricta* (Brug.), *Strigilla carnaria*, *Sportella constricta* (Conrad) (known as a fossil), *Solen viridis* Say (also reported by Aller), *Saxicava arctica* Linné, *Clypidella pustula*, *Mangelia rubella*, *Mangelia filiformis* Holmes, *Murex spinicostatus*, *Cancellaria reticulata*, *Actaeon punctostriata* Adams.

Osborn records *Bela plicata*.

NOTES ON THE THELEPHORACEAE OF NORTH CAROLINA

By W. C. Coker

Plates 14–35

Plants (the fruiting body) of this family varying from fibrous and tough and leathery to waxy when wet, in some species hard and brittle; form various, upright and fan-shaped to funnel-shaped (and simple or branched) or shell-shaped to bracket-shaped and laterally attached, or partially to completely spread out on the substratum (resupinate); the hymenium borne only on one surface, or rarely all over the fruit-body (amphigeneous), smooth (without teeth, pores or gills) or nodulated or wrinkled; basidia simple and club-shaped, usually with four spores (2–8). The great majority grow on dead wood, some grow on the ground, and some are parasitic.

Most of the genera of this family are composed of very insignificant species of slight popular or economic interest, except where involved in the rotting of timber. We have tried to treat fully only a few of the genera, in others we include only a few species as representative. All of the North American genera of this family are being carefully monographed by Dr. Burt, and his work, if published, is referred to under each genus. See also Massee: *A Monograph of the Thelephoraceae.* Journ. Linn. Soc. Bot. 25: 107. 1889; 27: 95. 1890, and Wakefield: *Some Notes on the Genera of the Thelephoraceae.* Trans. Brit. Myc. Soc. 4: 301. 1914. See also Bourdot and Galzin as cited under the genera. Interested students can turn to these papers for a fuller treatment.

Many of the drawings of Corticium, Peniophora, Hypochnus, and Coniophora were made by Mr. J. N. Couch, recently assistant in Botany. Miss Alma Holland, assistant in Botany, has inked in most of the drawings and made most of the spore drawings. The photographs and a good many of the drawings were made by the author.

Key to the Genera Treated

Parasitic on members of the Heath Family, causing galls or other abnormalities; spore-bearing surface forming a thin, adherent coat on the host ..... *Exobasidium* (p. 147)

Addenda

Add to the literature list given on page 146 the following: Höhnel and Litschauer, *Beiträge z. Kenntnis d. Corticieen.* Sitzungsb. K. Akad. Wiss. Wien **115**: 1549, with 10 text figs. 1906; **116**: 739, pls. 1-4 and 20 text figs. 1907; **117**: 1081, with 10 text figs. 1908. This series treats many species of most of the genera included by us.

Entirely resupinate on rotten wood; the context filled with brown stellate bodies (cystidia) ..... *Asterostroma* (p. 164)
Not as above in all respects.
Plant entirely resupinate, forming a crustaceous layer on wood with no shelving margin, or if with a narrow shelving margin then with dark spines in the hymenium; in one species of *Aleurodiscus* forming small cup-shaped, centrally attached plants with the margin upturned all around and in *Corticium lilacino-fuscum* and *Peniophora albomarginata* there may be a very narrow shelving margin.
Spores and basidia large to very large, the spores plump with the surface spiny or minutely rough; plant small, chalk-white or in one species the hymenium fawn-brown ..... *Aleurodiscus* (p. 152)
Spores smaller, elongated to subspherical.
Spores rough or echinulate, colored ..... *Hypochnus* (p. 165)
Spores smooth, ochraceous or rusty or brown ..... *Coniophora* (p. 157)
Spores smooth, white.
Hymenium with smooth, spine-like, dark setae projecting above the basidia ..... *Hymenochaete* (p.166)
Hymenium with specialized pale cystidia (club-shaped cells, which are usually warted) mixed with the basidia ..... *Peniophora* (p. 158)
Hymenium without setae or cystidia ..... *Corticium* (p. 168)
Plants growing on wood (in all here treated), shelf-like or petal-like, usually imbricated; spores white or pale, smooth ..... *Stereum* (p. 175)
Plant growing on wood or herbs or moss, very small, cup-shaped or saucer-shaped and centrally attached, often pendulous by a little stalk (compare also *Aleurodiscus Oakesii*) ..... *Cyphella* (p. 148)
Much like *Cyphella*, but more crowded and the fruiting bodies either more cylindrical or arising from a resupinate basal weft ..... *Solenia* (p. 150)
Plant upright, fan- or funnel-shaped, or branched like a tree, or in a few species bracketed like a Stereum when growing on wood; leathery; usually on earth, at times on wood; spores dark, warted ..... *Thelephora* (p. 185)
Plant tough and elastic, but fleshy, repeatedly branched into a thick mass of flat, contorted-anastomosing branches; growing from rotting roots or stump bases. *Sparassis* (p. 193)

EXOBASIDIUM

Parasitic on leaves, shoots and flowers of woody plants, mostly if not entirely confined to the Ericaceae, and forming on the surface of the host, which is usually hypertrophied or deformed into galls, a

layer composed rarely of basidia alone, or more rarely of a thin felted layer of interwoven hyphae which bears basidia and conidiospores. Basidia clavate, simple. Spores white, smooth, simple or septate.

The galls and other abnormalities produced vary so much, depending on what host or what part of the host is attacked, that many so-called species names have been published depending on the kinds of galls formed. Burt, who has studied the subject thoroughly, has concluded that almost all of these belong to one species, *E. Vaccinii* (Ann. Mo. Bot. Gard. 2: 627. 1915). He recognizes only two other species or varieties, one *E. Vaccinii uliginosi* Boud., the other *E. Symploci* Ell. & Martin. The latter is parasitic on *Symplocos tinctoria*, but in it the basidia and basidiospores have not been found. For an excellent article on the morphology of this group see Woronin, Naturforsch, Ges. Freiburg, Verhandl. 4: 397. 1867.

Exobasidium Vaccinii (Fuckel) Woronin.

PLATE 14

Characters of the genus: Basidia four-spored; basiospores 2.5–5 × 10–20μ. (Burt). Occurring on many genera and species of the Heath Family.

The most conspicuous and best known gall caused by *E. Vaccinii* in North Carolina is the one called honeysuckle apples, which are large, hollow, pale, sweetish, juicy formations often an inch or more thick that many children know and eat. They are found on *Azalea nudiflora* and *A. atlantica* and seem most abundant in the Coastal Plain. Another remarkable hypertrophy occurs on *Andromeda Mariana*, causing the flowers which are normally white and waxy subcylindrical bells, to become changed into larger, greenish, more open flowers with the petals more or less separated or quite free and spreading. This is shown in our illustration, together with the normal flowers. This is the form that has been named E. *Peckii*.

11a. On *Andromeda Mariana* near east gate of campus, May 6, 1909. Photo.

CYPHELLA

Very small, cup-shaped or beaker-shaped or saucer-shaped, attached by the center with a short stalk usually, and often hanging downward, the lower, concave surface covered by the hymenium; texture submembranaceous; basidia simple. The species grow on

PLATE 14

EXOBASIDIUM VACCINII on ANDROMEDA MARIANA.
Normal flowers above; hypertrophied ones below.

live mosses, dead stems and leaves of herbs, fallen twigs, branches and bark of trees, etc. Two of the species recognized by Burt have been reported from North Carolina by Curtis, and we are adding two others. See Burt, Ann. Mo. Bot. Gard. **1**: 358. 1914; Bourdot and Galzin, Bull. Soc. Myc. Fr. **26**: 223. 1910.

KEY TO THE SPECIES

On living mosses; saucer- or petal-shaped, up to 1 cm. broad...*C. muscigena* (1)
On alder bark; small, cup-shaped, reddish-tawny.....*C. fasciculata* (2)
On bark of red cedar; very small, whitish, cup-shaped, spores with a few long spines.....*C. cupulaeformis* (3)
On dead stems of herbs; cup-shaped, whitish.....*C. capula* (4)

1. Cyphella muscigena (Pers.) Fr.

PLATE 30

This is the plant treated by me as *Cantharellus retirugis* (No. 3224) in an earlier paper (Journ. E. Mit. Sci. Soc. **35**: 38. 1919). Since then we have made three other collections of the plant, one from the same spot a year later and two from other places. The two last mentioned showed spores (from good spore prints) that averaged longer than the two others, but otherwise there is no difference in the plants. The basidia of all are small, club-shaped, rather abruptly enlarged at the end, 7–7.5 μ thick, 4-spored. I cannot make out any difference of importance between descriptions and illustrations of *Cantharellus retirugis* and *Cyphella muscigena*.

3224. See above.
3931. On living moss (*Catharinia*), below Cobb's Terrace, January 8, 1920. Spores pip-shaped, 3–4.2 × 7–9.7μ.
4010. Same spot and one on same kind of moss as No. 3224. Spores the same, 3.7–4.5 × 6–8.5μ.
4018. Near No. 3931, but on different moss, January 24, 1920. Spores 3–4.5 × 7.5–9.7μ.

2. Cyphella fasciculata (Schw.) B. & C.

C. fulva B. & Rav.

PLATE 30

Cups gregarious in good numbers, and often in part densely fascicled in groups or lines, about 0.6–3 mm. broad and same length, attached in center by a short stalk about 0.3–0.8 mm. long; outer surface of cup reddish-tawny, usually with one or two circular zones,

finely tomentose with curled hairs. Hymenium smooth, pale straw or light buff, lining the inside of the cup, the mouth of which is whitish and contracted or, when wet and fully mature, open.

Spores (of No. 4001, spore print) cylindric, curved, smooth, white, 2–3 × 7.5–11μ. Basidia 5–6.5μ thick, flat at end, with four very small and short sterigmata.

4001. On dead Alnus twigs, January 22, 1920. Not fascicled in this collection.
4017. On dead Alnus twigs, January 24, 1920. Many densely fascicled groups in this lot, also many single ones.

Common on branches of alder (as *C. fulva*). Curtis.

3. **Cyphella cupulaeformis** Berk. & Rav.

PLATE 30

Centrally attached by a very short stalk; plant up to 1.5 mm. long by 2.5 mm. broad, cup-shaped or goblet-shaped, the outside minutely scurfy and pale gray-brown, the hymenium inside the cup smooth and about the color of the outside; the mouth open when wet, collapsed and practically closed when dry.

Spores white, very remarkable in being set with six or more spines which are about 3.7μ long, body of spore 4.5–5.5 × 5.5–6μ. The spines do not appear until the spores are nearly grown, the spores up to that time being smooth and oval; as the spines begin to develop the spores appear simply angular for a while. Basidia club-shaped, 8μ in diameter.

4019. On decaying cedar limb, January 24, 1920.

4. **Cyphella capula** (Holmsk) Fr.

We have not yet found this and adapt the following from Burt (l. c., p. 366).

Growing on dead stems of herbs and forming little whitish, pendulous cups drawn out to a stalk, the entire plant about 1–3 mm. long and 0.5–2 mm. broad; hymenium on the inside of the cup; outside of the cup and stem glabrous; the cup margin irregular.

Spores white, flat on one side, 3–3.5 × 4.5–6μ.

Common on stems of herbs. Curtis.

SOLENIA

Fruit bodies in the form of small to very small cups or tubes which are commonly so closely set as to appear almost as a continuous stratum to the naked eye. The cups are somewhat contracted

at the mouths and are seated directly on the substratum or are surrounded at base by a very delicate weft of threads, the subiculum. The smooth hymenium covers the inside of the cups. Basidia club-shaped with usually 4 sterigmata. Spores smooth, white (at least in *S. poriaeformis*). Distinguished from *Cyphella* by the more densely crowded cups which often arise from a superficial weft, and in some species by the more elongated, cylindrical cups.

A peculiar genus that has been placed usually in the Polyporaceae, but is probably better treated in the Thelephoraceae as its relationship to Cyphella seems obvious. It is placed next to Cyphella in Engler and Prantl's system (Hennings), and also by Bourdot and Galzin (Bull. Soc. Myc. Fr. **26**: 225. 1910), which see for a good treatment of the French species. See also Rabenhorst, Krypt. Flora Deutschland, etc. **11**: 390. 1884.

To represent this genus we are including only one species. In American herbaria are represented commonly about ten other species among which the most widely distributed are *S. anomala*, *S. candida*, *S. ochracea*, *S. stipitata* and *S. villosa*. All or nearly all known species grow on dead wood and branches or dead herbs (one is said to grow on dung).

Solenia poriaeformis (DC.) Fuckel.

PLATES 15 AND 30

Plant forming encrusting, non-removable patches quite variable in size and irregular in outline, which often fuse to make much elongated areas with rather definite margin; composed of a layer next the bark made up of extremely delicate, interwoven, white threads, about 1.2–2.5μ thick, in which are imbedded for about ⅓–½ their depth, minute, circular, or somewhat flattened cups, about 4 or 5 to a millimeter, which usually cover the entire surface and nearly touch when expanded, are about 90–110μ deep and are covered all over the outside with white, granular, easily removable powder, while the inside is covered with the smooth hymenium. Under moderate power the cups look like citron covered with sugar powder, and when the powder is rubbed off they are seen to be deep brown, contrasting strongly in section view with the white felt in which they are sitting. Wall of cups about 30–40μ thick, brown, the hymenium occupying a little less than half of this thickness and less dark than the closely woven outer part; margin incurved and partly closing the cups even

when wet. The color of the plant in the fresh state a dull white, which is a little darkened by the small openings of the cups and is almost entirely due to the fine white powder covering the exposed parts of the matrix as well as the outside of the cups. When very young the plant is thin and sterile, with a minutely granular appearance. The cups first appear as very small openings extending to within ⅓ mm. of the margin; later, when expansion ceases, they are formed almost to the marginal line.

Spores (of No. 4686) white, smooth, oval, 3.5–4.5 × 5–7.5μ. Basidia clavate, 4-spored, 6.5μ thick. A most peculiar plant differing from other species of Solenia in the short, partly embedded cups. We have compared our plants with several collections from America and one from Bresadola at the New York Botanical Garden and find them similar in all essentials. Most other collections have the cups less crowded and in some they are broader. Our plant seems to be a dense, small-cupped form Bourdot and Galzin give microscopic characters which agree with ours, as spores 4–5× 4.5–6.5μ, basidia 5–8 × 18–24μ, 2–4 sterigmata; and Dr. Burt writes me that a collection made by him in Sweden has spores 4.5–5 × 5–6μ. Hennings, in the Pflanzenfamilien, gives the spores as 3–3.5 × 11–14μ, which is probably an error.

4275. On dead bark of old live grapevine (*V. aestivalis*), April 15, 1920. Spores pure white, short, oval.

4317. On bark of Vitis, May 28, 1920.

4686. On dead bark of live, wild grapevines, November 13, 1920.

4700. On bark of live grapevine, December 4, 1920. Poorly developed specimens with few cups.

ALEURODISCUS

Plants in the species here treated growing on the bark of living trees or dead shoots and forming entirely resupinate, white, small, thin or thickish crusts with well-defined margins (the margin at times is vague in *A. botryosus*) and hard, brittle flesh; or in one case forming small cups with the margin free all around. Basidia and spores large to very large; spores white, minutely punctate or spiny; no cystidia or setae present, but paraphyses often of peculiar form occur in the hymenium or throughout.

Other groups of species included by Burt in this genus, but not treated by us, have other characters separating them from the Stereums. See Burt, Ann. Mo. Bot. Gard. 5: 177. 1918; Bourdot and

PLATE 15

ALEURODISCUS MACRODENS. No. 4734. [Above
SOLENIA PORIAEFORMIS. No. 4686. [Below.]

Galzin, Bull. Soc. Myc. Fr. **28**: 349. 1912; Lloyd, Mycological Notes No. **62**: 926, Pl. 147, figs. 1666–1681 and Pl. 148, figs. 1682–1688, and Pl. 145, fig. 1652. 1920. For morphology and cytology of *A. amorphus* see Am. Journ. Bot. 7: 445, Pls. 31–33. 1920.

KEY TO THE SPECIES INCLUDED

On bark of living trees.
  Spores very large, not smaller than 12 × 15μ.
    Flesh pliable and leathery when wet, margin free and upturned all around.....*A. Oakesii* (1)
    Flesh hard and woody even when damp, margin not free or scarcely so.
      On post oak or white oak; spores oval-elliptic, minutely punctate.....*A. candidus* (2)
      On elm; spores subspherical to short-oval, very minutely punctate (some appearing smooth).....*A. candidus* var. *sphaerosporus* (3)
      On ash; spores subrectangular, set with a few large, blunt spines.....*A. macrodens* (4)
      On cedars; spores subspherical to short-oval, covered with minute, slender spicules.....*A. nivosus* (5)
Spores not larger than 7 × 12μ.
    On maples (said also to grow on ash, elm and white oak); thinner and smaller than any of the above, irregular.....*A. acerinus* (6)
    On dead shoots of blackberry, lilac, etc. Spores 7.5–11 × 14–19μ.....*A. botryosus* (7)

1. **Aleurodiscus Oakesii** (B. & C.) Cooke.

PLATE 30

Small, saucer-shaped or shallow cup-shaped, rather broadly attached by the center, the margin quite free all around and curved up when damp, incurved over the hymenium when dry, the exposed outer (lower) surface white and fibrous, especially on margin and near attachment so as to appear tomentose; hymenium even or a little wavy, minutely pulverulent, pale avellaneous (light fawn brown) both when wet and dry. Flesh about 0.5 mm. thick, leathery and pliable when wet, rigid when dry.

Spores ovoid, white, minutely papillate-warted, 12–16 × 15–20μ. Basidia very large, 15–16μ thick with 4 large sterigmata. Paraphyses often moniliform by constrictions mostly with prong-like short branches at the tip or lower down.

The plant resembles in form a small Stereum attached by the center. Single plants are about 3–5 mm. broad when damp and expanded, but they fuse more or less completely when they touch, so

that elongated or irregular groups are produced which may be a cm. or more long and broad. When two plants meet and fuse a low ridge is left on the hymenium. This plant is easily distinguished from the other species of the genus here treated by the saucer-shaped form and pliable, leathery texture when wet.

3937. On bark of Ulmus near upper end of Scott's Hole, January 11, 1920. Photo.
Upper district. Bark of white oak. Curtis (as Corticium).

2. **Aleurodiscus candidus** (Schw.) Burt.

Stereum candidum Schw.

PLATES 16 AND 30

A small, entirely resupinate plant, growing on the bark of trees and forming hard, crustaceous, chalk-white patches of irregular shape and definite outline, usually under 2 cm. in diameter vith the margin free so as to show its under side which is blackish. Surface smooth, minutely pulverulent under a lens, showing irregularities of the bark over which it is spread. Flesh thick for so small a plant, about 0.5–1 mm. thick, white or pale creamy, quite hard and brittle. Under a lens the flesh shows a rather faint stratification with as many as 5 or 6 layers, each probably representing a period of fruiting, but the time required to form each layer is not yet known.

Spores white, subspherical to short-oval, minutely papillate, 12.5–16.7 $\times$ 16.6–22μ, most about 15 $\times$ 20.4μ. Basidia large, club-shaped, 11–14μ thick, with four very long sterigmata. Mixed with the basidia are delicate, dense, hyphal paraphyses branched like a bush above and much encrusted with granular crystals.

The plant is very common in Chapel Hill on bark of post oak and white oak, and is very easily recognized by its color, habit and place of growth. Burt describes the spores as smooth, but suggests that they may prove to be minutely rough walled. We find them minutely papillate.

1377a. On bark of post oak trees, November 28, 1913.
1517. On bark of a post oak tree, December 14, 1914.
3827. On living post oak, December 6, 1919.

Salem. Schweinitz.
Low and middle districts, bark of trees. Curtis.

3. **Aleurodiscus candidus** var. **sphaerosporus** n. var.

PLATE 30

Plant exactly like *A. candidus* except for smaller average size of the crusts and for the more spherical spores. The chalk-like, minutely pulverulent surface and hard, friable, pale flesh are the same in both. The smaller, more broken up pads seem to be the result of the more fragmented and mossy bark of the elm. The spore difference is constant here and taken with the different host furnishes about the right grounds for establishing a variety.

Spores (of No. 3902) nearly spherical, white, very faintly rough, 13–20 × 15.5–24μ, most about 16.3 × 19.2μ. Basidia large, about 13μ thick. The spores are even more faintly rough than in *A. candidus*.

To be found on most elm trees in Chapel Hill.

2021. On elm (*Ulmus alata*), March 10, 1916.
3902. On elm (*U. alata*), December 16, 1919.
3907. On elm (*U. alata*), December 18, 1919. Spores exactly as in No. 3902.

4. **Aleurodiscus macrodens** n. sp.

PLATES 15 AND 31

Forming irregular, often somewhat elongated patches about 2 mm. to 2 cm. long with well-defined margins and with much the aspect of *A. candidus;* surface minutely pulverulent, pure white or when old and weathered pale cream; entire thickness only about 150–190μ, the structure in section much obscured by very small crystals and the densely branched paraphyses.

Basidia entirely embedded, 12–15μ thick, irregular and bent, with four long, stout sterigmata, which only reach the surface by their tips. Spores (of No. 4734, print) commonly rectangular in outline, the surface set with a few large, irregularly placed, bluntly pointed spines which are up to 4μ long; body of spore 11.5–15 × 18.5–27μ

In passing the plant would be taken for *A. candidus*, but when examined is seen to be much thinner with the closely pressed margin not showing a dark underside. The spores are remarkable and unlike any others in the genus.

4734. On bark of a living tree of *Fraxinus*, December 14, 1920. Type.

5. **Aleurodiscus nivosus** (B. & C.) H. & Litsch.

Stereum acerinum var *nivosum* B. & C.

PLATES 16 AND 31

Plant forming crust-like elongated patches of definite outline, about 1–23 mm. long by 1–4 mm. broad, the elongated axis vertical, at first thin like a streak of whitewash, then thickening into a mattress-like patch about 0.5–0.7 mm. thick with a free margin that is black below; in age cracking across to make smaller areas as in *Stereum frustulosum*. Surface always chalk-white. Flesh brown below a thin surface layer; hard, dry and rather friable.

Spores (of No. 3897) white, oval, with a small, distinct mucro and short, sharp, delicate spines, 12.9–15.9 × 15.9–21.5μ. A few spores show a remarkable variation in having small blunt warts like a Hydnum.

Very common, and to be found on almost every cedar tree. Differs from *A. candidus* in more spiny spores, proportionately narrower, longer and thinner fruiting bodies, and in growth on cedar. Burt's description of the spores as smooth is incorrect for our specimens. The close-set, slender spicules distinguish the plant at once. Burt also describes the plant as thin with margin not free as in *A. candidus*. This is true only for the young condition. As growth continues the flesh becomes thicker and cracks across and the margin becomes free and shows the blackish outer (under) side.

3897. On bark of living cedar, December 14, 1919.
3920. On living cedar tree, December 22, 1919.

6. **Aleurodiscus acerinus** (Pers.) H. & Litsch.

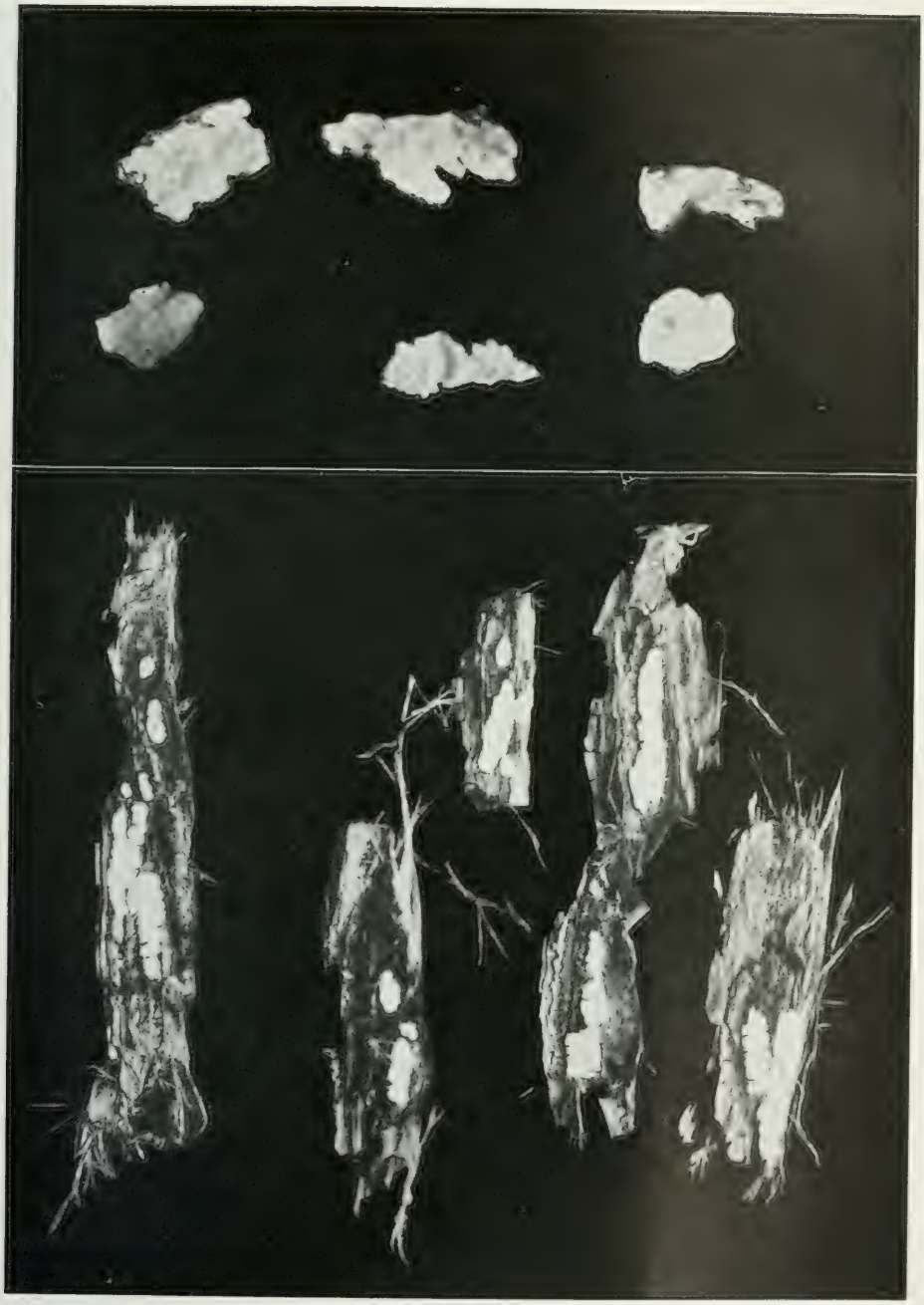
A smaller and thinner species than the others treated; crustaceous, irregular to subcircular or rarely elongated, up to about 3 mm. wide or when elongated up to a cm. long; chalk-white, minutely pulverulent, the abrupt margin definitely outlined. Hymenium containing slender branched paraphyses that are much encrusted with crystals.

Basidia clavate, about half as large as in *A. candidus*, sterigmata four, elongated. Spores (according to Burt) white, smooth, 6–7 × 10–12μ.

2020. On bark of living deciduous tree, December, 1915. We have misplaced this collection which was seen and determined by Burt, and so have not been able to make original observations on the spores.

Common on bark of trees. Curtis (as Stereum).

PLATE 16



ALEURODISCUS CANDIDUS. No. 3827 [above].
ALEURODISCUS NIVOSUS. No. 3897 [below].

7. **Aleurodiscus botryosus** Burt.

PLATE 31

Entirely effused to form elongated patches up to 5–6 cm. or smaller, more scattered patches. Surface under a lens more or less lacunose and granular-looking except in the thickest places where it is continuous; pure white or creamy, smooth, and removable as a soft, flexible membrane when wet; thickness in our collection only 45–65μ, nearly all of which consists of the hymenium, in which are embedded a large number of subspherical, amorphous, irregular bodies, probably of a proteid nature. Many bottle brush paraphyses present in hymenium.

Basidia 11–12μ thick, with four long, curved sterigmata 14–16μ long. Spores white, minutely rough, oval with an abrupt mucro, flattish on one side, very granular when shed, sprouting freely over night in a damp chamber, 7.5–10.5 × 14–19μ.

Except for its thinness, amounting to scarcely more than a hymenium on the substratum, our plant agrees well with Burt's species and our determination has been confirmed by him.

4710. On dead blackberry in low place, Glen Burnie Farm, December 5, 1920.

4724. On standing dead shoot of lilac, December 12, 1920. Spores white, surface minutely warted, 8.5–11 × 14.8–18.5μ.

4740. On dead vine of *Vitis* (*aestivalis ?*) December 18, 1920. Spores white, surface minutely rough, 8.5–11 × 14.8–18.5μ.

CONIOPHORA

Entirely resupinate, fleshy, subcoriaceous or membranaceous; hymenium undulate, tubercular, granular or even; basidia simple; spores smooth or slightly angular, ochraceous or at times nearly colorless. Saprophytic on dead wood, often causing serious decay of structural timber. Burt reports three species from North Carolina and nineteen from North America. See Burt, Ann. Mo. Bot. Gard. 4: 237. 1917. Also see Massee in Journ. Linn. Soc. (Bot.) 25: 128. 1889. We are including but one species.

Coniophora arida (Fr.) Karsten.

PLATE 31

Irregularly effused, membranaceous when wet, forming long, thin, narrow patches about 1–3 cm. broad by several cms. long and about 175μ thick on average, with indeterminate margins. Color

when dry a warm buff to buffy brown, usually darker in center. Surface even, pulverulent, sparingly cracked in places; context made up of loosely packed, thin-walled, hyaline hyphae 2–3.7μ thick; hymenium closely packed. No cystidia and no crystals present.

Spores fuscous in a good spore-print, smooth, elliptic with a distinct mucro, 6.6–7.2 × 9.3–11.1μ. Basidia club-shaped, swollen considerably at the distal end; extending out above the hymenium up to 20μ (counting the sterigmata); 8.5μ thick, sterigmata 4, prong-like, curved.

4219. On bark and wood of dead pine, March 23, 1920.
4235. On bark of pine log, April 15, 1920.

PENIOPHORA

Entirely resupinate as a thin encrusting layer, as in Corticium, but differing from the latter in having specialized cystidia included in the hymenium and usually projecting as far as the basidia or beyond them. We are including one (*P. albomarginata*) which often has a narrowly reflexed margin. The cystidia are commonly warted on the distal half, in which case they are easily distinguished. Spores smooth, white or (when fresh) pink. Hymenochaete differs in having dark, smooth, spine-like setae projecting far above the basidia. The pink color shown by a fresh spore print in several species we have studied fades out after a few months in the herbarium. We have included six species to represent the genus, which is a large one and often difficult to distinguish from Corticium. See Massee in Journ. Linn. Soc. (Bot.) **25**: 140. 1889; Bourdot and Galzin, Bull. Soc. Myc. Fr. **28**: 372. 1912; Cooke, Grevillea **8**: 17. 1879; Bresadola, Ann. Myc. **1**: 100. 1903 (as Kneiffia). See also Gleocystidium as treated by Bourdot and Galzin in Bull. Soc. Myc. Fr. **28**: 354. 1912. This last genus includes species usually treated under Peniophora, but its recognition, as Burt has well said, would lead to difficulties without compensating advantages. Other proposed genera as Peniophorella and Gloeopeniophora have similar objections. For a species parasitic on chrysanthemum (*Corticium* (*Peniophora*) *Chrysanthemi* Plowr.) see Trans. Brit. Myc. Soc. for 1904, p. 90. 1905.

KEY TO THE SPECIES TREATED

On pine wood, making an extensive, pale, sub-translucent, parchment-like membrane when dry; sub-waxy when wet.....*P. gigantea* (1)

On deciduous woods, mostly with bark on.
  Margin distinct and often uplifted a little in places.
    Deep brown with a conspicuous whitish border; surface velvety, not cracking.....*P. albomarginata* (2)
    Brownish purple; finely cracked superficially when dry.....*P. violaceo-lividum* (3)
  Margin very thin and indistinct, closely adnate;
    Light gray to white with creamy areas, texture loose and velvety-looking; spores very long and narrow, 2–2.6 × 13–16.6μ.....*P. longispora* (4)
    Not as above.
      Deep blackish brown when wet, a much lighter gray-brown when dry; only 55–75μ thick; surface glabrous, nodulated, cracked to the wood when dry. *P. cinerea* (6)
      Whitish to ochraceous buff; thick (200–250μ), surface glabrous, cracking when dry to show the pure white tissue beneath; margin thin and fading away. *P. mutata* (7)
  Margin distinct but irregular and byssoid when growing, in places connected with extensive ropy strands; color of surface buffy to chamois.....*P. filamentosa* (5)

1. **Peniophora gigantea** (Fr.) Massee.

PLATE 31

Patches up to 8 cm. wide by 14 cm. long, adnate, sub-waxy; when old smooth and even, when young slightly hypochnoid; color varies with age, grayish white or light cream to vinaceous buff when old; surface minutely granular under a lens; margin indeterminate when young, later determinate. Structure, in section, up to 1 mm. thick, made up of two distinct layers (apparently three before the application of KOH) of about equal thickness; lower layer consisting of closely packed, septate, considerably branched, clamp-connected hyphae (clamp connections are difficult to make out) 4.2μ thick which are more loosely packed at surface of substratum and become very closely packed toward the center of the plant; upper layer made up of closely packed, almost vertical hyphae with many faintly encrusted cystidia scattered throughout, which are 9.3–11.1μ thick. Basidia club-shaped with the end swollen, 4 × 11–18μ.

Spores oval, hyaline, smooth, 2–3.5 × 3.7–5.5μ.

Our plant agrees completely with plants of this species from Bresadola at the New York Botanical Garden Herbarium. The dried plant has a subtranslucent, parchment-like appearance.

4306. On ground side of new pine sills and leaves which had been on ground four months, Clark's Sawmill, May 10, 1920.

Common. Curtis (as Corticium).

2. **Peniophora albomarginata** (Schw.) Massee.

Stereum albobadium (Schw.) Fr.

PLATES 18 AND 31

Entirely resupinate or, when on the sides of branches, with a free shelving margin which is rarely over 7 mm. wide, beginning as subcircular or oblong patches which may later fuse into an extensive membrane, color of hymenium when damp a rich deep brown (about bister brown of Ridgway) with a conspicuous white margin which is sharply delimited and not byssoid; when dry the brown lightens to about avellaneous with a darker ring just behind the white margin; shelving part brown on back, inherently fibrous and roughish, not tomentose, obscurely zoned. The resupinate part can be removed from the wood without much difficulty as a pliable thickish membrane like chamois skin, which in cross section is concolorous, fibrous and about 0.6–0.8 mm. thick. The hymenium is not shining but has a velvety, glaucous appearance. When drying the plant does not crack, but remains a complete membrane.

Spores (of No. 3849) smooth, white, elliptic, some bent, 3–4 × 6.5–9.3μ. Basidia clavate, 7.2μ thick; sterigmata four. Cystidia pointed, encrusted with crystals.

This is treated as *Stereum albobadium* by Burt. We are not using the name *albobadium* because we do not want to make a new combination.

3849. Dead limbs of peach or cherry in a brush heap, December 9, 1919.
3873. On fallen branch of ironwood (*Carpinus*) in Arboretum, December 12, 1919.
3932. On dead sycamore limb, January 10, 1920.

Hartsville, S. C. Several collections, December, 1919. Coker.
Low and middle districts on trunks and branches. Curtis.

3. **Peniophora violaceo-livida** (Somm.) Bres. in Bourdot and Galzin, Bull. Soc. Myc. Fr. 28: 405. 1912.

Corticium violaceo-lividum (Somm.) Fr.

PLATE 31

Entirely resupinate and crustaceous or rarely the margin curled up for 1–2 mm., thin and pliable and leathery when growing, the margin appressed and rather definite but extending with short fibers; the very margin whitish purple, then a handsome brownish purple, the older surface losing most of the purple and becoming dry and

PLATE 17

PENIOPHORA MUTATA. No. 3993 [top].
PENIOPHORA LONGISPORA. No. 4242 [center].
CORTICIUM ARACHNOIDEUM. No. 4235a [below].

thinner and finely cracked, the cracks involving only the surface layer. Flesh brown, fibrous, about a quarter mm. thick near margin. The plant appears first as small, scattered patches with a plush-like surface which rapidly extend and coalesce to form large patches up to 6 cm. broad and 15 cm. long, perhaps larger at times. If protected in a Petri dish the growing margin becomes densely tomentose with short fibers of the same handsome purplish color. At full maturity the surface becomes glabrous.

Basidia club-shaped, 5.5μ thick, with four sterigmata. Spores (of No. 3914) white, elliptic, smooth, 3.6–4.4 × 6–8.5μ, rarely up to 10μ. Cystidia long, pointed, often crooked or constricted below, extending beyond the surface (at times twice as far as in the drawing), set with crystals. Bourdot and Galzin give the spores as 9–12 × 3–4.5μ; the basidia as 6–8 × 20–26μ

3914. On a dead stem of privet, December 20, 1919.
3946. On twig of Chinese privet (*Ligustrum Chinense*) in Arboretum, January 16, 1920.
3964. On *Baccharis* in Arboretum, January 17, 1920.

4. **Peniophora longispora** (Pat.)

PLATES 17 AND 32

Plant entirely resupinate, in patches up to 5 cm. long by 3 cm. wide and up to 148μ thick; open, hypochnoid, finely pubescent and somewhat resembling a mold; color light gray to white with small creamy areas, color depending upon age, margin indeterminate. Context made up of very loosely packed, much branched, clamp-connected, unencrusted hyphae 2.6μ thick. Hymenium of very inconspicuous basidia, mostly about 4.5μ thick, and many cystidia which are about 3.7 × 40μ, more or less pointed and encrusted with crystals and projecting far beyond the basidia. In untreated sections there is a distinctly darker region in the hymenium indicating the presence of numerous crystals.

Spores pure white, very long and peculiar, 2–2.6 × 13–16.6μ, pointed at both ends, straight or slightly bent and with two or three conspicuous droplets.

Bresadola's measurements in this species (as Kneiffia, l. c., p. 105) are: spores 2.5 × 12–15μ; basidia 5–6 × 30–32μ; cystidia 3–4.5 × 70–90μ, encrusted with granules.

4242. On bark of rotten oak limb, near Meeting of the Waters.
4250. On decorticated sycamore (?) wood, April 15, 1920.

4302. On rotten, decorticated oak wood, May 9, 1920. Spores white, smooth, very long-elliptic, some bent, 2.5–3.7 × 12–16μ. Cystidia thickly encrusted, slender, 4μ thick and up to 60μ long.

5. **Peniophora filamentosa** (B. & C.) Burt. Ms.

PLATE 32

Entirely effused and creeping irregularly over rotting bark or wood; margin distinct but irregular and byssoid when growing, in places connected with extensive ropy strands; surface when mature varying from dull buffy tan to chamois or even a deeper cinnamon buff at times, often with an olive tint, especially in youth; surface even, but responding to the substratum, having the appearance of chamois skin. Structure in section up to 350μ thick, composed of loosely woven, rather delicate, brownish hyphae, 3–4.5μ thick, without clamp connections, most of them heavily encrusted with crystals, some not; cystidia brownish, encrusted throughout or in places, about 6.5μ thick including crystals and projecting 11–30μ. They are hardly more than protruding hyphae and intergrade with them completely.

Basidia 4–spored, 5–6μ thick. Spores not found in our collection, said by Massee to be oblong-ellipsoid, 3 × 6μ.

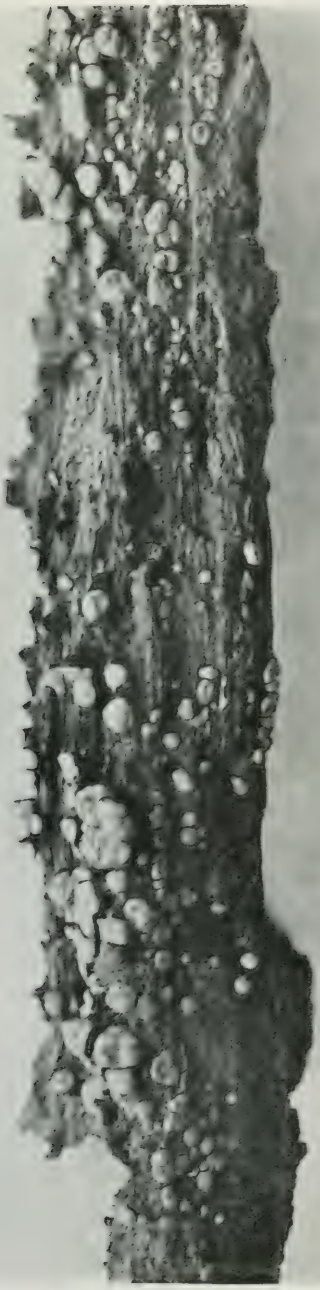
4245. On decorticated, rotten frondose wood, April 15, 1920.
4264. On rotten deciduous wood, April 17, 1920.
4607. On living and dead dogwood, July 31, 1920.

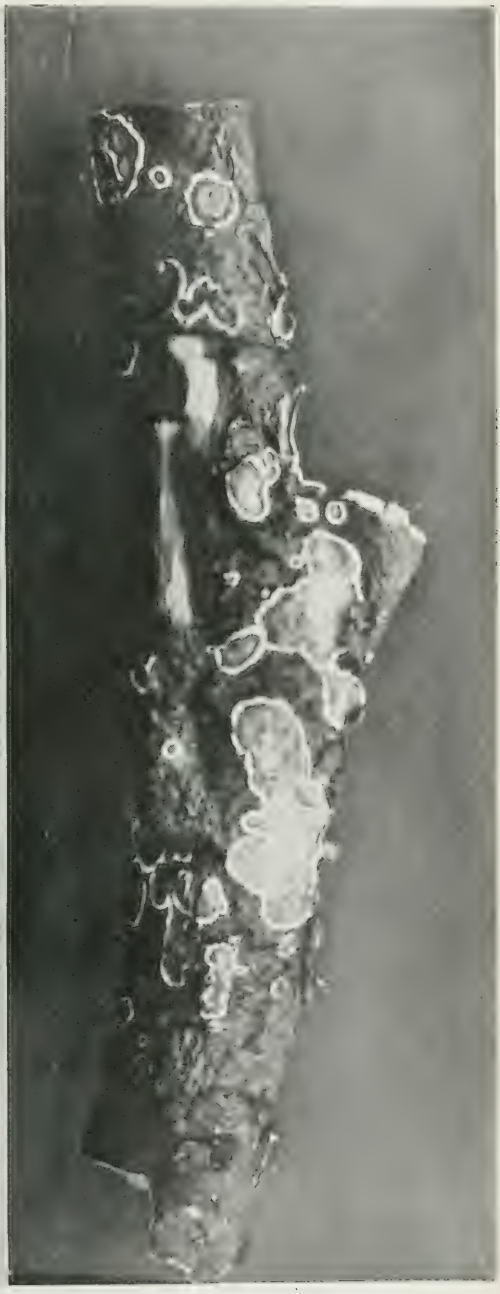
6. **Peniophora cinerea** (Pers.) Cooke.

PLATE 32

Extensively effused and combining into elongated irregular patches up to 10 or more cm. long at times, closely adnate and not removable, the rather definite margin not byssoid; in some fully developed specimens becoming thicker, almost as in Aleurodiscus; when damp a deep blackish brown with faint purplish tint, the substance rather waxy; when dry a much lighter grayish-brown, about ash color and cracking imperfectly into small irregular areas, the crack extending to the substratum. Surface glabrous, moderately nodulated both when wet and dry, nodules structural and not due to irregularities of the wood, although any irregularities also show. Entire thickness about 55–75μ.

PLATE 18





STEREUM FRUSTULOSUM. No. 1042 [left].
PENIOPHORA ALBOMARGINATA. No. 3849 [right].

Basidia 4.8–5.5μ thick, 4-spored, sterigmata very delicate. Cystidia oval to club-shaped, set with crystals, imbedded. Spores a clear salmon color, sausage-shaped, 2.5–3.4 × 7.4–9.5μ.

Our No. 4045 when compared with plants in the Curtis Herbarium and with others in the New York Botanical Garden Herbarium labelled *C. cinereum* agreed exactly. Bresadola (l.c., p. 104) gives the spores as 2.5–3 × 8–11μ, cylindrical and curved.

4045. On bark of dead branch of Crepe Myrtle, January 28, 1920. (Described above.)

4299. On bark of fallen oak limb, May 9, 1920. Spores curved-elliptic, 2.8–3.5 × 7–8.5μ.

Common on bark of limbs. Curtis (as Corticium).

7. **Peniophora mutata** (Pk.) Bres. In Bourdot and Galzin, Bull. Soc. Myc. Fr. **28**: 399. 1912.

PLATES 17 AND 32

Extensively encrusting the bark, forming large, thickish patches up to 20 cm. or more long and 6 cm. broad; white, then buff or ochraceous-buff, when wet nodulated and veined, but shrinking on drying and becoming plain, the smooth hymenium cracking to show the pure white, fibrous layer below which rarely cracks all the way through. Margin very thin and fading away to a film. Plant about 0.2–0.25 mm. thick, of which about half is the hymenium, the other half the white fibrous layer.

Spores white, rod-elliptic, 3.4–4.2 × 10–13.7μ. Basidia 7.7–8μ thick. Cystidia very few and scattered, mostly deep in the hymenium, a very few at the surface, club-shaped and covered with crystals.

This agrees in all respects with Peck's *Corticium mutatum*. Plants so determined at the New York Botanical Garden are the same as ours, and the careful description of Bourdot and Galzin agrees in all important particulars. They give the spores as averaging slightly longer, 3–5 × 8–16μ. There is also little doubt that this is *P. subgigantea* (Berk.) Massee, which was described by Berkeley from a collection of Ravenel on *Magnolia glauca*. Our plants are exactly like those distributed by Ellis on bark of Magnolia (N. Am. Fungi, No. 717). Another specimen on beech from Pennsylvania (at the New York Botanical Garden), which looks the same, was determined by Cooke as this. He says it is near *Corticium laeve*. A collection labelled C. *laeve* Fr. from Society Hill, S. C., on *Magnolia glauca* by Curtis is identical as is also a plant that Ellis distributed in his

North American Flora (No. 719 as *C. laeve* on Magnolia). Another from England (Berkeley) has the same appearance. They do not, however, agree with the description of that species by Wakefield (Trans. Brit. Nyc. Soc. 4: 115. 1912).

3993. On bark of dead *Magnolia tripetala*, January 21, 1920.

ASTEROSTROMA

Effused on rotting wood; soft and spongy; particularly characterized by deep brown, stellate cells (cystidia) included in the context and making up its greatest bulk; pale, simple, protruding cystidia also present in our species. We include the only species we have found.

Asterostroma cervicolor (B. & C.) Massee

PLATE 34

Extensively effused on very rotten deciduous wood, forming irregular patches up to 8–10 cm. or more wide and long; surface dull, minutely pruinose, pale fawn color when dry, deep dull brown when wet; margin fading out, indistinct, nearly concolorous. Texture soft and spongy except for a crust-like upper layer which may crack a little when dry, the thick, softer context not cracking. Distinctly but slowly bibulous, and soggy when wet.

Plant up to nearly 1 mm. thick. Hymenium 30–35μ thick, followed immediately by a very dense layer of stellate cells mixed with much granular material, below this a thick, much more open tissue, composed most conspicuously of the large stellate cells which characterize the genus. Mixed with these are bits of imperfect, fragmentary, very slender, hyaline hyphae and granular detritus. In the more open layer there may be a thin, much denser layer just like that beneath the hymenium. Many fat droplets are present in the cells of the hymenium.

Basidia projecting about 7–10μ, irregularly pole-shaped, about 4–6μ thick, with four slender, straight sterigmata about 4μ long. Cystidia broadly spike-shaped, almost colorless, with moderately thick walls, not encrusted, projecting a little farther than the basidia. Stellate cells deep brown, with about 4–12 spine-like arms which radiate from a central point and may be branched but are usually simple; their walls thick to very thick; arms variable in length, running from very short to 82μ long. These stellate bodies are evi-

dently of cellular origin and are formed apparently through the development of a single cell. Spores cream with a faint fawn tint in a heavy print, subspherical, angled or slightly tuberculate, 5–6μ thick.

4507. On very rotten oak wood and bark, south of athletic field, July 25, 1920.

HYPOCHNUS

Entirely resupinate, dry and coriaceous, felt-like or hypochnoid, that is, with the hyphae loosely woven throughout; hymenium even or papillose; basidia simple, four-spored; the spores rough or echinulate, distinctly colored in most species. The plants are saprophytic on rotten wood, and usually grow on the under-side of logs. Burt records 30 species from North America (Ann. Mo. Bot. Gard. 3: 203. 1916) of which several are mentioned from North Carolina. We are including two species to represent the genus. See also Wakefield, in Trans. Brit. Myc. Soc. 5: 476. 1917; Bourdot and Galzin, Bull. Soc. Myc. Fr. 28: 354. 1912 (as Gleocystidium in part).

KEY TO THE SPECIES TREATED

Color deep red-brown; surface very granular.....*H. atroruber* (1)
Color rusty brown with margin paler; surface felted.....*H. fuscus* (2)

1. **Hypochnus atroruber** (Pk.) Burt.

Zygodesmus atroruber Pk.

Entirely effused, thin, of a granular appearance, color a deep red-brown, about argus brown of Ridgway on the surface, the lower interior and the very thin, indefinite, hypochnoid margin a much lighter, honey color. Context of loosely interwoven, frequently branched, clamp-connected hyphae, paler and more delicate in the lower regions, about 4.5μ thick, reddish and coarser above, about 6–7.5μ thick; a few large strands next the substratum 15–18μ thick.

Spores brown under microscope, subspherical, echinulate, 5.5–7 × 6–7.7μ.

Our plants agree with Ellis No. 1390 of his North American Flora (on cedar) and with other collections on pine bark by Underwood, etc., at the New York Botanical Garden. They also agree well with Burt's description (l. c., p. 230). Peck found the type on poplar and Burt does not mention conifers, but all collections we have seen were on pine or cedar.

4692. On pine bark, spring of 1920.

2. Hypochnus fuscus Pers.

PLATE 32

Plant entirely resupinate and not removable as a membrane (Burt says separable), 300–500μ thick, more felted than hypochnoid, ferruginous-brown (dark cinnamon brown with brighter areas of Sudan brown) in center to light gray on the indeterminate margin, a slight vinaceous tint observable throughout or in places. Sections show such a packing of crystals as to make the structure unintelligible without the application of KOH (which dissolves the crystals); after such treatment the context is found to be composed of loosely packed, much septate and much branched hyphae 3.7–7.5μ thick, with clamp connections and bladder-like swellings up to 10.8μ thick. Hymenium composed of basidia 7.7–25.9μ, with four curved sterigmata and a few pointed structures which arise from the bases of the basidia. Spores smoky brown, irregularly angled and spiny, 5–7.4 × 7.4–9.3μ.

4267. On very rotten deciduous wood, April 18, 1920.

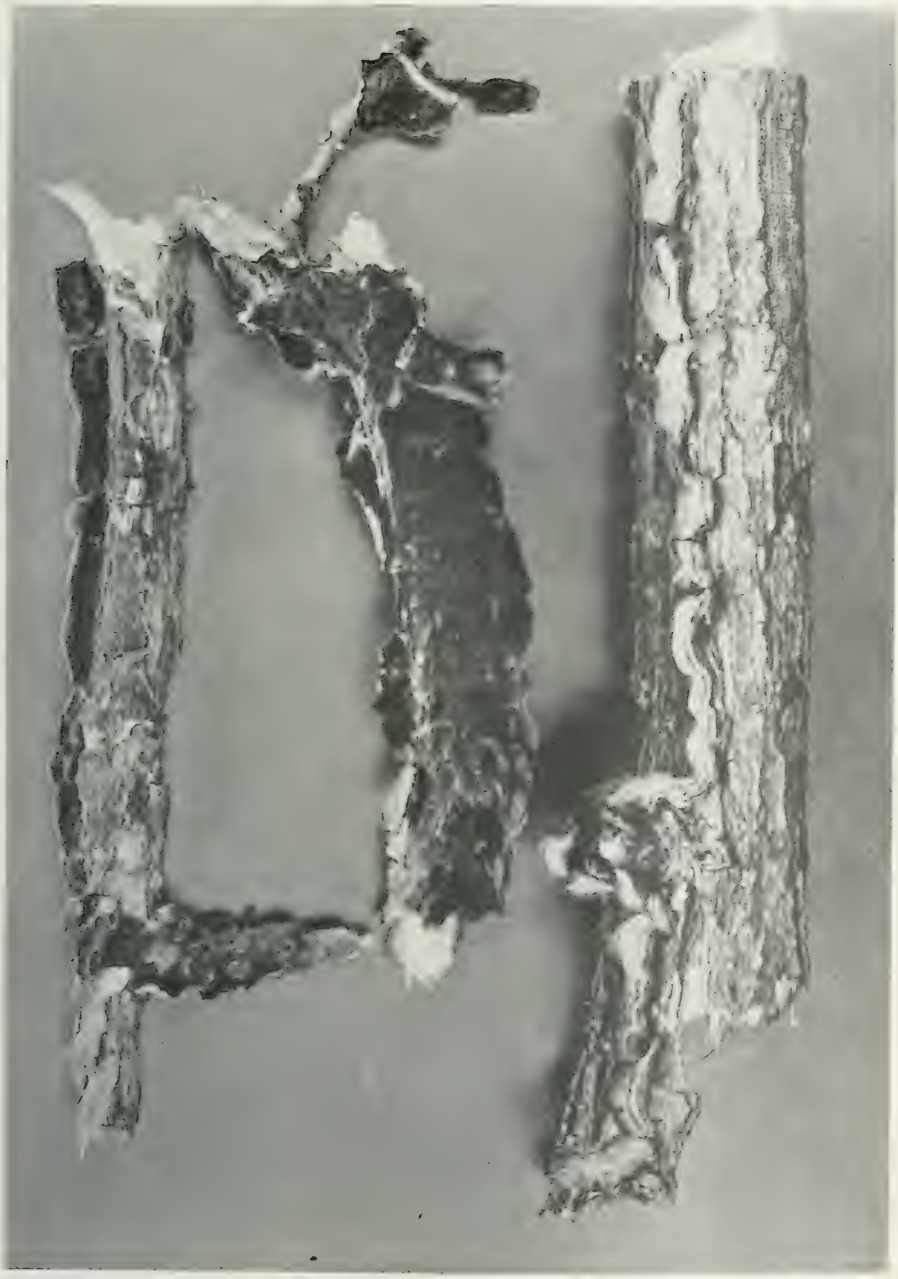
HYMENOCHAETE

Habit like that of a Corticium or small Stereum, that is, forming on dead wood an entirely resupinate crust or with the margin free and projecting like a bracket. Differing from these in the presence in the hymenium of elongated, smooth, dark, spine-like projections (setae) which extend beyond the basidia. Peniophora differs in the colorless cystidia which are usually set with warts and crystals, and which may or may not project beyond the basidia. We include but three species to represent the genus. For a full treatment, see Burt, in Ann. Mo. Bot. Gard. 5: 301. 1918. Also see Massee, in Journ. Linn. Soc. 27: 95. 1890.

KEY TO THE SPECIES TREATED

Hymenial surface not tomentose-felted
  Color a deep rich brown; the margin usually free.....*H. Curtisii* (1)
  Color slate-brown when wet, clay-brown when dry; margin not free.....*H. corrugata* (2)
Hymenial surface tomentose-felted, at least on the margin; usually rusty or brownish red, the margin paler.....*H. agglutinans* (3)

PLATE 19



HYMENOCHAETE CURTISII. No. 3830.

1. **Hymenochaete Curtisii** (Berk.) Morg.

Stereum Curtisii Berk.

PLATES 19 AND 32

Extensively resupinate on the underside of oak branches and twigs, the free shelving margins extending about 4–8 mm. and forming extensive wings on both sides of the branch; dorsal surface of the caps zoned by ridges and colors, inherently fibrous, but not tomentose, rough, exactly the color of the oak bark (deep gray) except for a pale cinnamon marginal zone. Flesh very thin and cloth-like, quite pliable, not very strong, cinnamon color; distinctly stratified under the microscope. Hymenium a deep rich cinnamon brown (about argus brown of Ridgway) at all ages unless much weather-worn, then paler; velvety from the close-set, short, curled and looped hairs among which are scattered longer and stouter, straight, tapering, red spines which project up to 60μ. These last are very scattered and are apt to be missed unless several sections are studied. They are dark internally and most show a sheath-like hyaline thickening of the wall, which is most conspicuous below.

Spores (of No. 3830) white, smooth, curved, 1.5–2.8 × 6–8.2μ.

Not rare on post oak limbs, where it extends as a complete cover over the underside of dead branches for a considerable distance, often several feet. This habit, with the deep, rich color and narrow wings, will easily determine it.

3805. On an oak twig, November 29, 1919. Young plants.
3830. On post oak twigs, December 6, 1919. Photo.
3842. On a fallen oak limb, December 7, 1919.
3843. On a fallen post oak branch on campus, December 7, 1919.
3875. On a fallen oak limb, December 11, 1919.
3899. On a branch of white oak, December 14, 1919.

Common on the bark of white and post oaks. Curtis.

2. **Hymenochaete corrugata** (Fr.) Lév.

PLATE 32

Extensively effused and entirely adnate and not removable; surface tuberculate, dull but not pulverulent, much cracked when dry, color when wet slate-brown with a tint of clay, when dry a lighter clay-brown except for the abrupt margin which is black on its very edge; thickness of entire fructification about 225μ, the cystidia pointed, brown, with a colorless sheath, projecting about 75μ from the surface.

Spores white, elliptic, smooth, 3 × 7.3–8.1μ; basidia about 4.8μ thick, projecting (including the 4 sterigmata) about 7.5μ beyond the surface.

When put in water the hymenium is not wetted, but is finely silvered by a film of air.

4076. On a corticated branch of a deciduous tree, February 4, 1920.

Common on bark and wood. Curtis (as Corticium).

3. **Hymenochaete agglutinans** Ellis

Forming circular or elongated patches up to 2 or more cm. across which fuse on touching and also firmly bind together any two branches in contact in its course; growing margin thick and definite, pure white, tomentose, older surface distinctly zoned with brown and brownish red, covered entirely or in all except the older parts with a thin, felted whitish or tan or drab or rich brown superficial coat. Substance firmly leathery, tough, solid, about 500–700μ thick; yellowish, except for the red upper layer which is about 75μ thick, and which is at first covered with the looser, felted, tomentose, paler coat in which are the strong, red, pointed cystidia which project about 37–70μ above the felt. These are lost as the felt wears away and are absent in the older, smoother parts. Threads of the context about 2.5–3μ thick, much branched. Context very compact and solid, resembling a real tissue, but bibulous, at least in the surface layer.

No spores or basidia could be found in our collections, and they are not mentioned by Ellis (Bull. Tor. Bot. Club 5: 46. 1874).

On drying the margin may become elevated in places, pulling up the upper layer of the bark with it. It does not become truly free as in *H. Curtisii*. The species is certainly parasitic, at least after getting started.

4694. On living branch of buckeye, New Hope Swamp, December 4, 1920.

4743. On living branch of hornbeam, University Station, N. C., January 7, 1921.

CORTICIUM

Plants forming an entirely resupinate, encrusting, thin layer which is usually leathery and fibrous or hard and brittle, in some cases waxy when damp; hymenium without specialized cells projecting or included. Spores smooth, or rarely angled, white, or (when fresh) pink. When pink the color of the spores fades soon in the herbarium. Most of the species are saprophytic on wood or bark

or more rarely on the ground and over mosses, etc., but a few are parasitic as e. g., *C. Stevensii* and *C. vagum* (see below). We are including *C. lilacino-fuscum* in Corticium for convenience, as it has only a very narrow reflexed margin, if any. Burt treats it as a Stereum. We include only a few of the numerous North Carolina species. Burt has treated three parasitic species in Ann. Mo. Bot. Gard. 5: 119. 1918. For important papers on the genus see Massee in Journ. Linn. Soc. 27: 117. 1890; Wakefield, Trans. Brit. Myc. Soc. 4: 113. 1913; Bourdot and Galzin, Bull. Soc. Myc. Fr. 27: 223. 1911 (this gives microscopic characters of the French species); Bresadola, Ann. Myc. 1: 93. 1903; Bresadola, Fungi Tridentini 2: 36 & 57.

KEY TO THE SPECIES TREATED

Not parasitic on leaves and twigs of fruit trees.
- Color deep blackish indigo blue when damp.....*C. caeruleum* (1)
- Color creamy gray with a lilac tint.....*C. lilacino-fuscum* (2)
- Color sordid whitish or cream to pallid yellowish or ochraceous; surface cracking when dry into easily removable, rather chalky scales.....*C. scutellare* (3)
- Color pale flesh both when wet and when dry, cracked when dry; on deciduous woods.....*C. roseum* (4)
- Color of mycelium and context deep orange, of hymenium pale sulphur; growing on grapevines.....*C. Viticola* (5)
- Color pure white, margin pulverulent or hypochnoid.....*C. arachnoideum* (6)
- Color light slate when wet, yellowish gray when dry; texture wefty and resembling a mold.....*C. vagum* (7)
- Much like *C. vagum* in color and texture, but spores smaller and hyphae with clamp connections.....*C. subcoronatum* (8)

Parasitic on apple, pear, or quince and forming a pinkish buff felt on the lower surface of the leaf and also brown sclerotia on the twigs.....*C. Stevensii* (9)

1. **Corticium caeruleum** (Schrad.) Fr.

Thelephora indigo Schw.

PLATE 33

Forming small or large patches up to 9 cm. long on twigs and small branches of deciduous woods with the bark on; closely applied to the bark, dull, when damp deep blackish indigo blue with more or less gray tint, when dry blackish gray with often only a faint tint of blue; the margin whitish, well defined, irregular. When well grown the surface cracks into many small, unequal areas and has a thickish,

somewhat tuberculate look. Flesh 180–260μ thick, a beautiful clear indigo in thin sections except for the outer part of the hymenium, which is suddenly colorless.

Spores white, elliptic, smooth, 4.3–5.2 × 8.5–11μ. Basidia 6.5–7.5μ thick, irregular. The spores sprout very soon in a damp chamber, the filaments coming usually from one side of the distal end.

Easily recognized by the color and finely cracked surface. Massee's colored figure (Pl. 33, fig. 3) does not represent well the color of our plant, but there seems to be no doubt of its identity. Plants in the Curtis Herbarium from South Carolina, Alabama and England are the same. The miscroscopic characters as given by Bourdot and Galzin also agree.

3997. On California privet by President's house, January 21, 1920.
4018. On standing branches of privet and crepe myrtle, January 24, 1920.
4722. On privet in President's yard, December 10, 1920.

Common on wood and bark. Curtis.

2. **Corticium lilacino-fuscum** B. & C.

Stereum roseo-carneum (Schw.) Fr.

PLATE 33

Extensively effused; margin definite, not fimbriate; not removable. When wet membranous and soft, pale creamy gray with distinct tint of lilac; when dry slightly duller and cracking through the hymenium into numerous, rather small areas, showing the whiter context beneath, not tuberculate except over the inequalities of the bark. Entire thickness about 185μ; the context composed of rather loosely woven, clear threads, 2.4–3.5μ thick, with clamp connections and many crystals. In the hymenium are numerous slender paraphyses with short branches near their ends. Unfortunately our figure shows only one and that not branched. Basidia 6.3–7.5μ thick; up to 30μ long, 4-spored.

Spores white or pale cream, smooth, elliptic, 3.8–5.5 × 7–9.3μ, easily collapsing.

Our plants agree with plants so named from Ellis (N. Am. Fungi, No. 515), and with Burt's description and figure of *Stereum roseo-carneum*. In treating this as a Stereum, Burt is no doubt right, but for convenience we retain it for the present in Corticium.

4071. On bark and wood of an oak limb, February 4, 1920.

3. **Corticium scutellare** B. & C.

PLATE 34

Extensively effused on corticated or decorticated wood, cracked into innumerable small areas, inseparable as a whole, but when dry the upper, rather friable and chalky part is easily removed from a thin white layer covering the wood; color varying from sordid white through cream or clay to pallid yellowish or ochraceous; obscurely nodulose; margin fading quickly out to a thin granular-looking edge, not byssoid. Entire plant about 148–260μ thick; hymenium about 65–75μ, no cystidia. Clearing with potash shows a dark, dense layer of about the same or greater thickness beneath the hymenium, and a thinner, more delicate, pale layer next the wood; hyphae delicate, 2.5–3.5μ thick.

Spores long-elliptic, 4 × 7.5–9.3μ. Basidia slender, long-clavate, about 7.4μ thick, with four long sterigmata.

This matches well with a collection from Bresadola so named at the New York Botanical Garden, and agrees well with the original description (Grevillea 2: 4. 1873).

4043. On a very rotten but partly corticated branch of *Aesculus octandra*, January 21, 1920.

4223. On bark of oak wood, March 27, 1920. Spores subelliptic, 4.4–5.1 × 9.3–10μ.

4696. On bark of limb from a deciduous tree (birch or cherry), December 4, 1920. Spores (print) subelliptic, some slightly curved at mucro end, hyaline, 3.7–4.5 × 7–9μ.

Common on bark of limbs. Curtis.

4. **Corticium roseum** Pers.

PLATE 33

Plant effused, arising as small patches which fuse on meeting without leaving a trace of the line of junction; margin definite and at times a little uplifted, furnished with a very narrow white fringe of fine fibers when growing; surface smooth, dull with the appearance of fine felt, pale flesh color both when wet and dry, cracked when dry, the cracks reaching nearly to the substratum, but usually showing at the bottom the white fibers of the subiculum; 140–280μ thick; threads of context not densely packed, 2.8–3.8μ thick, with clamp connections. Hymenium dense, about 50μ thick, composed, in addition to the basidia, of crowded, much-branched, more or less contorted threads, the tips of which extend above the general surface and help to give the pruinose appearance.

Basidia 4-spored, long club-shaped, about 7.5μ thick and projecting about 40–50μ; sterile cells of much the same appearance are scattered among them and may be young basidia. Spores (of No. 4703) clear salmon, smooth, elliptic, 5.5–7.5 × 9.3–13μ, granular, sprouting over night in a damp chamber.

Our plants agree perfectly with a collection of *C. roseum* from Bresadola at the New York Botanical Garden and with collections so named at Washington. Dr. Burt has seen our No. 3981 and determined it as *C. roseum*.

3981. On decaying hickory tree, January 18, 1920. Hyphae delicate, clamp-connected, 3–4μ thick. Spores smooth, subelliptic, 4.5–6 × 10–15μ.

4703. On bark and wood of branches of *Salix sericea*, Glen Burnie Farm, December 5, 1920.

5. **Corticium Viticola** (Schw.) Fr.

PLATE 33

Plants appearing as small, irregular patches with deep orange-red centers and paler byssoid margins which extend and fuse to form elongated crusts up to 2 or more cm. long and 1 cm. wide. Hymenium forming irregularly and at times in scattered patches, again continuous, pale sulphur yellow, with the appearance of fine leather, about 45–50μ thick; the substance below about 185–250μ thick and composed of very loosely woven, rather even threads about 3–4μ thick, without clamp connections, which are usually a deeper, more orange color.

Spores white, smooth, elliptic, with one side flattish, 5–5.5 × 8.5–9.4μ

Among the layers of the bark run deep orange rhizomorphic strands with byssoid fringes which connect with the superficial part.

4693. On dead bark of a live grapevine, New Hope Swamp, December 4, 1920. Middle and upper districts on bark of grapevines. Curtis.

6. **Corticium arachnoideum** Berk.

PLATES 17 AND 33

Effused irregularly over area of several centimeters, closely adherent, color pure white; margin indistinct and pulverulent or hypochnoid, in center thicker and smooth, and in most places minutely powdery, having the appearance of a thin white-wash. In section about 111μ thick; context made up of very loosely packed, clamp-

connected, incrusted (so as to look very rough-walled) hyphae, 4.2μ. thick; hymenium about 18μ thick, made up entirely of young and old basidia, which are clavate, 4.8μ thick, with four minute sterigmata; no cystidia, but at base of the hymenium is a layer of crystals which KOH does not dissolve entirely.

Spores white, short-elliptic, hyaline, 2.5–3.5 × 3.8–5μ.

When compared with specimens of *C. arachnoideum* from New Jersey (Ellis and Everhart, Fungi Columbiana No. 309) at New York Botanical Garden, our plants agreed exactly and Dr. Burt has kindly confirmed the determination.

4235a. On very rotten, decaying, deciduous wood, March 25, 1920.

Common on wood and bark. Curtis.

7. **Corticium vagum** B. &. C.

Corticium botryosum Bres. Ann. Myc. 1: 99. 1903.

PLATE 33

Entirely resupinate, pulverulent-looking, margin indeterminate; easily separable from the substratum when wet, and with an open wefty structure that resembles a mold; color when wet, light slate, drying to a yellowish gray. Structure in section about 240μ thick, consisting of very loosely packed, very large (7.4μ thick,) considerably branched, frequently septate hyphae without clamp connections which are *yellowish* towards the substratum.

Spores subelliptic (flat on one side, curved on the other), pointed at each end, 3.8–5.5 × 7.5–11μ. Basidia simple, very peculiar, hardly distinguishable from the hyphae and not forming a distinct hymenial layer, 7.4–9 × 18–25μ, with two, four or six curved sterigmata. No cystidia.

The small group of Corticiums to which this species belongs is peculiar in the undifferentiated condition of the fruiting surface. There can scarcely be said to be a hymenium any more than in a mold. The plant is at times parasitic, again saprophytic. Burt (l. c.) has studied it along with two other related species and his description agrees substantially with ours. *Hypochnus Solani*, *Corticium Solani* and *Rhizoctonia Solani* are the same as this. Our plant also agrees in all important particulars with Bresadola's description of his species and with the more detailed description by Miss Wakefield (Trans. Brit. Myc. Soc. 4: 117. 1913).

4230. On bark of a dead poplar limb, April 4, 1920.
4236. On inside of decaying poplar log, April 15, 1920. Spores pointed, subelliptic, 3.7–4.5 × 8.5–11.5μ.
4259. On bark and wood of dead pine, April 15, 1920.
4276. On dead pine wood, April 20, 1920.

8. **Corticium subcoronatum** v. Hoehn. and Litsch.

Adnate, thin, pulverulent-looking, so loosely woven as to be lacunate under a hand lens, when wet slate colored, drying to whitish gray; margin indeterminate. Structure in section after application of KOH about 90μ thick, made up of extremely loosely packed, much branched, clamp-connected, hyaline hyphae 5.5–7.4μ thick; no definite hymenial layer present but basidia are borne on the tips of much branched hyphae at outer surface and the large number of collapsed basidia give the appearance of a layer of crystals; basidia 6.6–7.4 × 12.5μ, with four sterigmata and not distinguishable from hyphae except for the presence of sterigmata.

Microscopic appearance like *C. botryosum*, but differing in section in that the present plant has more delicate hyphae which are not yellowish at base as in *C. botryosum*, and has clamp connections at septae and smaller spores than the latter. See Wakefield in Trans. Brit. Myc. Soc. 4: 118. 1913.

4271. On bark of very rotten oak log, near Meeting of the Waters, April 18, 1920.

9. **Corticium Stevensii** Burt.

While we have not found this in Chapel Hill, its frequent presence in the mountain region of this state and its importance as a parasite of apples, pears, and quinces leads us to include it here. We adapt the following condensed description from Stevens and Hall (Ann. Myc. 7: 49. 1909, as *Hypochnus ochroleucus*) and from Burt (l. c., p. 125):

Fructification forming a felty, dull pinkish buff, easily removable membrane on the under side of the leaf; hyphae 4.5–7.5μ thick, not nodose septate, bearing the basidia scattered along them on short lateral branches; basidia 7–8 × 11μ, with 4 sterigmata; spores hyaline, flattened or slightly concave on one side, 3–4 × 8–11μ.

The vegetative mycelium lives on the twigs and forms there chestnut-brown Sclerotia from which rhizomorphic strands run to the leaves and are dissipated into the fructifying hyphae.

Stevens and Hall report the fungus from numerous places in western North Carolina where it does much damage to neglected orchards. The species is evidently related to *C. vagum*, and a true hymenium is absent.

STEREUM

Plants growing on wood in all species here treated; thin, flat, tough and leathery, or more woody and rigid; petal- or bracket-shaped; in our species usually growing horizontally with a broad attachment directly from the wood or from a more or less extensive resupinate portion; dorsal surface often velvety or hairy, concentrically zoned and radiately strigose or rugose; hymenium quite smooth and not furnished with sterile spines (setae) projecting among the basidia, but cystidia or paraphyses may be present; basidia simple, spores smooth in our species, nearly white to pale smoky flesh color in a good print. Some species exude a colored juice from the wounded hymenium when in a growing condition. Burt has recently published his monograph on the American species in Ann. Mo. Bot. Gard. **7**: 81. 1920. He records twenty species from North Carolina (including *S. fuscum*), two of which we are treating under Peniophora and Corticium. Two of these North Carolina species grow on the ground, both reported from the mountains. See also Massee, Journ. Linn. Soc. **27**: 158. 1890. I am under obligation to Dr. Burt for having determined a number of my plants. For interesting remarks on *S. abietinum* Pers. see N. Y. Sta. Mus. Bull. 219, 220, p. 54, containing Report of Director for 1918. 1920.

KEY TO THE SPECIES TREATED

Plant forming small tuberculate bodies like crowded molar teeth; hymenium with many warted cystidia..... *S. frustulosum* (4)
Not as above.
  Hymenium becoming reddish when bruised.
    Growing on frondose wood; surface tawny..... *S. çausapatum* (1)
    Growing on frondose wood; surface blackish with rusty margin; texture hard and woody when dry..... *S. subpileatum* (3)
    Growing on pine; surface pallid..... *S. sanguinolentum* (2)
  Hymenium turning dark brown when bruised..... *S. fuscum* (10)
  Hymenium not becoming red or brown when bruised (*S. subpileatum* and *S. fuscum*, in which the hymenium changes color when bruised are included below, as this character is obscure except when quite fresh.)

Dorsal surface grayish, zoned, coarsely hairy.....*S. fasciatum* (5)
Dorsal surface grayish, zoned, tomentose; plant small, growing on cedar.....*S. rameale* a form (7a)
Dorsal surface in large part smooth and shining; chestnut or lighter reddish-brown, tomentose at base and at times on some of the zones.....*S. rameale* (7)
Dorsal surface satiny-tomentose, with zones of tan, cinnamon, reddish-brown, etc.....*S. lobatum* (6)
Dorsal surface smooth, silky-shining, pale tan to whitish.....*S. sericeum* (8)
Dorsal surface white when dry and densely woolly hairy all over; hymenium golden yellow when dry; plant small.....*S. ochraceoflavum* (9)
Dorsal surface dull brown, subtomentose on the whitish margin; flesh spongy.....*S. fuscum* (10)
Dorsal surface smoothish or more or less scurfy-tomentose, particularly towards the margin; deep purplish brown or blackish, margin tawny when growing.....*S. subpileatum* (3)

1. **Stereum gausapatum** Fr.

S. spadiceum Fr.

PLATES 20 AND 35

Plant laterally sessile forming a complicated mass of branched, wavy, imbricated, horizontal caps which project a distance of about 1.5–5 cm.; a compound group at times extending laterally up to 8–9 cm. Dorsal surface zoned frequently with ridges and proliferations, densely matted tomentose all over; color when damp dull tawny with brownish zones, the margin reddish brown (where the reddish flesh shows through the thinner tomentum), when dry all parts are a clearer tawny or buffy tawny except for a narrow reddish margin. Hymenium wavy and undulating to form radial ridges, when damp dull dark brown with a tint of bay, the marginal part for about a cm. being reddish ochraceous; all parts of the hymenium turn instantly dull red when bruised and emit a little reddish latex. When dry the hymenium becomes a somewhat lighter dull smoky buff or tan with a faint fleshy tint. Flesh when wet very tough and pliable, about 0.5 mm. thick, deep reddish brown, the hymenium about 0.4 mm. thick (unusually thick for a Stereum) and the tomentose coat about 0.6–1.4 mm. thick; tasteless and odorless. When dry the caps are rigid and rather brittle.

Spores (of No. 4110) pale creamy flesh, smooth, elliptic, 2.5–3.7 × 6–8.5μ.

PLATE 20

STEREUM GAUSAPATUM. No. 3821.

Not rare on rotting oak stumps and logs. The species is easily recognized by its good size, complicated structure, tawny and tomentose surface and dark hymenium which turns red at once when bruised. It differs from *S. sanguinolentum* in tawny color and growth on oak. The latter is pallid and grows on pine.

334. On the base of a rotten oak stump, October 4, 1908.
3821. On oak log at "Long Bridge," December 5, 1919. Spores 3–3.8 × 6–8.2μ.
3912. On dead oak log by Battle's Branch, November 5, 1919.
4110. Oak limb by Battle's Branch, February 13, 1920.

Common on trunks and stumps. Curtis
Blowing Rock. Atkinson.
South Carolina, Hartsville. Coker.

2. **Stereum sanguinolentum** (A. &. B.) Fr.

PLATE 35

Largely resupinate, the upper margin reflexed and bracket-like, in our plants extending only about 4–5 mm.; surface of the free caps inherently fibrous, radiately striate, zoned lengthwise by thin brown lines, the remainder nearly white or brown, the thin margin white; flesh leathery, tough, elastic, thin. Hymenium more or less wrinkled and ridged, when young whitish (very pale fawn) sooner darker through light fawn to dusky fawn; when bruised in the fresh state immediately exuding a deep red juice which stains the surface, later the stained parts becoming dark dusky brown with only a tint of red.

Spores (of No. 3967) white, sausage-shaped, 2–3 × 6–8.5μ.

Easily distinguished from others that turn red by growth on pine and different color. Our plants form patches about 1.5–2 × 1.5–4 cm., some with and some without the narrow reflexed margin. If soaked again after drying the hymenium turns red almost all over and on drying again darkens to a very deep brown, the margin only remaining white.

3967. On a pine log, January 17, 1920. Photo.

Low and middle districts on pine trunks. Curtis.

3. **Stereum subpileatum** B. &. C.

PLATES 21 AND 35

Plants bracketed from a resupinate layer, extending about 1.5–5 cm. or more, often anastomosing and contorted; dorsal surface velvety-scurfy when young and more or less persistently so, the older

part often quite smooth; multizonate, the more conspicuous zones with obscure ones between; usually crimped and waved to form radiating ridges like an oyster or pecten shell; color on younger growing margin buff-tawny, then dull tawny-brown or at times abruptly blackish-brown, with dull purple zones and often deep gray zones near the margin. Flesh about 0.5–0.8 mm. thick, very hard and woody, not at all pliable when dry, composed of four distinct layers, the lower, just under the pale hymenium, thickest, ochraceous buff color, with vertical fibers and distinctly stratified in old plants (this representing the different layers of old hymenium); the next layer thinner (unless plant is young) and lighter with horizontal fibers; the next thinner still and black or nearly so and hard and shining like rosin; the upper brownish and densely spongy; threads of flesh densely packed, 3–4μ thick, without clamp connections. Hymenium smooth, pale creamy flesh color, cracking in age, often wrinkled and nodulated and obscurely zoned, becoming dull brownish red when bruised in the fresh state.

Spores (of No. 3828) smooth, white, oval, 2.5–3.7 × 3.8–5.5μ. Cystidia numerous, encrusted, blunt, about 5.2–7.5μ thick, projecting about 7.5–11μ—a few bottle-brush paraphyses were seen in our preparations.

The caps are perennial, the new growth arising from the lower layer of flesh only, and forming a new hymenium over the old one. Old plants may be practically black and the old hymenium may become straw color or dull creamy yellow with discolorations due to black or green molds. It is not often that one finds plants in so fresh a condition as to show the change to reddish in the hymenium, but the plant is easily determined by its other characters. Rare at Chapel Hill; apparently more common in the Coastal Plain. Our plant is just like *S. subpileatum* B. & C., as represented by No. 219 in the Ravenel Exsiccati. *Stereum sepium* is very near, but is separated by Burt on account of the abundance of bottle-brush paraphyses. *Stereum insigne* also differs in having many such paraphyses and in the absence of cystidia. *Stereum rugosum* has been considered in a different section on account of the red juice in its hymenium, but in our collections of *S. subpileatum* the hymenium also turns red when bruised, a fact which has not been mentioned by others. There is, however, no obvious juice in the latter.

2837. On an oak log, September 23, 1917.
3828. On the same log as No. 2837, December 6, 1919.

PLATE 21

STEREUM SUBPILEATUM. Nos. 1522 and 2837 [above].
STEREUM FUSCUM. No. 689 [center].
STEREUM RAMEALE. Nos. 3813 and 3825 [below].

3955. On a standing dead white oak, January 17, 1920.

Common on logs and stumps. Curtis.
Blowing Rock. Atkinson.
South Carolina. Hartsville (No. 1522.) Coker.

4. **Stereum frustulosum** (Pers.) Fr.

PLATES 18 AND 35

Plant forming small flat, tuberculate, usually crowded bodies which are somewhat expanded at the top. The upper, spore-bearing surface is usually grooved and uneven like a molar tooth, is brownish-gray in color and nearly glabrous. The sides are blackish brown and rugosely zoned. Flesh brown, very hard and woody, about 1.5–3 mm. thick, zoned, each zone representing a renewed growth added over the hymenium of the preceding growing season as in Fomes.

Spores white, smooth, oval, 2.5–3.5 × 4–5.1μ. Basidia club-shaped, 5.5–7μ thick, with four very long sterigmata. Cystidia numerous, club-shaped, covered over the distal half with close-set short spines like a giant's club. These spines are not so long in our preparations as in figures by Burt (l. c., p. 227). (See also Lloyd, Letter 51, fig. 565; and Myc. Notes No. 49, p. 696, fig. 1041. 1917.) These peculiar cystidia, together with the perennial habit, indicates a relationship with *S. subpileatum* which is, I think, related to *S. rugosum*.

The plant is common on decorticated, but still sound and hard oak stumps and logs. Plants in cavities and unexposed to weather may be buffy brown in color, and some of these at least are sterile. As they grow older the plants expand slowly above and if on vertical wood may become slightly shelving above, in such case looking very like a miniature Fomes.

332. On hard dead wood of white oak, October 4, 1908.
389. On hard dead oak trunk, October 20, 1911.
1042. On stump of *Liriodendron tulipifera*, December 6, 1913. Photo.
3814. On oak stump, December 3, 1919.
4127. On oak stump, February 15, 1920. Plants up to 3 mm. thick, with as many as ten layers.

Low and middle districts on wood and stumps. Curtis.
Blowing Rock. Atkinson.

5. **Stereum fasciatum** (Schw.) Fr.

PLATE 22

Plants very thin, tough and pliable when fresh, rather brittle when dry, sessile, and attached by a narrowed base, often imbricated, individuals reaching a width of about 8 cm., the upper surface covered densely with a rather harsh, fibrous tomentum; color light creamy gray or grayish tan, with distinct, rather closely set zones. After maturity the upper surface soon becomes green from the growth there of the alga *Pleurococcus*. Hymenium smooth, faintly zoned and of a light fleshy-cream color. Spores (of No. 3815) smooth, elliptic, 2.1–2.9 × 5.1–6.5μ, just like those of *S. lobatum*.

The plant is very common on logs and stumps and may occur in such abundance as almost to cover a large log. It is not rarely intermixed with *Coriolus versicolor*. The caps are only about a quarter to a half mm. thick. The plant is easily recognized by the strigose-hairy cap, light hymenium and comparatively large size. It is often referred in American herbaria to *S. hirsutum*.

938. On an old rotting log by Fern Walk, September 14, 1913.
3815. On dead, deciduous twigs and bark, December 3, 1919.
3820. On rotting oak, December 5, 1919.

Common on trunks and limbs. Curtis.

6. **Stereum lobatum** Kunze.

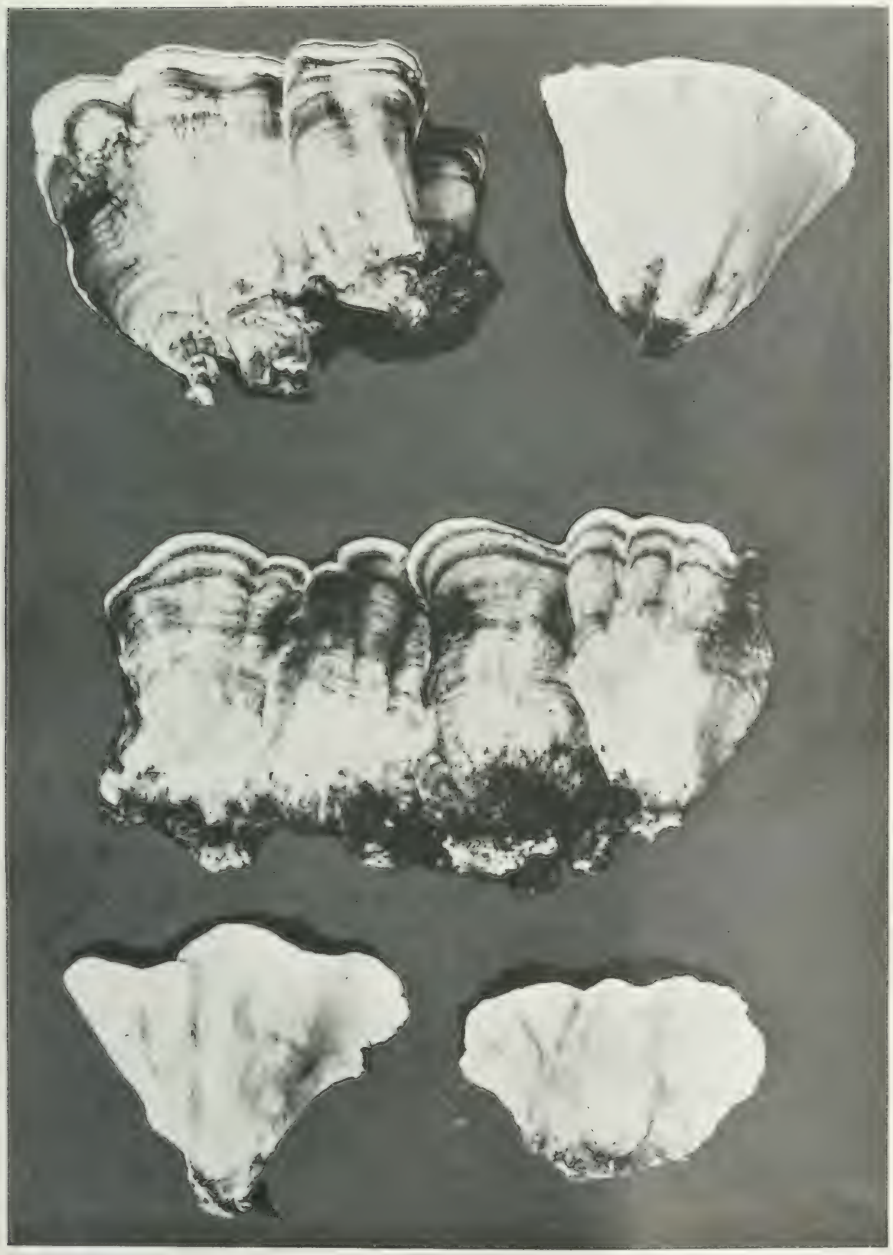
PLATES 22 AND 35

Plants about 1.3–5 cm. broad, sessile and attached by a narrowed base, petal-shaped and often fused laterally, surface conspicuously zonate with varying shades of light tan, cream, deep reddish brown, cinnamon, etc. Most of the surface is covered with a thick, close interwoven tomentum of satiny texture, but narrow zones on or near the margin may be free from it. Texture pliable when fresh, less pliable and rather brittle when dry, very thin. Hymenium smooth, faintly zoned; color a light fleshy salmon or fleshy tan.

Spores (of No. 3816) smooth, white, elliptic, 2.2–3 × 5–6.5μ, like those of *S. fasciatum*.

This species is about as common as *S. fasciatum* which it resembles closely in shape, colors and texture. It averages smaller than that species and may be distinguished best by the interwoven, feltish

PLATE 22



STEREUM LOBATUM. No. 3816 [top].
STEREUM FASCIATUM. No. 3815 [center and below].

surface layer, which is not strigose hairy. *Stereum versicolor* Swartz, to which authors have referred this species, was collected in Jamaica and has a smooth surface (Lloyd, Myc. Notes 33: 429. 1909). My plants have been seen by Burt, who determines them as above.

331. On dead wood, September 25, 1908.
3816. On dead deciduous twigs and bark, December 3, 1919.

Common on trunks and limbs. Curtis.
Hartsville, South Carolina. Coker.

7. **Stereum rameale** Schw.

S. complicatum Fr.

PLATES 21, 23 AND 35

Caps small, shelving from a more or less resupinate base, petal-shaped or shell-shaped, often fused laterally, usually projecting 3–17 mm.; surface zoned, smooth and silky-shining except near the base where it is covered with white, gray or tawny fibers, or the hairs may occur on some of the zones more than half-way to the margin, or very rarely all over; color when quite fresh and damp a light ochraceous on margin, passing through ochraceous to reddish ochraceous at base, when dry a deep chestnut brown with paler zones, or when old and weathered the color may fade to much lighter. Hymenium smooth, strong, uniform ochraceous when fresh and damp, changing to a creamy flesh color when dry. When on horizontal branches the under side of the branch may be completely covered by the resupinate part, which gives rise on the sides to a long fringe of the projecting caps. On drying the plant contracts so much that the resupinate portion is often split and torn.

Spores (of No. 3863) faint smoky flesh-color in a good print, smooth, rod-elliptic, 2–2.8 × 5–7μ. Hymenium (of No. 3802) about 35μ thick.

When damp the hymenium also is faintly zoned but when dry it is not zoned. The dorsal surface is on the contrary more conspicuously zoned in the dry state. A very pretty little plant which often occurs on small twigs and wings them on both sides if they are horizontal, also appearing in large numbers on larger branches.

333. On a dead oak branch, January 14, 1909.
362. On branches and small twigs, October 11, 1911. Tawny tomentose all over.
3813. On a dead oak limb, December 3, 1919. Spores 2–2.8 × 5–7.2μ.
3825. On deciduous twigs, December 3, 1919. Hymenium strong orange salmon.
4106. On an oak twig, February 13, 1920.

4174. On a corticated oak branch, February 23, 1920. Color of damp hymenium about gold; grayish flesh when dry.

Also many other collections on oak, sumac, ironwood, privet and peach.

Blowing Rock. Atkinson.

Common on dead limbs (as *S. complicatum*). Curtis.

7a. **Stereum rameale.** Form on cedar.

We have in Chapel Hill a form on Juniperous poles which differs from the typical in the much grayer and more tomentose surface in the smoky hymenium, and in never reaching the larger sizes often found in the latter. These differences remain constant from year to year, but as the spores and other microscopic characters are the same, I agree with Dr. Burt, who has seen my plants, that it is best to refer them to *S. rameale.* A description follows:

Shape and size as in smaller examples of the typical form, mostly petal-shaped and attached by a constricted base, projecting about 4–8 mm., at times largely resupinate, often in rows; dorsal surface light brown when damp with narrow zones of blackish brown, the margin white or black; scurfy tomentose nearly all over (a few narrow glabrous zones are present at times); radially channelled; when dry pale gray with narrow blackish zones and an obscure cinnamon tint towards the margin. Hymenium uneven, smoky brown to smoky buff when damp, when dry smoky gray, the marginal part darker.

Spores exactly like those of *S. rameale,* smoky flesh color, 1.8–2.8 $\times$ 5–6.6μ.

Stereum radiatum Pk. which also grows on conifers (hemlock and spruce) in the northern states is very different.

4026. On cedar poles with bark on, January 24, 1920.

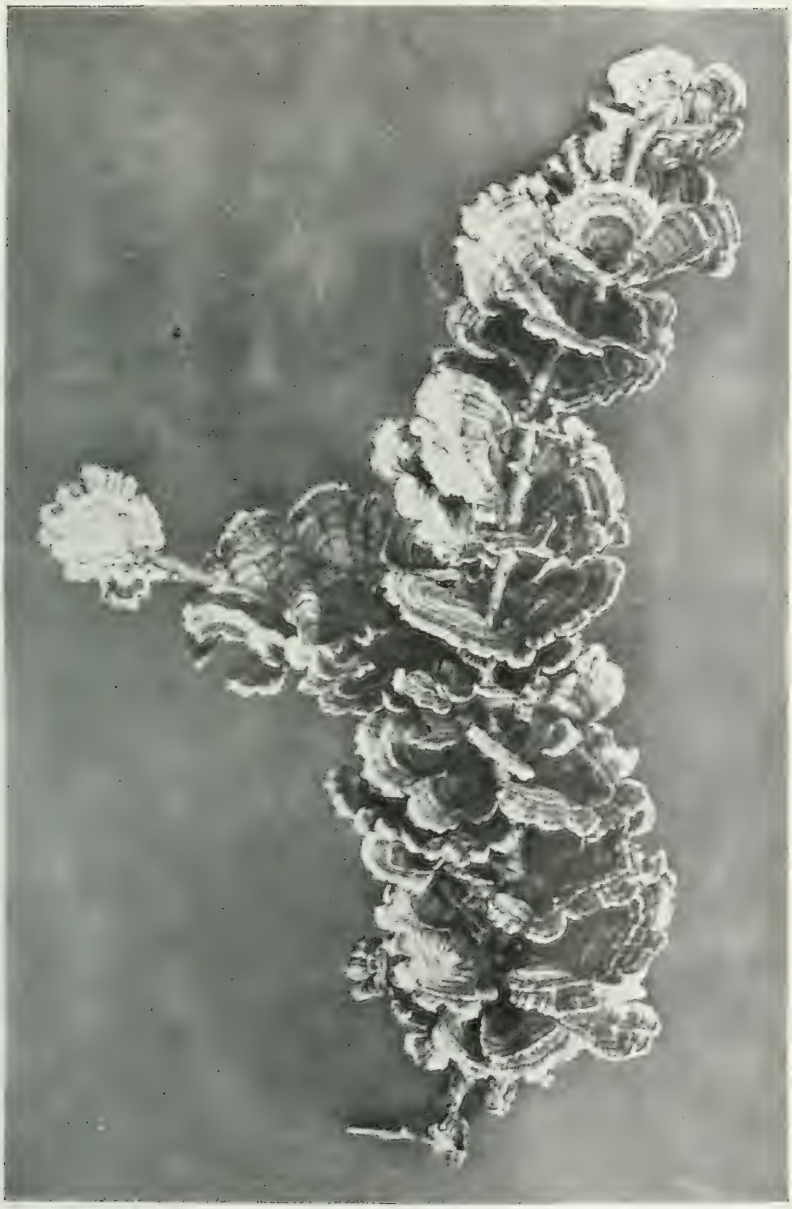
4318. Same spot as No. 4026, June 20, 1920.

8. **Stereum sericeum** (Schw.) Sacc.

PLATE 35

Plant arising from a little tubercle and, if beneath a branch, largely resupinate by fusions, reaching a length of 6 or 7 cm., the free and shelving margins not continuous but discrete and forming separate petal-like brackets which vary from very small up to 2 cm. broad and extending 1.5 cm.; often not resupinate and attached directly to the wood by a point. Dorsal surface smooth, silky-

PLATE 23



STEREUM RAMEALE. No. 4106.

shining, pale straw or whitish gray, radially striate, transversely zoned by narrow lines of brown. Hymenium pale fleshy-straw color to whitish, faintly ridged radially. Flesh very thin, hardly a fifth of a cm. thick, when damp very soft and pliable like softest leather, when dry subrigid and elastic.

Spores (of No. 3962, Hartsville, S. C.) pale flesh color in a good print, rod-elliptic, 2.2–3.4 × 7–10μ, a few up to 11μ.

The plants arise from points and if resupinate spread out and fuse when touching, forming a faint line on the hymenium to show the line of union just as in *Eichleriella Leveilliana*. The point of origin is indicated by a small central nipple in the center of each component part. The species is easily distinguished by the quite smooth, silky, pale caps, small size, and thin, papery structure. In age the plants often become split radially into narrow frayed strips. Rather common.

1043. On dead branch of Carpinus, December 6, 1913.
4040. On blackgum twig in Arboretum, January 26, 1920.

Hartsville, South Carolina. Several collections on black gum (*Nyssa*), December, 1919. Coker.

9. **Stereum ochraceoflavum** (Schw.) Curtis

PLATE 35

Plants typically cup-shaped or elongated cup-shaped, if hanging then attached by a broad base or if on small twigs by an elongated line; if on upright branches then broadly attached by a resupinate side of the cup, size varying from quite small up to about 1.5 cm. broad, or several may be fused to make a length up to 3 cm. Dorsal surface densely woolly-hairy all over, when damp dull white with narrow straw-colored zones towards margin and deeper reddish ochraceous zones near the base, when dry white all over (due to the colored flesh not showing through the white hairs). Hymenium somewhat uneven, of a beautiful golden-yellow color when dry, a more ochraceous yellow when wet; not changing when cut; after some exposure the color may fade to a paler buff. Texture tough and very pliable, like soft leather when wet, sub-rigid when dry; flesh about the color of the hymenium, both together hardly a half mm. thick.

Spores (of No. 4033) white, elliptic, smooth, 2–3 × 5.5–7.4μ.

A striking and unique plant, easily recognized by the small size, golden-yellow hymenium and woolly-white cap. This is certainly

S. ochraceoflavum. I have compared a good collection of that species from the Schweinitz Herbarium and another from Schweinitz in the Curtis Herbarium, and find them identical. It is also like plants under this name in the Curtis Herbarium from Massachusetts, New York and Mississippi. The same thing from Alabama, South Carolina and Cuba in the Curtis Herbarium was labelled *S. hirsutum.* Specimens of the latter from Europe are quite different. Our plant is also like *S. ochraceoflavum* as represented in the Kew Herbarium, where I sent some of my plants for comparison. *Stereum sulphuratum* B. & Rav. (Journ. Linn. Soc. 10: 331. 1868) seems very near. From the description the species would hardly be connected, but the type of *S. sulphuratum* in the Curtis Herbarium from Cuba, as well as a collection from Georgia, can scarcely be distinguished from our plants with a hand lens. Burt finds the microscopic characters of the two species to differ in several respects.

2941. On dead twig of *Rhus copalina,* October 8, 1917.
4033. On twigs of a deciduous wood, January 25, 1920.
4738. On a dead vine of Vitis, December 16, 1920.

Common on limbs. Curtis.

Hartsville, S. C. On twigs of various deciduous woods as black gum, *Ilex glabra,* etc., December 25–26, 1919. Coker.

10. **Stereum fuscum** Schrad.

S. bicolor Pers.

PLATE 21

Caps from 1–2.5 cm. wide, much fused and folded and rising from a common resupinate stratum; surface grayish snuff color, the margin abruptly pallid; tomentose when young, the tomentum collapsing on exposure to weather, the growing margin remaining tomentose; obscurely marked with structural zones, especially near the margin, where there may appear an interrupted blackish zone. Flesh about 1 mm. thick, color of surface, fibrous and rather spongy. Hymenium thin, about 55–65μ thick, white when young, then approaching the cap color, becoming dark brown when bruised in the growing state; texture much more firm and brittle than the flesh; furnished with thick, refractive, embedded gleocystidia; cystidia also present, encrusted, blunt or pointed, 3.5–4μ thick, projecting about 9–22μ.

Spores oval, smooth, 2.3–2.5 × 3.5–4μ.

Burt makes an error in not crediting this from North Carolina, putting Salem, under South Carolina.

689. On dead sweetgum, December 3, 1912. Photo.
Blowing Rock. On rotting wood. Atkinson.
Common, on logs and limbs. Curtis.

THELEPHORA

Plants tough, leathery, fan-shaped, or funnel-shaped, or much branched; hymenium smooth or somewhat wrinkled, covering only the interior (or outer) surface in most species, but clothing all but the stalk in a few branched forms; basidia simple; spores colored, rough or spiny. A few branched kinds as *T. palmata* and *T. anthocephala* have the form of Clavarias but are distinguished from these by the tough, leathery texture and very dark spores. Lachnocladium forms of Clavaria approach these in texture, but have light spores. (See Burt, Ann. Mo. Bot. Gard. 1: 199. 1914, for a full treatment of the genus in North America.)

KEY TO THE NORTH CAROLINA SPECIES

Plants stalked and upright, growing on the ground
- Branched like a tree or shrub and rather stout, 3–6.5 cm. high.
  - Odor very strong and foetid..... *T. palmata* (1)
  - Odor none..... *T. multipartita* (2)
- Branched like a tree or shrub, slender, 1.5–2.7 cm. high..... *T. caespitulans**
- Simple, small, flattened and broadened upward..... *T. regularis* (4)
- Simple, or lobed, expanded above into more or less complete shallow, thin and pliable cups. In pine or cedar woods or open fields.
  - Cap not zoned, fibrous-squamulose, margin fimbriate... *T. terrestris* (5)
  - Cap zoned, inherently squamulose, margin even at maturity..... *T. intybacea* (6)
  - Cap zoned, silky fibrous, margin fimbriate..... *T. griseozonata* (7)
- Expanding above into a complicated mass of concentric plates, lobes or tubercles, thick and firm..... *T. vialis* (3)

Plants laterally sessile, bracketed, growing on wood or up from the ground onto bases of stems. Sometimes centrally stalked and expanded into a cup above when growing upright.

* *Thelephora caespitulans* has not been found in North Carolina, but should be looked for as it occurs both north and south of us. We take the following from Burt (l. c. 1: 204. 1914): "Fructification erect, coriaceous, dusky drab to olive-brown below, paler above, very much branched, forming clusters 2½ cm. high by 2½ cm. broad; pileus with numerous divisions joined together into a solid base but assurgent above and pressed together closely compressed, subcanaliculate, frequently obtuse and whitish at the apex; hymenium amphigenous: spores umbrinous under the microscope, sparingly tuberculate, 7–8 × 5–6μ. On the ground in mixed woods, Vermont to South Carolina, and in dense coniferous woods, Washington. September. Rare. This species is related to *T. palmata* but is more olivaceous, and it is probably inodorous,—at least no odor has been noted."

Blackish when fresh, with white margin when dry, brownish above with a gray-drab hymenium.....*T. cuticularis* (8)
Dull cinnamon or chestnut, margin paler when growing, soft and spongy.....*T. albido-brunnea* (9)
Yellowish, hard when dry.....*T. lutosa* (10)
Plants incrusting and ascending small plants or twigs from the ground.....*T. fimbriata* (11)

1. **Thelephora palmata** (Scop.) Fr.

This species, which is sharply marked by its upright branched habit, dark color and very foetid odor, has not yet been found in Chapel Hill, and in the following description of the fresh plant I have made use of notes by Miss M. McKenney, of Olympia, Washington. The species is northern in its range and descends to our state only in the mountains, so far as known with certainty. Curtis reports it as common in woods in this state, but he may have had some other plant in mind.

Gregarious or tufted, 3–6 cm. high, 2.5–4 cm. broad, trunk thin, flattened, black. Branches numerous, flattened, black; these branch again into slender branchlets which are round, flexible, tough, simple or occasionally flattened, divided, narrowing at the tip, which is white or gray. Odor most disagreeable, something like decayed cabbage combined with iodoform. Spores (of a plant from Olympia, Wash.) blackish brown, irregularly warted or spiny, 7.4–9.3 × 8–11.1μ.

In the dried state the plants are deep brown on the surface, the central flesh remaining black. They are rather brittle with nearly as much the appearance of a Clavaria as of a Thelephora, entirely smooth with a surface of velvet-like appearance all over. Odor retained, taste similar, bad, a good deal like that of *Hygrophorus Peckii*. Burt gives the color of fresh plants as fuscous purple. The plant is found under conifers or in grassy fields.

Asheville. Beardslee.
Common on earth in woods. Curtis.

2. **Thelephora multipartita** (Schw.) Fr.*

PLATES 24 AND 35

Plants about 2.5–3.5 cm. high, and 1.5–2.5 cm. broad above, distinctly stalked and dividing above into rather narrow, flattened

* *Thelephora anthocephala* (Bull.) Fr. is reported from North Carolina by Burt (from Beardslee) and by Curtis. We have not found a plant that we can separate from *T. multipartita* as this, and as we cannot work out any difference from descriptions that will make a clear distinction between the two species we refrain from copying a description (see Burt, l. c., p., 203).

PLATE 24

THELEPHORA MULTIPARTITA. No. 3468.

and channelled branches with white or whitish, finely tomentose, sterile tips; hymenium deep brown when fresh and moist, about warm sepia of Ridgway, in drying becoming lighter, between fawn and wood-brown of Ridgway. Stem rough, irregular, usually more or less flattened, surface felt-like. Texture tough, pliable; tasteless and *odorless*.

Spores (of No. 2590) deep smoky sepia, a large mucro, irregularly set with blunt spines, 5.5–7.4 × 7.4–9.3μ.

The tomentose tips, densely spinulose spores and particularly the lack of odor separate this from *T. palmata*. Dr. Burt has seen our plants and refers them as above. The stem is said to be villose, but this is not the case in our plants and ours are at times much larger than the maximum dimensions given by Burt.

2590. On earth, upland rocky woods (mixed oak and pine), Battle's Park, July 5, 1917. Photo.

2641. Low, damp woods by Meeting of the Waters branch, July 11, 1917.

2695. Low, damp woods by Creek at Upper Laurel Hill, July 17, 1917.

3468. In rich humus near base of oak near Meeting of the Waters, August 16, 1919. Photo. Deep brown with tint of purple; tips lighter. On drying colors become lighter. Spores deep smoky brown, irregularly warted or with blunt spines, 4.5–7 × 6.5–8.5μ.

4610. Damp, sandy soil below Meeting of Waters, July 31, 1920. Plants 2–3 cm. high.

North Carolina. Schweinitz.

3. **Thelephora vialis** Schw.

T. tephroleuca B. & C.

PLATE 26

Plant about 3–5 cm. high, and about 3–6 cm. broad, expanding and branching upward from a contracted base. The branchlets are broad and flat and fuse at any point, usually so consolidated as to form one complicated mass with the upper surface deeply lobed and nodulated. Flesh firm, coriaceous, very hard on drying and then giving off a distinct, rather sharp, aromatic odor that is hardly disagreeable. Hymenium inferior, rugose or smoothish, pale yellowish when young, becoming brown.

Spores said by Burt to be olive buff under the microscope, bluntly angular, 4.5–5 × 4.5–7μ.

Burt notices a "disagreeable" odor in drying; others do not mention an odor. We have found the plant to be rare here. When

Curtis speaks of it as common he probably included the very common *Tremellodendron candidum*.

1059. On ground in woods near campus, fall of 1913.

Asheville. Beardslee.
North Carolina. Atkinson.
North Carolina. Schweinitz.
Common, woods and roadsides. Curtis.

4. **Thelephora regularis** Schw.

PLATE 25

Small plants growing on damp mossy earth; at times spathulate in form, flat or the margins rolled back so as to be half infundibuliform, again infundibuliform with the margin divided and multiple (as in No. 4435), height about 2–3 cm., the base narrowed gradually into a cylindrical stalk about 1–2 mm. thick. Flattened portion about 5–15 mm. wide. Dorsal surface nearly smooth or roughish tomentose with light channels, and sometimes tubercles, a buffy flesh color; spore-bearing surface a dark fleshy gray or purplish fawn, with a glaucous bloom. Flesh tough, elastic, about color of the dorsal surface, with a bitterish harsh taste. In drying the plants become grayish brown, losing their flesh tints. Young parts of both hymenium and dorsal surface turn a dark wine brown when rubbed.

Spores when fully mature, angular, about honey color under the microscope, subspherical, smooth, 5–6μ in diameter. The spores are slow to take their color and to become rough, still appearing white and smooth until nearly full grown. Basidia club-shaped, four-spored, sterigmata about 4μ long; no cystidia.

According to descriptions the plants may assume a regular infundibuliform shape like a perfect cup, and Burt thinks (l. c., p. 206) that *T. multipartita*, which is reported by Schweinitz from this state, is only a branched form of this species.

1597. In damp mossy earth by branch southwest of graded school, July 10, 1915.
1622. Same spot as No. 1597, July 21, 1915. Photo.
4435. Damp, sandy soil by Battle's Branch, July 17, 1920.

Salem. Schweinitz.
North Carolina. Atkinson.

PLATE 25

THELEPHORA REGULARIS. No. 1622.

PLATE 26

THELEPHORA VIALIS. No. 1059 [above].
THELEPHORA TERRESTRIS. No. 3840 [below].

5. **Thelephora terrestris** Ehrh.

T. laciniata Pers.

PLATE 26

Caps scattered to densely imbricated, in part incrusting, more or less fused, bracketed and broadly attached by the side, projecting about 1–2 cm., upper surface deep brown, fibrous-squamulose and ridged all over, not zonate; hymenium brown, paler on margin, uneven; margin thin, fimbriate. Flesh thin, very soft, pliable and spongy-fibrous, color of surface, absorbing water immediately.

Spores not to be obtained from our plants when found. Burt gives them as pale fuscous, irregular, angular, sometimes slightly tuberculate, 6–9 × 6μ.

Recognized by the squamulose cap, dark color, very soft and spongy, bibulous flesh and shelving growth on coniferous substrata, upon which it climbs from the ground. According to Burt the species also grows in sandy fields. For further interesting observations by Burt see Ann. Mo. Bot. Gard. 1: 219. 1914.

3840. Running up the base of a cedar from the ground, south of athletic field, December 7, 1919. Photo.

Asheville. Beardslee.
Salem. Schweinitz.
Common on earth and trunks. Curtis.

6. **Thelephora intybacea** (Pers.) Fr.

PLATE 35

Plant 5.5 cm. high, 4.5 cm. broad, compound from a solid amorphous base, the flabelliform, petaloid or infundibuliform blades arising on more or less distinct stalks and gradually expanding upwards; margins thin, expanded, more or less lobed and cut, but not fimbriated; dorsal (interior) surface inherently fibrous and ridged but not squamulose, dark brown, about Prout's brown to bister of Ridgway; when dry the margins black; hymenial (outer) surface a lighter gray-brown (buffy-drab), the younger parts paler. Texture when dry rigid and hard above, very firmly spongy below; when wet pliable and elastic and quite bibulous; odor none when dry, but when wet it has a strong rank smell, something like freshly cut black oak. When wet the hymenium is much darker and approaches the dorsal surface in color.

Spores (of No. 4672) irregularly angled, strongly papillate-warted, 5–7 × 6–7.5μ.

Distinguished from *T. terrestris* by the absence of free squamules and the non-fimbriate margin. Both are found on coniferous substrata. In our only specimen there has been proliferation on the dorsal surface which has obscured the color by adding a spongy whitish layer over much of the middle and lower region.

4672. Mixed woods by Battle's Branch, among pine needles and a few oak leaves, October 9, 1920.

Asheville. Beardslee.

7. **Thelephora griseozonata** Cooke

PLATES 27 AND 35

Plants up to 5.5 cm. wide, usually about 2.5–3 cm., stalked and upright, the thin, pliable, tough cap spreading upward like an irregular dish with deep lobes or only shallow cuts, very fibrous and radiately ridged, the margin fimbriated in all cases; color deep brownish-purple all over, the upper side with rather conspicuous zones of different tints. Hymenium rugose with low veins, disappearing gradually into the stalk Stalk 3–7 mm. thick and 1–1.8 cm. long, tough, color of cap.

Spores purplish brown, irregularly lobed and warted, oblong, about 5.5 × 7.5μ.

The plants are gregarious but usually single or lightly clustered. They occur in colonies under pines.

975. In pines, hillside pasture, west side of Glen Burnie Farm, November 11, 1913. Photo and drawings. It also occurs in a similar situation on the east side of Glen Burnie Farm.

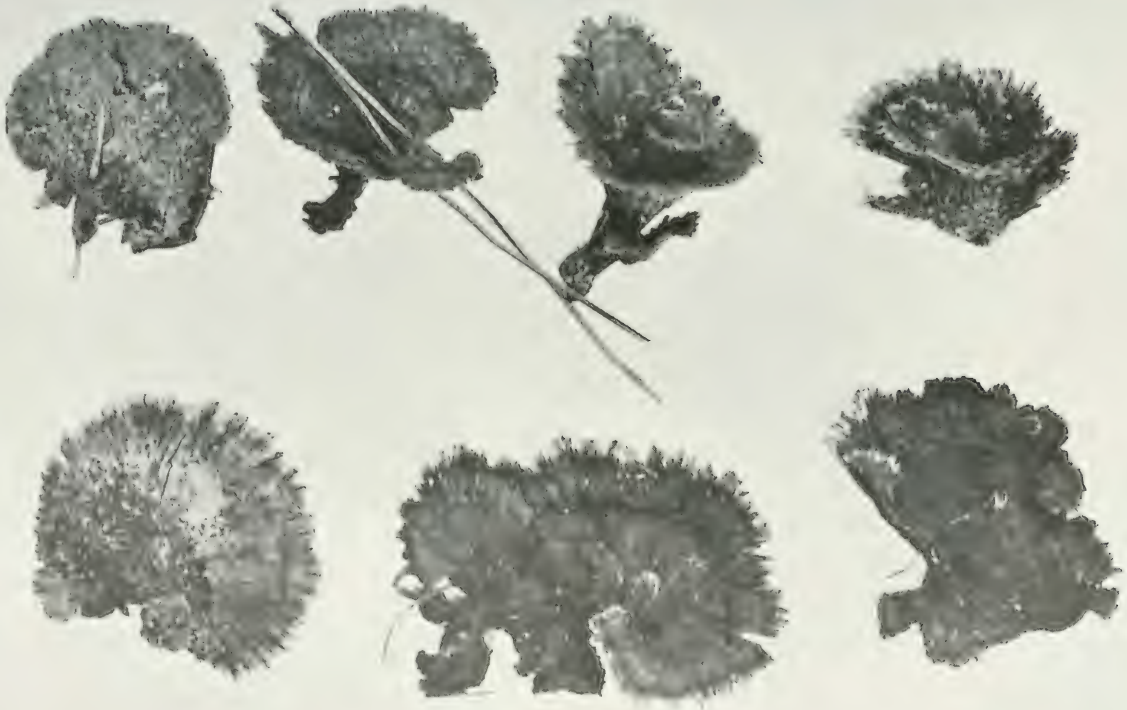
2426. Under young pine on Three Pine Hill, Glen Burnie Farm, July 26, 1916. Photo.

8. **Thelephora cuticularis** Berk.

PLATE 35

Plants shelving, laterally sessile by a more or less resupinate base, often confluent laterally, projecting about 2–4 cm. Dorsal surface radially wrinkled, inherently fibrous and felted, the margin felted pubescent when quite fresh; in the wet, growing state nearly jet black, the wrinkled margin pure white; hymenium drab with a tint of purple when dry, nearly black when wet. Flesh rather thin,

PLATE 27



THELEPHORA GRISEOZONATA. No. 2426.

about 1–1.5 mm. thick, pliable, easily water-soaked, color of the surface both when wet and when dry. In our plants there was no noticeable odor in the fresh state, but the dried plants have a faint, not unpleasant drug-like odor. The species is said by Berkeley to have a foetid odor, and Burt noticed such an odor in the dried state.

Spores (of No. 3432) smoky brown, subspherical, flattened on one side, covered with sharp spines, 7.4–9 × 7.4–11μ.

The black color of the plants (both dorsal surface and hymenium) in the damp growing state is not mentioned in the descriptions. It is the most conspicuous field character. If dropped in water after drying the dorsal surface and context absorb water and change color instantly as in *T. terrestris* and *T. albido-brunnea*, but unlike those the hymenium absorbs water much more slowly and becomes black only after several minutes. This, with the blacker color (when wet), furnishes an easy mark of distinction.

3432. On bark of oak tree, Battle's Park, and some from below Meeting of the Waters, August 15, 1919.

9. **Thelephora albido-brunnea** Schw.

PLATES 28 AND 35

Caps tough and elastic, horizontal and irregularly bracketed or sometimes centrally stipitate from an amorphous, resupinate, often spore-bearing base, extensively fused together, the individual caps not often more than 3.5 cm. wide, or extending more than 1.8 cm.; often encircling and climbing up sticks or shrubs or small saplings for several inches and in such case thicker and more amorphous; surface fibrous-spongy, tomentose when young, distinctly or obscurely zonate, dull cinnamon or buffy cinnamon, or when young pale brown to whitish, becoming paler when washed out in age by the weather; margin blunt, white in growing stage, later concolorous. Flesh about 1–2.5 mm. thick in the distinct caps, thicker in the amorphous masses; felty and soft, the fibers extensively furnished with clamp connections at the joints, color of surface or a darker rust color. Hymenium when fresh brownish drab to wood brown, fleshy-looking, when old and dry very light fleshy brown, smooth, no setae, easily wearing off and exposing the rust-colored flesh below.

Spores (print of No. 4409) smoky brown, irregularly angled, echinulate, 7–10 × 7.4–11μ.

When dropped in water after drying the entire plant, including the hymenium, becomes water-soaked immediately.

1328. On soil and sticks, just above path by Battle's Branch, east of Dr. Battle's, October 9, 1914. Spores rusty, tuberculate-spiny, subspherical, about 7.6μ in diameter.

4409. Around bases of young living trees and shrubs, July 14, 1920. Photo.

4467. Base of tree near Meeting of the Waters, July 27, 1920. Spores dark smoky purple, spiny, 6–7.5 $\times$ 7.5–10μ.

4470. Around a rotten twig on damp soil, July 30, 1920.

10. **Thelephora lutosa** Schw.

This is known only from the type collection which is from Salem, N. C. Burt describes the plant as follows (Ann. Mo. Bot. Gard. *1*: 216):

"Pilei cespitose, densely imbricated, at first somewhat fleshy but at length hard, undulate-plicate, yellowish, almost subtomentose with pulverulence, somewhat horizontally attenuated behind, margin sublobate, at length inflexed; pileus less than 2 mm. thick, with hyphae 3μ in diameter; hymenium becoming yellowish, even; spores olive-buff under the microscope, angular, 5–6 $\times$ 3½–4μ.

"Cluster about 1½ cm. high and broad.

"On the ground in roads and in woods. North Carolina.

"The type is distinct from *T. albido-brunnea*, having thinner pileus, finer hyphae, and smaller and paler spores. The pilei were crowded together into a small buff-colored cluster about 1½ cm. high and broad, somewhat as in *Tremellodendron pallidum* (Schw.); I failed to find stems at their bases."

11. **Thelephora fimbriata** Schw.

The only record from this state seems the original one by Schweinitz (as *Merisma*). We have examined two collections of this from Andros, Bahamas (determined by Burt), and find that there are dense clusters of branches, simple to sparingly branched which reach a length of 1.3 cm. They are a buffy ochraceous when dry and are densely felted with intricately branched hairs. As we have not found the plant in the fresh state we take the following from Burt (Ann. Mo. Bot. Gard. 1: 222. 1914):

"Fructification coriaceous-soft, incrusting and ascending small plants (mosses, etc.) here and there emitting fascicles of branches united below, subterete, acuminate or fimbriately incised, at first

pale or whitish, soon ferruginous brown, drying Rood's brown; hymenium even, pruinose-pubescent; spores umbrinous, tuberculate, 7–11 × 6–9μ.

"Incrusting and ascending upward 1–3 cm.; free branches 5–10 mm. long, 1 mm. thick, sweep of fascicle about 5–10 mm.

"In moist places. New York to South Carolina, and west to Illinois. July and August.

"The type is an incrusting specimen, covering as its main axis a small twig in one specimen and a moss in the other, and sending out a few lateral branches which are flattened towards the free ends and subfimbriate; main trunk is cylindric, latericius (of 'Chromotaxia'), ends of branches paler; spores umbrinous under the microscope, tuberculate, 7–8 × 6μ. Schweinitz described the species as becoming hard and cartilaginous, but this is an error probably due to the foreign matter surrounded by the main trunk. Several other specimens are present in his herbarium under various names."

Salem. Schweinitz.

SPARASSIS

Tough and elastic but fleshy, repeatedly branched into a semiglobose mass of flat, contorted, anastomosing branches, the hymenium covering only the outer (morphologically under) surfaces, except at times on the innermost vertical branches (see Cotton, Trans. Brit. Myc. Soc. 5: 333. 1911). This fact requires the removal of Sparassis from the Clavariaceae, where it has usually been referred.

We have found only one species in Chapel Hill, which we refer to *S. Herbstii* Pk., without conviction that it is different from *S. spathulata* Schw. *Sparassis crispa* is found in our mountains.

All species are edible, and are credited with being delicious. For parasitism of Sparassis see Hedwigia 54: 328. 1914; and Journ. Royal Myc. Soc. for 1914, page 386.

KEY TO THE SPECIES

Branches thick, blunt, not crisped ..... { *S. Herbstii* (1) / *S. spathulata* (2) }

Branches thin, much crisped ..... *S. crispa* (3)

1. **Sparassis Herbstii** Pk.

PLATES 29 AND 35

A large and very pretty plant of a complicated growth, that occurs on wood that is usually under or at the surface of the ground. It is composed of many upright and spreading, flat, rather thick, anastomosing branches with blunt ends that spring from a single large fleshy base. The entire plant is approximately globose or flattened-globose and is of variable size, in No. 1363 being about 14 cm. high and 15 cm. broad. The apices of the branches are whitish and tomentose, the lower parts cream colored, water-soaked, and smooth. The texture of the whole is very tough and elastic. The plate-like branches bear spores only on the outer surface, and in fresh specimens the texture of the two surfaces can be seen to be different.

Spores (of No. 1363) white, nearly spherical to short-elliptic, smooth, one large oil drop, 3.4–4.2 × 4.6–6.8μ.

This is possibly not different from the next.

524. In pine woods northwest of Mr. Weaver's house across railroad, October 6, 1912. Photo.
787. Woods south of athletic field, September 17, 1913.
1363. Growing from between the bark at foot of a pine stump in the new road to Piney Prospect, October 16, 1914.

2. **Sparassis spathulata** (Schw.) Fr.

Stereum carolinense Cooke and Rav.

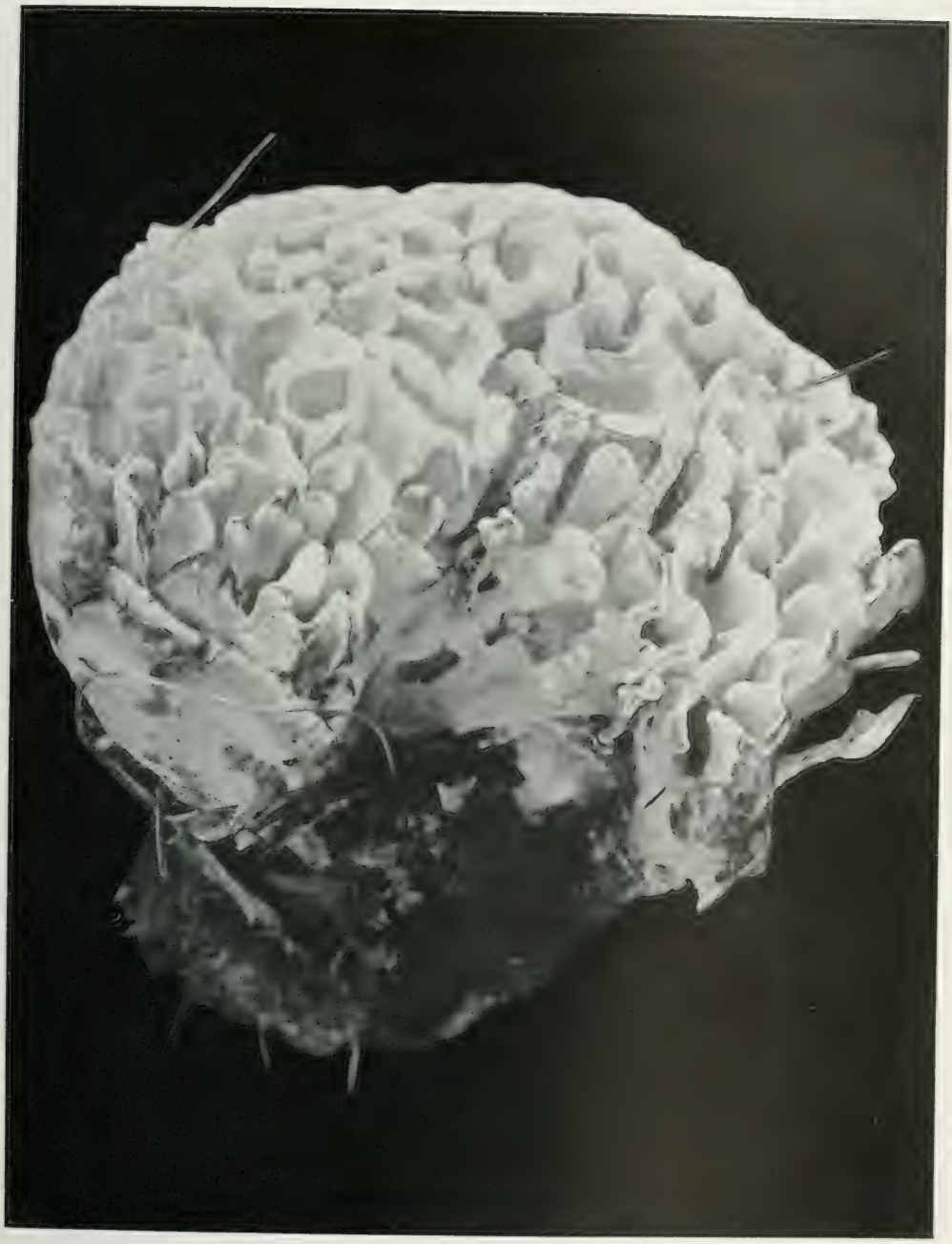
This is possibly not different from *S. Herbstii* Pk. but I give below the original description (translation):

"Erect, coriaceous, pallid brown, concrescent from upright blades, with spathulate branches wavy at the apex and rounded zones. Rare in grassy places, also sent from Georgia; reaching six inches in height, growing in large groups, with concentric horizontal zones. Of doubtful genus and said to be uncertain as to whether it is more nearly related to *Clavaria crispa* or Spathularia."

To this scanty diagnosis I add the original description of *Stereum carolinense* Cooke and Ravenel (Journ. Myc. 1: 130. 1885), which Cotton has shown to be almost certainly *Sparassis spathulata*. (Trans. Brit. Myc. Soc. 5: 336. 1911.)

"Pileus multiplex, infundibuliform, deeply incised, forming lobes variable in size, all confluent at the base in a common stem. Whole plant six inches high, 4–5 inches broad, ochraceous, with faint zones

PLATE 29



SPARASSIS HERBSTII. No. 524. Slightly reduced.

of darker color, margin of lobes entire, surface smooth. Hymenium even, ochraceous-white; stem minutely velvety."

Wilmington, N. C. (As *Stereum caroliniense* Cke. and Rav.) Dr. Thomas F. Wood.

Low and middle districts on earth. Curtis.

3. Sparassis crispa (Wulf.) Fr.

This fine species is rare in North Carolina. It has not been found in Chapel Hill, but I have seen it at Kanuga, and Beardslee has it from Asheville. It is much more crisped and irregular than *S. Herbstii*, with thinner and more intricate branches that do not form the rather obvious labyrinths that are characteristic of the latter species. Its diameter is usually about 10–20 cm., but it has been reported larger. The color is a soaked, translucent, yellowish-white, becoming brownish in age. Like *S. Herbstii*, it also grows from the wood of conifers that is on or under the ground. Edible and very good.

Asheville. Beardslee.

Kanuga. Coker.

Upper district, on earth. Curtis.

CHAPEL HILL, N. C.

EXPLANATION OF PLATES

PLATE 30

Cyphella muscigena. No. 3931. Fig. 1.
Cyphella fasciculata. No. 4001. Fig. 2.
Cyphella cupulaeformis. No. 4019. Fig. 3.
Solenia poriaeformis. No. 4686. Figs. 4–6.
Aleurodiscus Oakesii. No. 3937. Figs. 7–11.
Aleurodiscus candidus. No. 3827. Figs. 12–14.
Aleurodiscus candidus var. *sphaerosporus.* No. 3902. Figs. 15–17.
Figs. 1, 2, 5, 11, 13, 15, × 1440; fig. 6 × 108; others ×720.

PLATE 31

Aleurodiscus nivosus. No. 3897. Fig. 1; No. 3920. Figs. 2 and 3.
Aleurodiscus botryosus. No. 4710. Figs. 4–6 (fig. 5, paraphysis and proteid body).
Aleurodiscus macrodens. No. 4734. Figs. 7–9.
Coniophora arida. No. 4219. Figs. 10 and 11.
Peniophora gigantea. No. 4306. Fig. 12.
Peniophora violaceo-lividum. No. 3914. Fig. 13.
Peniophora albomarginata. No. 3849. Figs. 14 and 15.
Figs. 1, 4, 11, 14, ×1440; others ×720.

PLATE 32

Peniophora cinerea. No. 4299. Fig. 1; No. 4045. Fig. 2.
Peniophora longispora. No. 4250. Fig. 3.
Peniophora mutata. No. 3993. Fig. 4.
Peniophora filamentosa. No. 4264. Fig. 5; No. 4607. Fig. 6 (in fig. 5 crystals dissolved off by KOH).
Hypochnus fuscus. No. 4267. Figs. 7–9.
Hymenochaete corrugata. No. 4076. Fig. 10.
Hymenochaete Curtisii. No. 3830. Fig. 11; No. 3875. Fig. 12.
Figs. 1, 8, 11, ×1440; others ×720.

PLATE 33

Corticium caeruleum. No. 4018. Fig. 1.
Corticium lilacino-fuscum. No. 4071. Fig. 2. (This fails to show paraphyses well.)
Corticium roseum. No. 4703. Figs. 3 and 4 (basidium and contorted thread of hymenium); No. 3981. Fig. 5.
Corticium Viticola. No. 4693. Fig. 6.
Corticium arachnoideum. No. 4235a. Figs. 7 and 8.
Corticium vagum. No. 4259. Fig. 9; No. 4230. Fig. 10.
Figs. 5, 6, 8, 9, ×1440; others ×720.

PLATE 34

Corticium scutellare. No. 4223. Fig. 1; No. 4696. Fig. 2.
Asterostroma cervicolor. No. 4507. Figs. ~~7–10~~ 3–6 (Fig. ~~10,~~ 6 fragmentary hyphae of lower region).
Figs. 2, ~~3, 8~~ 4 × 1440; 1, ~~5~~ × 720; ~~4 × 107~~; others × 4~~1~~7. 4

PLATE 35

Stereum gausapatum. No. 3821. Fig. 1.
Stereum sanguinolentum. No. 3967. Fig. 2.
Stereum subpileatum. No. 3955. Fig. 3.
Stereum lobatum. No. 3816. Fig. 4.
Stereum rameale. No. 3863. Fig. 5. Form on cedar. No. 4318. Fig. 6.
Stereum sericeum. No. 3962. Fig. 7.
Stereum ochraceoflavum. No. 4033. Fig. 8.
Stereum frustulosum. No. 3814. Figs. 9 and 10.
Thelephora multipartita. No. 3468. Fig. 11.
Thelephora intybacea. No. 4672. Fig. 12.
Thelephora griseo-zonata. No. 975. Figs. 13–15.
Thelephora cuticularis. No. 3432. Fig. 16.
Thelephora albido-brunnea. No. 4467. Fig. 17.
Sparassis Herbstii. No. 1363. Fig. 18.
Figs. 1–8, 10–12, 16–18, ×1440; others ×720.

PLATE 28

THELEPHORA ALBIDO-BRUNNEA.
No. 4470 [top left]; No. 4467 [top right]; No. 4409 [below].

PLATE 30

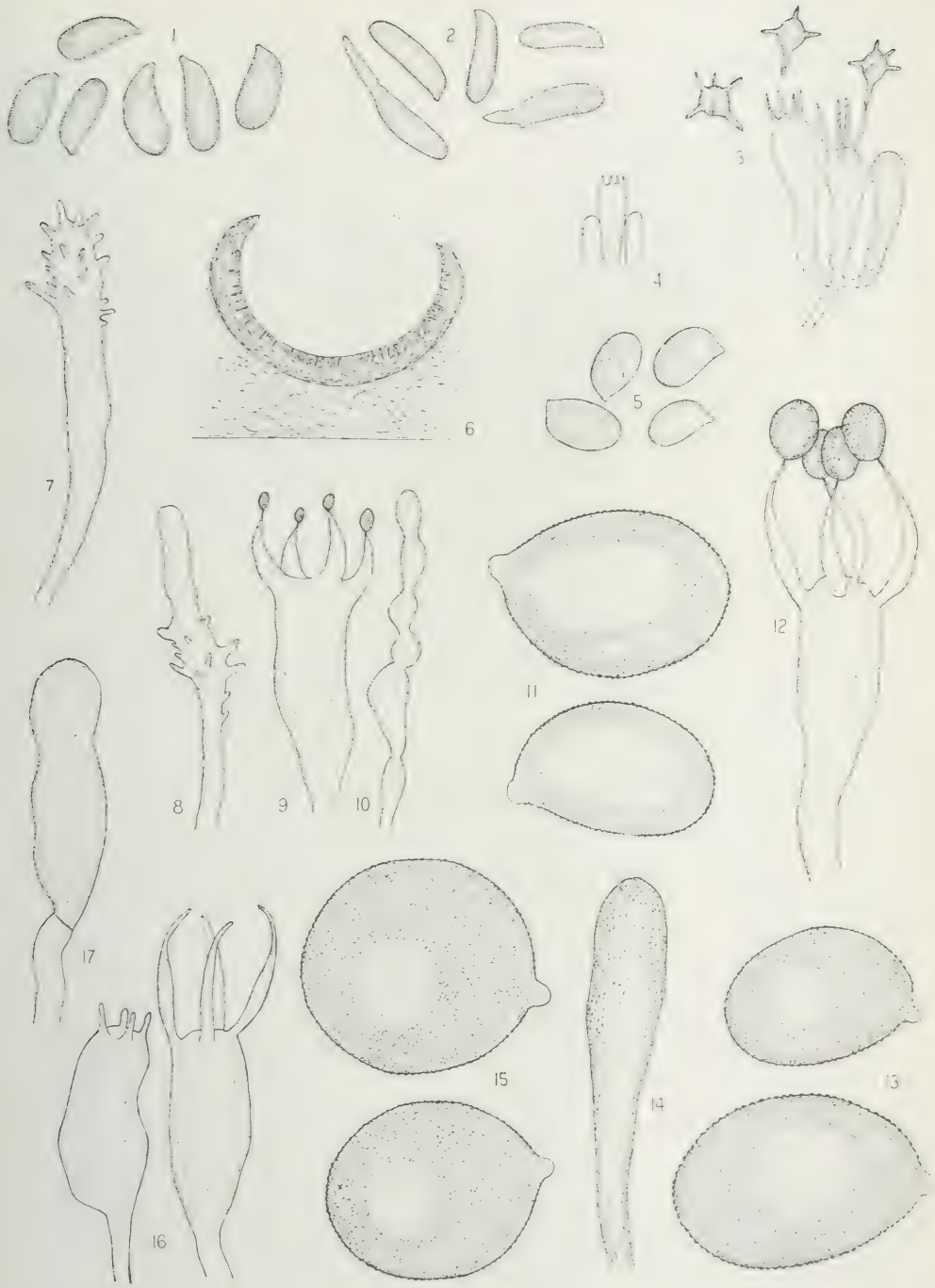


PLATE 31

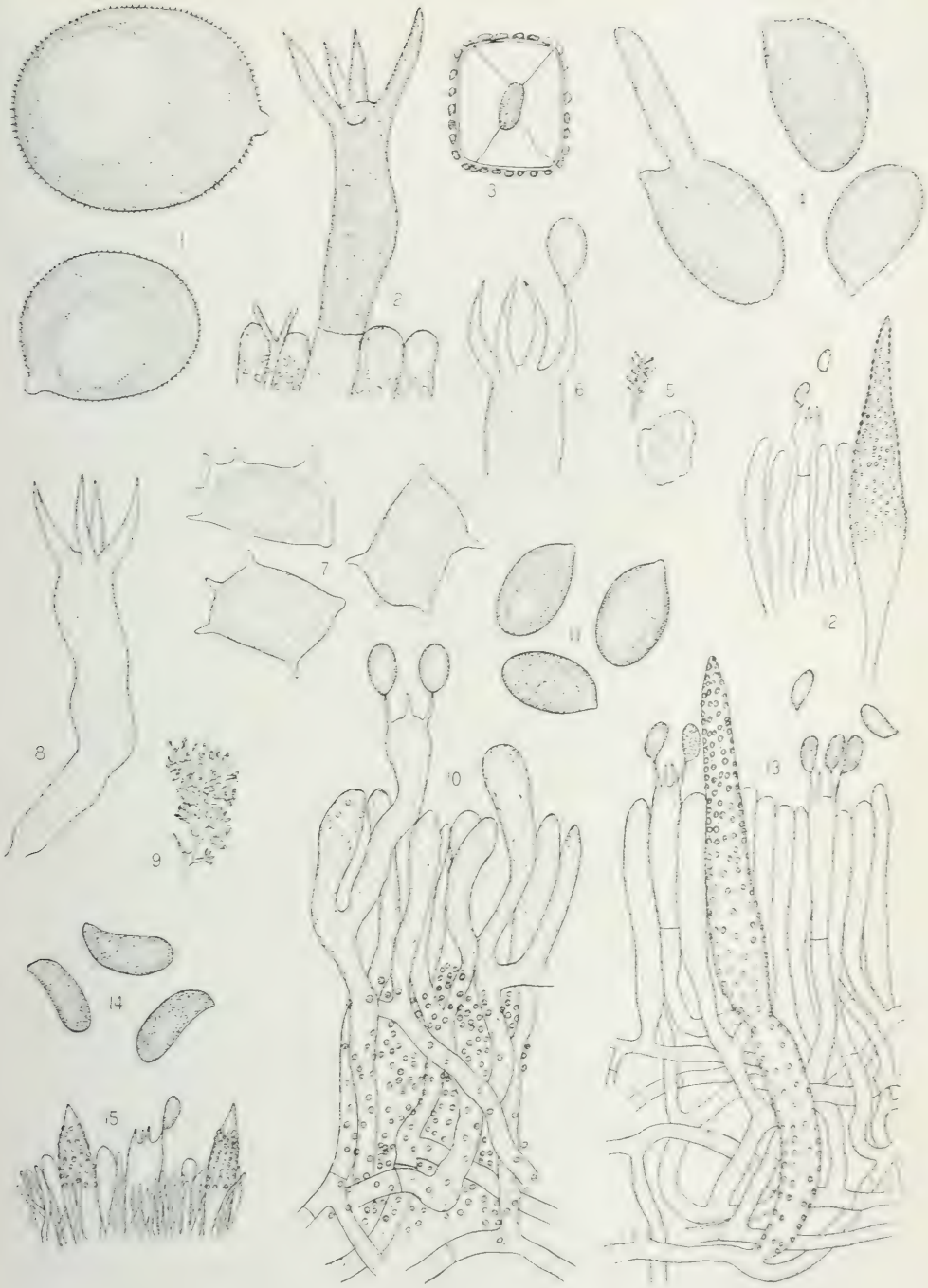


PLATE 32

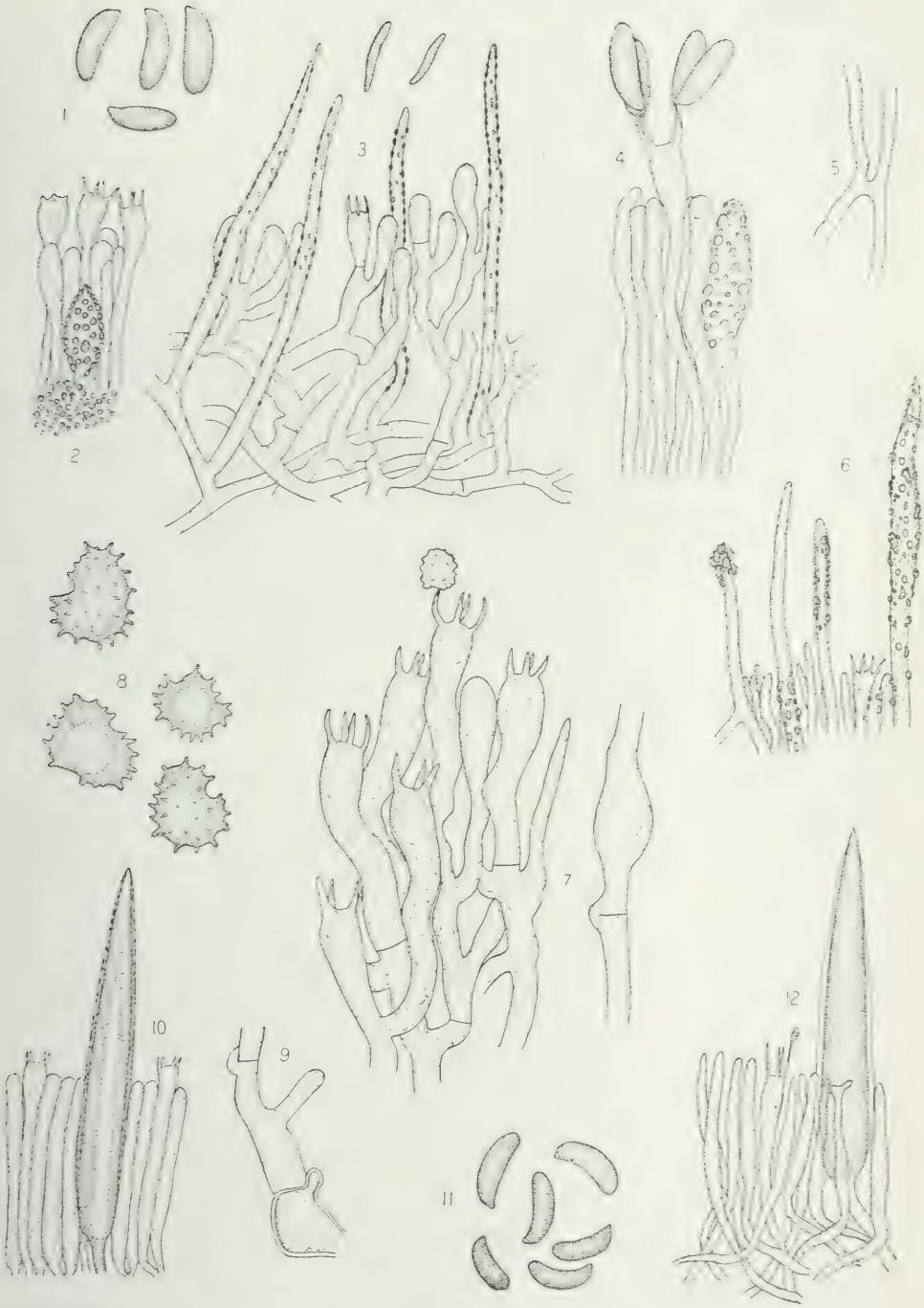


PLATE 33

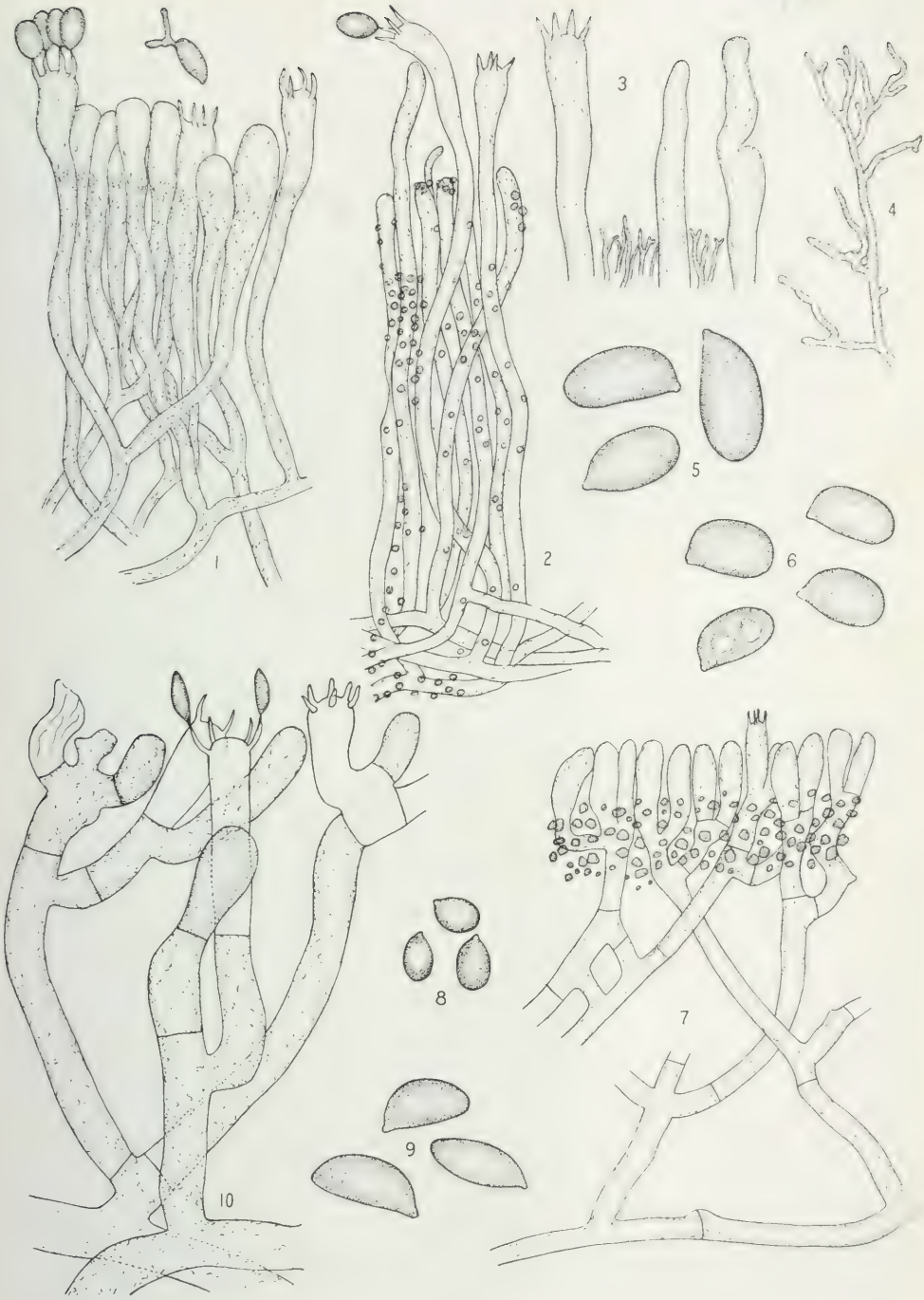
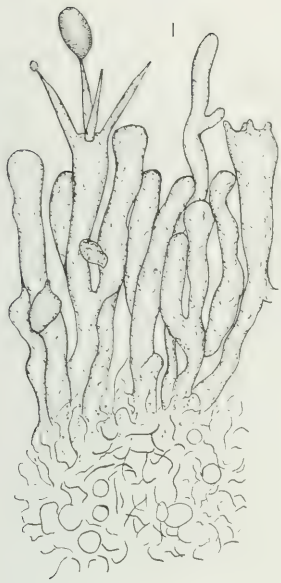
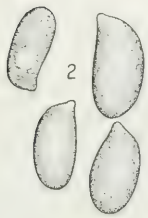
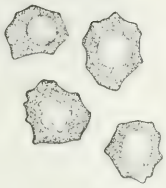


PLATE 34







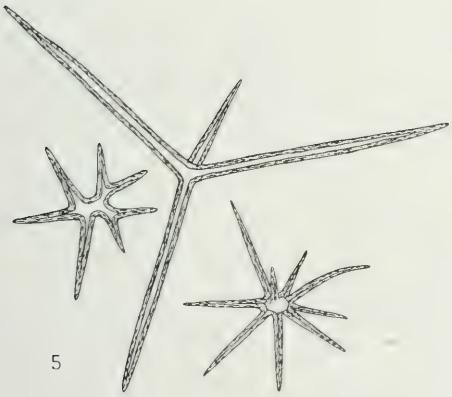
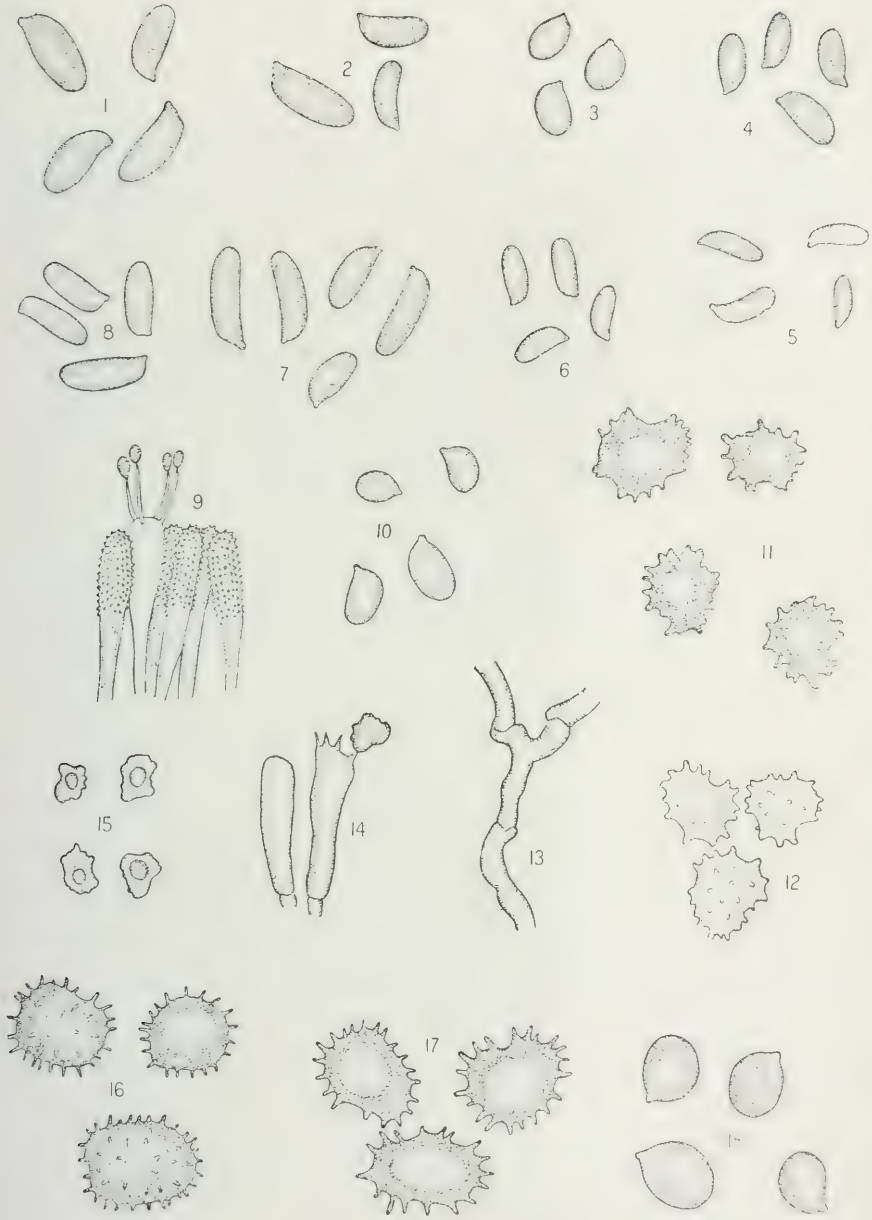


PLATE 35



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OF THE

Elisha Mitchell Scientific Society

VOLUME XXXVII
1921-1922

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JOURNAL

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Volume XXXVII DECEMBER Nos. 1 and 2

PROCEEDINGS OF THE ELISHA MITCHELL SCIENTIFIC SOCIETY, FEBRUARY, 1921, TO MAY, 1921

246th Meeting—February 8, 1921

Dr. Edward J. Wood (Class of 1899), of Wilmington, N. C.—*Our Debt in Medicine to the British.*

The speaker mentioned briefly a few of the outstanding contributions to the making of modern medicine by the British. The pioneer worker was William Harvey who described the circulation of the blood and must be accredited with the discovery. Special reference was made to that little group of nineteenth century physicians in London who, at Guy's Hospital, made such a remarkable contribution within a few years. There was Addison who first described Addison's disease, Bright who first described Bright's disease, Hodgkin who first described Hodgkin's disease and finally Sir Ashley Cooper, a great surgeon and a pioneer in medical education.

The real burden of the address was the contribution in parasitology. The remarkable achievements of Sir Patrick Manson were mentioned briefly, the genius of Louis W. Sambon applying his great knowledge of medical zoology, the discovery of the mosquito in its role in malaria transmission by Sir Ronald Ross, the work of Sir David Bruse and others in determining the relation of the trypanosome to sleeping sickness of Africa and the relation of the tse-tse fly to its transmission. The work of Sir William Leishman in the discovery (with division of honor to Donovan) of the protozoal cause of dum-dum fever of India.

The need of a medical zoological survey in North Carolina was mentioned. It was hinted that schistosomiasis had been recently found in the state and at least one case of kala-azar. The educational need along these lines was also emphasized.

247th MEETING—MARCH 8, 1921

W. C. GEORGE.—*Comparative Anatomy of the Brain.*

The principal morphological subdivisions and connections of the human brain were described and their probable phylogeny outlined. The relation of the environmental conditions and habits of life of animals to the degree of development of special parts of the brain was indicated. Dissections of brains of an elasmobranch fish, a frog, reptile, bird, rat, mole, cat and man were exhibited to show homologous parts of the brain and the degree of development under different conditions of life.

OTTO STUHLMAN, Jr.—*Some Unsolved Problems of Modern Physics.*

No science has gone through a more stormy period of development than physics during the last decade. Our most cherished theories have undergone most violent upheavals, the result of which no one at this time can predict with certainty. These discoveries have forced us to adopt new and contradictory explanations, which in general may be divided into three groups: (*a*) X-rays and the emissions from radio-active substances; (*b*) The theory of radiation; (*c*) The so-called theory of relativity.

Of these the "Theory of Radiation" was discussed and some of the outstanding problems that require solution were explained in detail.

Amongst those mentioned was Wien's Displacement Law and the contributions made by Planck. The classical theory of specific heat and entropy and its quantum modifications were discussed. The quantum theory as applied to the emission of electrons from bodies was mentioned and some of the outstanding problems were discussed in detail. The unsolved problems in the photo-electic field were next enumerated and their possible bearing on the structure of matter was sketched. Series spectra and the numerous problems confronting the physicist in this field were finally enumerated. The paper closed with a review of the Lewis-Langmuier theory of the structure and physical properties of nitrogen and carbon monoxide.

248th MEETING—APRIL 12, 1921

THORNDIKE SAVILLE—*The Water Power Situation in North Carolina.*

This paper presents the results of a statistical study of the devel-

oped hydro-electric power in North Carolina. It is shown that there is at present a total installed capacity of about 356,000 H. P. in plants producing hydro-electric power. Of this, 80,000 H. P. or 22 per cent is transmitted for use outside the state; 113,000 H. P. or 32 per cent is used at Badin in the local reduction of aluminum; while only 164,-000 H. P. or 46 per cent is available for general industrial and public use. Of the latter 98,500 H. P. or 28 per cent of the total (60 per cent of the 164,000 generally available) is developed by two large public service corporations.

The total output of electrical energy by public service plants has increased 25 per cent from 1919 to 1920, and over 6000 per cent from 1907 to 1920. If the output increases at 12 per cent per year (one half the present annual rate) there will be a demand in 1925 for 1,434,000 kw. hr. and in 1930 for 2,528,000 kw. hr. To meet this demand, if the present proportion of output by water power is to be maintained (85 per cent) there will be needed additional development of 200,000 H. P. by water power in 1925 and of 624,000 H. P. by 1930. To develop this amount of water power will mean many new hydro-electric installations in the state, and the utilization of most of the economically available water power sites. It is estimated that about 1,500,000 H. P. is still undeveloped at sites in this state, but only a portion of this amount can be economically developed under present conditions.

FRED F. BAHNSON (Class of 1896), of Winston Salem, N. C.—*The Science of Humidification, with Demonstration of a New Humidifier.*

Entirely too little attention has been paid to humidification in all manufacturing processes except those where the advantages are very plainly apparent, such as textiles. All materials of animal or vegetable origin and a number of mineral origin are affected by the humidity of the air in which they are stored or used, and this effect is proportional to the relative humidity or percentage of saturation, rather than the actual humidity or pounds of water per thousand cubic feet of space.

Since the weight of a cubic foot of saturated aqueous vapor just about doubles for each twenty degrees rise in temperature, it is obvious that even if the out-door humidity is sufficiently high, the indoor humidity will always be too low whenever artificial heat is used. This simply means that artificial means of supplying moisture must be used practically every day in the year, because even in summer

weather out-door humidity is apt to be below what it should be for satisfactory manufacture.

With exception of textile fibres, the curves for moisture content of various materials with reference to atmospheric conditions have not been determined.

The various commercial methods of humidification were mentioned and briefly described, and the Bahnson Humidifier was demonstrated under actual operating conditions.

249th MEETING—MAY 10, 1921

ARCHIBALD HENDERSON—*The Lorentz Transformation in Einstein Relativity.*

Dr. Henderson attempted to give in the simplest possible mathematical terms the explanation of the Principle of Relativity (in the restricted sense), following the lines worked out by Einstein himself. After deriving the equations of the Lorentz transformations, Dr. Henderson gave their mathematical interpretation (1) The systems are entirely symmetrical; (2) A beam of light must have the same velocity, when viewed in the variables of either system; (3) The equations for low velocities reduce to the Newtonian equations; (4) A meter-stick perpendicular to the direction of motion remains constant. Analyzing these equations further, Dr. Henderson showed the interdependence of time and space which they present, so that the phrase "points" in "space" is replaced by the expression "events" in "the world." The invariance function was interpreted as indicating a "rotation" in four-dimension Euclidian space with imaginary time-axis; or else, a "rotation" in four-dimension non-Euclidian space with real time-axis. It was pointed out that the Einstein theory of Relativity raises the deepest questions regarding space, time, gravitation, and the essential characteristics of the physical universe.

W. C. COKER—*Effect of Length of Day on Growth and Reproduction of Plants.*

A review was given, illustrated by lantern slides, of the highly significant work of Garner and Allard on this subject. Mr. Allard was assistant in botany in this University sixteen years ago and went from here to the Department of Agriculture in Washington, where he is still working. In an extended series of experiments with growing plants the authors have shown that the length of day, that is the time

of exposure to light, is by far the most important factor in initiating or retarding the production of flowers and fruit. For example, a certain variety of soy-beans when exposed to light for only seven hours a day blossomed on June 15th, while those exposed to full daylight did not bloom until September 4th. The majority of the plants experimented with showed similar hastening of flowering when exposed to short day, but several plants responded in the opposite manner and were much retarded in blooming by a short day. The authors believe that their work will have a considerable practical effect on agriculture, as it shows that the time of seeding for best results will depend on the lengths of day to which the crops will be exposed. They also believe that the natural distribution of plants on the earth is governed more or less directly by the seasonal length of day which obtains for the different latitudes from the equator to the poles.

Election of Officers:

President—W. DeB. MacNider.
Vice-President—W. F. Prouty.
Permanent Secretary—J. M. Bell.
Recording Secretary and Treasurer—H. R. Totten.
Editorial Committee—W. C. Coker, chairman; J. M. Bell, Collier Cobb.

PROCEEDINGS OF THE TWENTIETH ANNUAL MEETING OF THE NORTH CAROLINA ACADEMY OF SCIENCE

Held at Wake Forest College, Wake Forest, N. C.
April 29-30, 1921

The Executive Committee met at 2.00 P. M. on April 29th in the Lecture Room of the Alumni Building with the following present: Z. P. Metcalf, President, and C. S. Brimley, Acting Secretary, other members, R. N. Wilson, F. A. Wolf, and A. H. Patterson, the latter acting for H. R. Totten, who was absent.

President Metcalf stated that the Legislative Committee authorized at the last meeting of the Academy to solicit funds from the legislature had not been appointed, owing to the financial stringency existing in the state at the time of the session of that body. He also stated that affiliation with the American Association had been completed except for the official notice from the permanent secretary of that organization.

The Executive Committee then passed resolutions recommending the following measures to the Academy for favorable action:

1. Increasing the annual dues to $2.00 per member.

2. That the terms of the officers of the Academy should begin with the adjournment of the meeting at which they are elected, and should expire with the adjournment of the next regular annual meeting.

3. That the 10 per cent allowed the Secretary-Treasurer should be only on the Academy dues collected by him, and not on the American Association dues collected by him for that body in future.

4. Appointment of a Publicity Committee.

5. Appointment of a Committee on Preservation of our Natural Resources.

The Executive Committee then received and accepted the offer of the University of North Carolina to hold the 1922 meeting at Chapel Hill.

President Metcalf then announced that he had appointed Messrs. W. H. Pegram, R. N. Wilson, and A. H. Patterson to draw up suitable resolutions on the death of past-President of the Academy J. J. Wolfe, and that the same had been prepared and published in the Mitchell Journal, and that he had also appointed Messrs. W. L. Poteat and C. E. Brewer to do the same with regard to the death of past-President J. S. Lanneau.

Thirty-six new members were elected as follows:* W. J. Andrews, Miss Lucretia Baker, Miss E. E. Barrow, H. L. Blomquist, J. T. Barnes, Wayne Burch, Miss E. G. Campbell, L. A. Denson, R. T. Farrington, W. C. George, J. P. Givler, H. N. Gould, E. P. Jones, J. W. Lasley, Jr., W. Bruce Mabee, T. B. Mitchell, W. deB. MacNider, N. M. Paull, Charles Phillips, T. E. Powell, Jr., R. H. Ruffner, E. E. Randolph, A. F. Roller, Miss Mildred Sherrill, S. C. Smith, William E. Speas, Otto Stuhlman, Jr., R. W. Sullivan, C. C. Taylor, O. J. Thies, Jr., H. M. Vann, R. B. Wilson, Mrs. B. W. Wells, Miss Lula G. Winston, Miss E. K. Wright, D. B. Wilson.

The Executive Committee then adjourned.

The Academy met at 2:30 P. M., when papers were read and discussed. The following committees were then announced by President Metcalf: Nominating—W. L. Poteat, A. S. Wheeler, and C. W. Edwards. Resolutions—Messrs. Bert Cunningham, J. B. Derieux and A. H. Patterson. Auditing—Messrs. R. N. Wilson, J. W. Nowell and W. C. Coker.

The Academy then rose to accept the invitation of the Ladies' Community Club to take tea with them at the Golf Cabin.

At 8.00 P. M. the Academy re-assembled in Wingate Memorial Hall to hear the Presidential Address of President Z. P. Metcalf on the "Age of Insects," which subject he handled in a highly instructive and scientific manner. A very interesting paper on Judgments of Length, Mass, and Time by Dr. A. H. Patterson, of the University of North Carolina, followed, after which the Academy adjourned for the night.

On Saturday morning, April 30th, the Academy held its business meeting at 9.00 A. M., President Metcalf in the chair.

The Secretary then read the report and recommendations of the Executive Committee, all of which were adopted by the Academy.

The Nominating Committee then reported the following names for officers of the Academy for the year beginning May 1, 1921.

President—James L. Lake, Professor of Physics, Wake Forest College.

Vice-President—Joseph Hyde Pratt, State Geologist.

Secretary-Treasurer—Bert Cunningham, Professor of Biology, Trinity College.

Additional Members of the Executive Committee—Messrs. H. R.

* For addresses see full list of Academy membership.

Totten, University of North Carolina; R. N. Wilson, Trinity College; F. A. Wolf, State College.

The Secretary then on motion cast the vote of the Academy for these gentlemen and they were declared elected.

The Resolutions Committee reported the following resolutions which were adopted by a rising vote of the Academy:

1. That the North Carolina Academy of Science extend to the Faculty and President of Wake Forest College most hearty thanks for and appreciation of their courtesy in tendering the use of the buildings and equipment of the college for the meeting of the Academy, and in opening their homes to its members. This is the fourth meeting to be held here and our memory of Wake Forest, both of the town and of the college, has been one of consistent and generous hospitality.

2. That the North Carolina Academy of Science extend its thanks to the Ladies' Community Club of Wake Forest for the pleasant social courtesies extended to the members of the Academy at the Golf Club on yesterday afternoon and its hearty appreciation of the spirit of kindly hospitality which prompted the giving of the tea at the Club House.

The Auditing Committee then reported that they had examined the accounts of Secretary R. W. Leiby and Acting Secretary C. S. Brimley and found them correct and in good condition.

Reports follow:

REPORT of R. W. LEIBY, SECRETARY

Balance on hand April 29th, 1920 (audited)		$196.32
Receipts April 29 to Sept. 1, 1920		43.00
Interest April 29, 1920, to April 1, 1921		5.77
Total		$245.09
DISBURSEMENTS		
Expenses Secretary at 1920 meeting	.28	
Telegram to E. W. Gudger	.95	
Stenographic Services (Miss Hinsdale)	5.00	
Collection on check	.10	
Elisha Mitchell Journal	75.00	
		81.33
Balance on hand April 15, 1921		$163.76

REPORT of C. S. BRIMLEY, ACTING SECRETARY, MARCH 25 to APRIL 29, 1921

Receipts, dues and entrance fees		$105.00
Disbursements—		
Printing programs	$17.00	
Letterheads	6.00	
500 stamped envelopes	12.31	
Multigraphing 4 letters	3.00	
10 per cent. on $105.00	10.50	
		48.81
Balance on hand April 29		$56.19
Estimated Financial Condition of Academy—		
Leiby's balance	$163.76	
Brimley's balance	56.19	
Unpaid dues and fees (est.)	50.00	
For programs from Chemists	5.00	
Total Credit		$274.95
Expenses—		
Secretary's expenses at meeting	5.00	
10 per cent. on $50.00	5.00	
Elisha Mitchell Journal	75.00	
		85.00
Estimated balance Jan. 1, 1922		$189.95

President Metcalf then announced the appointment of the following committees:

Publicity—Bert Cunningham, Chairman; A. H. Patterson, W. A. Withers.

Preservation of Natural Resources.—Z. P. Metcalf, Chairman; J. S. Holmes, W. C. Coker, J. P. Givler, H. L. Blomquist, B. W. Wells.

On motion the Academy resolved to request the Mitchell Journal to publish the names of the officers and standing committees on the back of the Journal.

The Committee on Science Teaching in the High Schools was after some discussion continued and the business session ended.

The Academy then met in joint meeting with the North Carolina Section of the American Chemical Society and heard several papers, after which the chemists and physicists held a joint session separate from the remainder of the Academy.

After the reading of the last paper the Secretary reported that he had received a letter from Dr. E. W. Gudger, stating how much he had

appreciated the Academy meetings in the past and how much he missed them now that it was impossible for him to attend. He furthermore stated that he would retain his membership, and extend his best wishes for a successful meeting. On motion the Secretary was instructed to write Dr. Gudger, thanking him for his continued interest and good will.

The Academy adjourned at 3 P. M. to meet at Chapel Hill in 1922.

Following is the present membership of the Academy. Those marked with an asterisk were present at the meeting.

Andrews, William J., Civil Engineer.....Raleigh, N. C.
Arbuckle, H. B., Professor of Chemistry, Davidson College.....Davidson, N. C.
Babb, Josiah S., Dept. of Geology, University of North Carolina.....Chapel Hill
Bahnson, F. F., 28 Salisbury Road.....Winston-Salem, N. C.
Baker, Miss Lucretia, Meredith College.....Raleigh, N. C.
*Balderston, Mark.....Guilford College, N. C.
*Barnes, J. T., Dept. of Biology, Trinity College.....Durham, N. C.
Barret, Dr. H. P., 211 Vail Ave.....Charlotte, N. C.
Barrow, Miss Elva E., North Carolina College for Women.....Greensboro, N. C.
*Bell, J. M., Smith Professor of Chemistry, University of North Car....Chapel Hill
Binford, Raymond, President Guilford College.....Guilford College, N. C.
Bonney, Miss E. C., 1421 Fourteenth Ave.....Hickory, N. C.
Bottum, Miss F. R., St. Mary's School.....Raleigh, N. C.
*Blomquist, H. L., Dept. of Biology, Trinity College.....Durham, N. C.
Brewer, C. E., President Meredith College.....Raleigh, N. C.
*Brimley, C. S., Division of Entomology, N. C., Dept. of Agriculture, Raleigh, N. C.
Brimley, H. H., Curator State Museum.....Raleigh, N. C.
Browne, Wm. Hande, Dept. of Electrical Engineering, State College, Raleigh, N. C.
Bruner, S. C., Estacion Agronomica.....Santiago de las Vegas, Cuba
*Bullitt, J. B., Professor of Pathology, Univ. of North Carolina.....Chapel Hill
*Burch, Wayne, Trinity College.....Durham, N. C.
Cain, William, Kenan Prof. Emeritus of Math., Univ. of N. C.....Chapel Hill
*Campbell, Miss Eva G., Dept. of Biology, North Car. Coll. for Women, Greensboro
Clapp, S. C., Superintendent State Test Farm.....Swannanoa, N. C.
Cobb, Collier, Professor of Geology, University of North Carolina....Chapel Hill
Cobb, William B., Louisiana State University.....Baton Rouge, La.
*Coker, W. C., Kenan Prof. of Botany, Univ. of North Carolina.....Chapel Hill
Collett, R. W. .....White Hall, S. C.
Couch, J. N., Biology Teacher, Charlotte High School,.....Charlotte, N. C.
*Cunningham, Bert, Professor of Biology, Trinity College .....Durham, N. C.
Davis, Harry T., Assistant Curator State Museum.....Raleigh, N. C.
Denson, Lee A., U. S. Weather Bureau.....Raleigh, N. C.
*Derieux, J. B., State College.....Raleigh, N. C.
*Dixon, A. A., State College.....Raleigh, N. C.
Downing, J. S.....Elsmere, Del.

*Edwards, C. W., Professor of Physics, Trinity College.....Durham, N. C.
Farmer, C. M., 115 Orange St.....Troy, Ala.
*Farrington, R. K., Trinity College.....Durham, N. C.
George, W. C., Assoc. Prof. of Histology and Embryology, Univ. of N. C., Chapel Hill
*Givler, J. P., Professor of Biology, North Carolina College for Women, Greensboro
*Gould, H. N., Dept. Biology, Wake Forest College.....Wake Forest, N. C.
*Gross, Paul, Dept. of Chemistry, Trinity College, 1001 Trinity Ave...Durham, N. C.
Groves, Miss Pattie J., 802 Watts St.....Durham, N. C.
Gudger, E. W., American Museum of Natural History.....New York City
*Haber, V. R., Division of Entomology, N. C. Dept. of Agriculture..Raleigh, N. C.
*Halverson, J. O., N. C. Dept. of Agriculture.....Raleigh, N. C.
Hatley, C. C.....Durham, N. C.
Heck, C. M., State College.....Raleigh, N. C.
Henderson, Archibald, Prof. of Mathematics, Univ. of North Car....Chapel Hill
Hickerson, T. F., Prof. of Civil Engineering, Univ. of North Car.....Chapel Hill
Hobbs, A. W., Associate Prof. of Mathematics, Univ. of North Car...Chapel Hill
Hoffman, Dr. S. W.....Statesville, N. C.
Holland, Miss Alma, Dept. of Botany, Univ. of North Carolina.....Chapel Hill
Holmes, J. S., State Forester.....Chapel Hill
Ives, J. D., Stetson University, Deland, Fla.....Pine Bluff, N. C.
Ivey, J. E., State College.....Raleigh, N. C.
*Jones, E. P., Trinity College.....Durham, N. C.
Kilgore, B. W., Director of Experiment Station.....Raleigh, N. C.
Krausz, H. B.....Raleigh, N. C.
*Lake, J. L., Prof. of Physics, Wake Forest College.....Wake Forest, N. C.
Lasley, J. W., Jr., Assoc. Prof. of Mathematics, Univ. of North Car....Chapel Hill
*Lehman, S. G., State College.....Raleigh, N. C.
Leiby, R. W., Division of Entomology, N. C. Dept. of Agriculture..Raleigh, N. C.
Lewis, Dr. R. H.....Raleigh, N. C.
Lugn, A. L., Dept. of Chemistry and Physics, Lenoir College.....Hickory, N. C.
Mabee, W. Bruce, Div. of Entomology, N. C. Dept. Agriculture...Raleigh, N. C.
MacNider, W. DeB., Kenan Prof. of Pharmacology, Univ. of N. Car., Chapel Hill
Marion, S. J., Dept. of Chemistry, State College.....Raleigh, N. C.
Markham, Blackwell, 92 Toxtech St.....Brookline, Mass.
Mendenhall, Miss Gertrude, 1023 Spring Garden St.....Greensboro, N. C.
*Metcalf, Z. P., Prof. of Zoology and Entomology, State College..Raleigh, N. C.
*Mitchell, T. B., Div. of Entomology, N. C. Dept. Agriculture....Raleigh, N. C.
*Nowell, J. W., Wake Forest College.....Wake Forest, N. C.
*Patterson, A. H., Professor of Physics, Univ. of North Carolina.....Chapel Hill
Paull, N. M., Assistant Professor of Drawing, Univ. of North Car...Chapel Hill
Pegram, W. H., 308 Buchanan Road.....Durham, N. C.
Petty, Miss Mary, North Carolina College for Women.....Greensboro, N. C.
*Phillips, Charles, Dept. of Pathology, Wake Forest College....Wake Forest, N. C.
Pillsbury, J. P., State College.....Raleigh, N. C.
Plummer, J. K., 499 Courtland St.....Atlanta, Ga.
*Poteat, W. L., President Wake Forest College.....Wake Forest, N. C.
Powell, T. E., Jr., Professor of Biology, Elon College.....Elon, N. C.
Pratt, J. H., State Geologist.....Chapel Hill

Prouty, W. F., Prof. of Stratigraphic Geology, Univ. of North Car...Chapel Hill
*Randolph, E. E., Dept. of Chemistry, State College.....Raleigh, N. C.
Randolph, E. O.....College Station, Tex.
Randolph, Mrs. E. O.....College Station, Tex.
Rankin, W. S., State Board of Health.....Raleigh, N. C.
*Rhodes, L. B., Div. of Chemistry, N. C. Dept. Agriculture.....Raleigh, N. C.
Robinson, Miss Mary, North Carolina College for Women.....Greensboro
*Roller, A. F., Science Teacher, Raleigh High School.....Raleigh, N. C.
Ruffner, R. H., State College.....Raleigh, N. C.
*Satterfield, G. H., Trinity College.....Durham, N. C.
Saville, Thorndike, Assoc. Prof. of Engineering, Univ. of North Car., Chapel Hill
Seymour, Miss Mary F., North Carolina College for Women.....Greensboro
Shaffer, Miss Blanche E., North Carolina College for Women.....Greensboro
Sherrill, Miss Mary L., North Carolina College for Women.....Greensboro
Sherrill, Miss Mildred, Science Teacher, Henderson High School, Henderson, N. C.
Sherwin, M. E., State College.....Raleigh, N. C.
Sherman, Franklin, Entomologist, N. C. Dept. Agriculture.....Raleigh, N. C.
Shore, C. A., State Laboratory of Hygiene.....Raleigh, N. C.
*Shunk, I. V., 222 West Morgan St.....Raleigh, N. C.
Smith, J. E., Iowa State College.....Ames, Iowa
Smith, M. R., Science Teacher, High School.....Fort Mill, S. C.
Smith, S. C., Dept. of Chemistry, University of North Carolina.....Chapel Hill
Smithey, Ira W., Dept. of Chemistry, Univ. of North Carolina.....Chapel Hill
*Speas, William E., Dept. of Physics, Wake Forest College.....Wake Forest, N. C.
*Spencer, H., State College.....Raleigh, N. C.
Stiles, Dr. C. W.....Wilmington, N. C.
*Stuhlman, Otto, Jr., Assoc. Prof. of Physics, Univ. of North Car. ....Chapel Hill
*Sullivan, R. W., Dept. of Chemistry, Wake Forest College.....Wake Forest, N. C.
Taylor, C. C., State College.....Raleigh, N. C.
Taylor, Haywood M., Dept. of Chemistry, Univ. of North Carolina...Chapel Hill
*Taylor, W. F., Wake Forest College.....Wake Forest, N. C.
*Thies, O. J., Jr., Dept. of Chemistry, Davidson College.....Davidson, N. C.
Totten, H. R., Dept. of Botany, University of North Carolina.....Chapel Hill
*Vann, H. M., Dept of Anatomy, Wake Forest College.....Wake Forest, N. C.
Venable, F. P., Kenan Prof. of Chemistry, Univ. of North Carolina..Chapel Hill
*Wells, B. W., Dept. of Botany, State College.....Raleigh, N. C.
*Wells, Mrs. B. W., State College Sta.....Raleigh, N. C.
*Wheeler, A. S., Professor of Organic Chemistry, Univ. of North Car...Chapel Hill
Williams, C. B., State College .....Raleigh, N. C.
*Williams, J. H., State College.....Raleigh, N. C.
Williams, L. F., State College.....Raleigh, N. C.
Wilson, Donald B., Dept. of Farm Crops, State College.....Raleigh, N. C.
*Wilson, Henry V., Kenan Professor of Zoology, Univ. of North Car., Chapel Hill
*Wilson, R. B., Dept. of Biology, Wake Forest College.....Wake Forest, N. C.
*Wilson, R. N., Trinity College.....Durham, N. C.
Winston, Dr. Lula G., Meredith College, 124 E. Edenton St.....Raleigh, N. C.
Winters, R. Y., State College.....Raleigh, N. C.
Withers, W. A., Dept. of Chemistry, State College.....Raleigh, N. C.

*Wolf, F. A., Plant Pathology, State College.....Raleigh, N. C.
*Wright, Miss Eva K., North Carolina College for Women.....Greensboro
Total 133.

The following papers were presented at the meeting:

Age of Insects. Z. P. Metcalf. (Presidential address.) Appears in full in this issue.

The Genus Raspailia and the Independent Variability of Diagnostic Features. H. V. WILSON.

Appears in full in this issue.

Current Research in Organic Chemistry at the University of North Carolina. ALVIN S. WHEELER.

Active work is being done upon six research problems. First, the nature of kelp oil from the distillation of kelp, a seaweed in the Pacific Ocean, is being investigated. Nothing whatever about it is known. Second, the bromination of 2-Amino-p-cymene yields a mono-bromo derivative and new compounds derived from it have been prepared. Third, the chlorination of 2-Amino-p-cymene also yields a chlorine derivative. The constitution of the two halogen compounds presents a fine puzzle in orientation. Fourth, further work is being done with Tribromojuglone as raw material. Fifth, the chlorination of juglone proceeds differently from the bromination and good results are being obtained. Sixth, a shorter process of obtaining bromo-amino-cymene is being sought, by brominating nitrocymene and then reducing. My assistants in these studies in the same order as the problems above are: H. M. Taylor, I. W. Smithey, I. V. Giles, T. M. Andrews, P. R. Dawson, S. C. Smith.

Some Fungi New to North America or the South. W. C. COKER.

Sirobasidium sanguineum, another species of a rare genus of gelatinous fungi which has been known before only from South America, has been found here. The author has previously reported *S. Brefeldianum* from Chapel Hill.

A remarkable form of a well known edible mushroom, the early *Pholiota* (*P. praecox*), occurs in Chapel Hill and Raleigh. It is distinguished by the absence of any visible trace of a veil. This would entirely mislead one as to its real place in classification, as the veil is supposed to be a generic character.

The only species of the mushroom genus *Tricholoma* (*T. venenata*) that is known to be poisonous was collected at Chapel Hill in the fall

of 1919. This has been known before only from Michigan, where it made seriously ill seven people who ate it.

A peculiar little mushroom of the genus *Lepiota* (*L. caerulescens*) which turns a deep indigo blue all over when it dries has been found here. It has been known before only from Missouri and Ohio.

Apodachlya brachynema, a minute but interesting and very rare mold growing on dead insects in water, has recently been found in Chapel Hill. It has been reported only once before from America, in Massachusetts.

Notes on the Oecology and Life History of the Texas Horned Lizard. J. P. GIVLER.

To appear in full in a later issue.

Artificial Incubation of Turtle Eggs. BERT CUNNINGHAM.

Chrysemys picta Herm. is recognized as a good species. *C. marginata* Agassiz, *C. cinerea* Bonnaterre, and *C. bellii* Gray are all included under the specific name of *C. cinerea*. *Chrysemys oregonensis* Nuttall, is also provisionally included under *C. cinerea*.

In some of the experiments eggs laid in the usual manner were used, but the majority of eggs were taken from the uterus. The latter showed a higher developmental rate. The fundamental requirements are proper moisture and temperature, and in the case of laid eggs they must be secured within a few hours of laying. Development may be stopped by low temperatures for a period of a month at least, and development of such eggs seems to proceed in a natural manner when brought back to a normal temperature.

The artificial incubation allows one to keep a record of the incubation time and thus secure a more graded series than is possible under natural conditions. It also makes possible much experimental work on the rate of development, inhibitors and activators.

Some Considerations in Defense of the General Biology Course. J. P. GIVLER.

To appear in full in a later issue.

An Interesting Anomaly in the Pulmonary Veins of Man. W. C. GEORGE.

In one of the anomalies found this spring in the anatomical laboratory at Chapel Hill the blood from the upper left lobe of the lung was drained not into the left atrium but into the systemic circulation. A

vein about a centimeter in diameter emerges from near the middle of the ventral surface of the upper left lobe and courses directly cephalad to empty into the left innominate vein. A short distance before it empties into the innominate this vein receives the accessory hemi-azygos vein. The right pulmonary veins and the pulmonary vein from the lower left lobe communicate with the left atrium as usual.

Alfred Brown (Anatomical Record, 1913) has shown that the pulmonary system in the cat arises from an indifferent splanchnic plexus in the region of the lung bud. This plexus has venous connections on the one hand with the sinus venosus and on the other with neighboring systemic veins (cardinals, segmentals, and others). Conditions similar to those shown in the anomaly cited apparently arise as a result of some interference with the return of blood through the pulmonary portion of the embryonic plexus thus causing both pulmonary and bronchial blood to enter the bronchial veins and causing their great enlargement. In this particular case then the large vein draining the upper left lobe seems to represent the enlarged left bronchial vein and that portion of the accessory hemi-azygos between the innominate and the junction of the left bronchial with the accessory hemi-azygos. Due to the enlargement of the bronchial vein the accessory hemi-azygos appears to be a side branch of it.

A More Phenomenal Shoot. WILLIAM F. PROUTY.

At the last meeting of the North Carolina Academy of Science Dr. B. W. Wells described "*A Phenomenal Shoot*" which grew near Raleigh during the season of 1919. This shoot "grew from the stump of a beheaded tree of *Paulownia tomentosa.*" The shoot described by Dr. Wells was 7.75 inches in circumference at the base, had 20 internodes and was 19½ feet in length. This shoot was supposed to have grown in one season, though this fact was not definitely known.

During the past season the writer has witnessed the development of a shoot from a tree of the same species cited by Dr. Wells which surpasses in its dimensions the one above referred to. This shoot grew during this past season to a height of 21½ feet. It has a circumference at base of 10 inches and has 24 internodes. One of the leaves, measured in the latter part of July, was 38 inches in largest dimension. This shoot grew in a clay-loam soil, residual from granite, on property adjoining the Campus, in Chapel Hill.

The following papers were read but no copies or abstracts furnished:

A Photometric Study of the Fluorescence of Iodine Vapor. W. E. SPEAS.
Breeding Results from Overwintering Cocoons of the Polyphemus Moth. C. S. BRIMLEY.
New North Carolina Gall Types. B. W. WELLS.
Solid Culture Media with a Wide Range of Hydrogen and Hydroxyl Ion Concentration. F. A. WOLF and I. V. SHUNK.
Judgments of Length, Mass, and Time. A. H. PATTERSON.
Effects of Desiccation on Cotton Seeds and on the Seed-borne Element of Cotton Anthracnose. S. G. LEHMAN.
Chlorination with the Silent Electrical Discharge. PAUL GROSS.
The Electron, its Measurements and Applications. J. B. DERIEUX.
Some Questions Concerning the Teaching of Physics in North Carolina. C. W. EDWARDS.
Questions Arising from the Discovery of Occasional Vertebrate Hermaphrodites with a Demonstration of a Case in a Pig. HARLEY N. GOULD.
The Anatomy of Angiopteris. H. L. BLOMQUIST.
Further Studies on the Pure Culture of Diatoms. BERT CUNNINGHAM and J. T. BARNES.
Aphidius, a Parasite of the Cotton Louse. H. SPENCER.
Notes on the Salamanders of the Cayuga Lake Basin, N. Y., with Reference to Eggs and Larvae. JULIA MOESEL HABER.
A Method of Differentiating Mucous and Serous Cells. EVA GALBRAITH CAMPBELL.
Recent Views on the Nutritive Qualities of Milk. J. O. HALVERSON.
Relationship of Temperature and Relative Humidity to the Distribution of Cockroaches. VERNON R. HABER.
From Egg to Frog in two Months. H. V. WILSON.

The following papers were read by title only, in the absence of their authors:

On the Polyembryonic Development of the Parasite, Copidosoma gelechiae. R. W. LEIBY.
The Lorentz Transformation in Einstein Relativity. ARCHIBALD HENDERSON.
The Inheritance of Economic Qualities in Cotton. R. Y. WINTERS.
Notes on Recently Discovered Miocene Whale. WILLIAM F. PROUTY.

The following paper was transferred to the Chemical and Physical program:

Ionizing Potentials of Gases by Negative Electrons. A. A. DIXON.

C. S. BRIMLEY, *Acting Secretary.*

JOHN FRANCIS LANNEAU
1836–1921

A long and variously distinguished career came to a close when John Francis Lanneau died in Wake Forest, March 5, 1921. He was born of Huguenot parentage in Charleston, South Carolina, February 7, 1836. His father was Charles Henry Lanneau, his mother, Sophia Lanneau. He was graduated from the South Carolina Military Academy in 1856. His teaching career began at once in 1857 as tutor in mathematics, and from 1858 to 1861 as professor of physics and chemistry, in Furman University, Greenville, S. C. Then came the Civil War in which he served four years first as Captain of cavalry in Hampton's brigade, later as Lieutenant and Captain of engineers. At the conclusion of the war he resumed his connection with the Furman faculty, being professor of mathematics and astronomy from 1866 through 1868. For the next four years he was professor of mathematics in William Jewell College of Missouri. In 1873 he accepted the presidency of the Alabama Central Female College, Tuscaloosa, holding that position for six years. From 1879 to 1888 he was president of the Baptist Female College, Lexington, Missouri. The next two years he was president of the Pierce City Baptist College of the same state. In 1890 he accepted the professorship of physics and applied mathematics in Wake Forest College. From 1899 to his death he was professor of applied mathematics and astronomy.

The honorary degree of M. A. was conferred upon him in 1869 by Baylor University, LL. D. in 1915 by Furman University.

Of striking physique and courtly bearing Dr. Lanneau won attention and respect wherever he appeared. He was of the finest type of the Christian gentleman and up to the day of his death was chairman of the board of deacons and treasurer of the Wake Forest Baptist Church.

Apart from the immediate tasks of the class room, Dr. Lanneau showed his deep scientific interest in several ways. He was probably the first man in North Carolina to give demonstrations and public lectures on the X-rays. In 1907 he invented the Cosmoid manufactured by Wm. Gaertner & Co., of Chicago, and described by him in "Popular Astronomy," December 1913. It is an ingenious apparatus for illustrating many astronomical conceptions and motions.

It is capable of numerous and easy adjustments. He was an active member of the North Carolina Academy of Science and of the Astronomical Society of the Pacific.

A list of his scientific papers is appended:

The Source of the Sun's Heat. Popular Astronomy **14**: 410. 1906. Also published in Journ. E. M. Sci. Soc. **22**: 45. 1906.

The Sparsity of The Stars. Popular Astronomy **15**: 390. 1907.

Sirius, the Bright and Morning Star. Popular Astronomy **19**: 393. 1911.

The Cosmoid. Popular Astronomy **21**: 613. 1913.

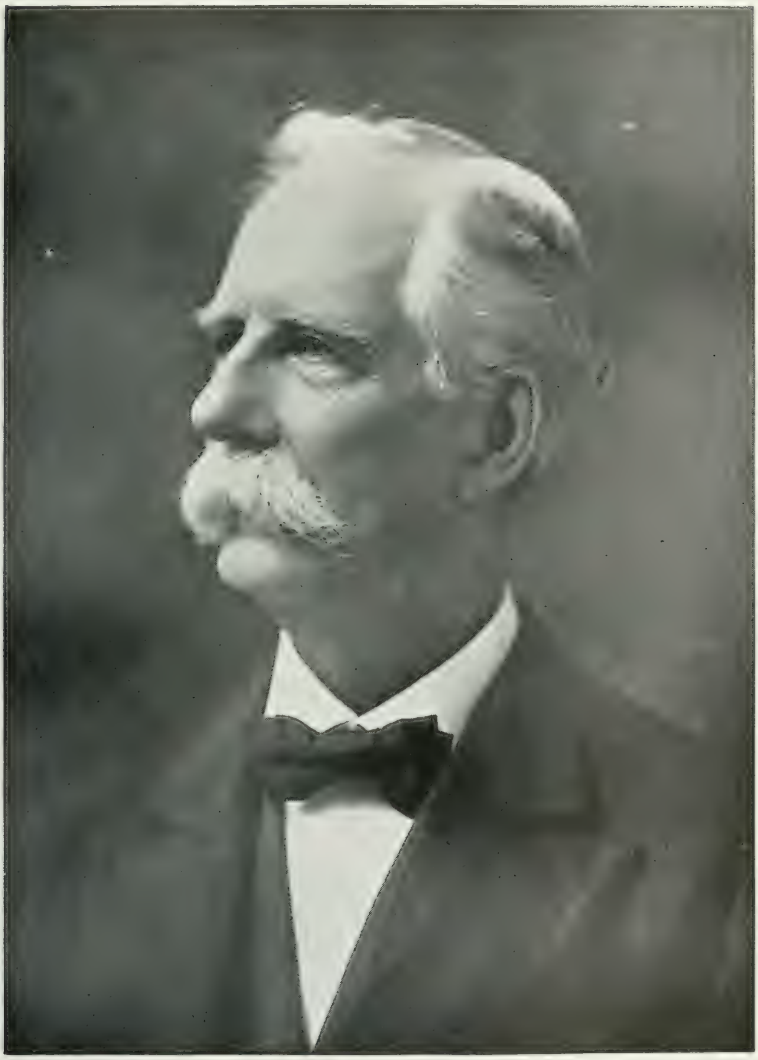
The Sun's Eclipse of June 8, 1918: Question. Popular Astronomy **26**: 299. 1918. Also published in Journ. E. M. Sci. Soc. **34**: 76. 1918.

Sunspots in July, 1903. Popular Astronomy **11**: 372. 1903.

Physics of Shooting Stars. Popular Astronomy **13**: 434. 1905.

Approaching Sun-Spot Maximum. Journ. E. M. Sci. Soc. **20**: 21. 1903.

WM. LOUIS POTEAT
CHARLES E. BREWER,
H. V. WILSON.



JOHN FRANCIS LANNEAU
1836–1921

THE AGE OF INSECTS.

By Z. P. Metcalf

Geologists are in the habit of speaking of this as the "age of man" or the Psycozoic era. From this stated opinion I wish to dissent, for this evening at least, and call your attention to the fact that while we as humans may speak of this egotistically as the "age of man" it is not the age of man but the age of insects in which we are living. Man may try to dominate this age but on every hand he finds his efforts thwarted and at every point he must give way to numerous hordes of insects whose chief aim seems to be to overthrow the kingdom of man on this world. The late unpleasantness in Europe is remembered by our soldiers, not so much as a war on the Boche, as a war on innumerable insect pests denominated cooties. And even those of us who had no chance at first-hand knowledge can sympathize with the young Canadian who, when he was decorated with some medal or other for outstripping his fellows in a charge, remarked that his interest in the matter was not in the charge but in the hope that he could run fast enough and far enough to escape the cooties.

As in war so in peace, on every hand we find our lives circumscribed and our efforts limited because of the presence of numerous insect pests. Our crops, our domesticated animals are increasingly subjected to their attacks. Our forests are devastated by them. Our houses and our stores are destroyed by them. Our books and our paintings are marred by them. Whole regions of the world are practically unfit for human habitation because of the diseases they carry, and human want and human suffering abound in all quarters because of these troublesome little pests. In fact, they have so adapted themselves that it is impossible to think of any relation of human life and human culture that is not colored in some way by insects, yea even as pointed out below our very existence is dependent upon them.

It would seem logical, therefore, that anything that touches us so vitally ought to be pretty well understood. Yet, I believe I am safe in saying that there is no group of animals so little known, to zoologists even, as insects. This in spite of the fact that more of our zoological literature, each year, is devoted to insects than all other animals combined. Whole regions of the insect kingdom are still unsurveyed and, while we know a little about the external anatomy of a few forms, our knowledge of the internal anatomy is still largely based on the

work of Swammerdam in the seventeenth century, who worked without a compound microscope or a microtome. Our knowledge of the ecological relations is largely based on superficial studies of the life histories of isolated species and all the rest is sweeping generalizations that are almost certain to fail in the acid test of real ecological experiments. Our knowledge of insect vectors of human, animal, and plant diseases are equally poorly grounded on the knowledge that the tsetse fly carries sleeping sickness, that the malarial mosquito carries malaria, that the cattle tick (not an insect) carries Texas fever, and a few other cases from which we generalize often wisely, if not too well.

We are often guilty of orating, sometimes rather loudly, I am afraid, about the damage done by the gypsy moth, or the boll weevil or what not, but do we even stop to ask ourselves about the remarkable interplay of physiological processes between plant and insect or the ecological relations between the insect and the host of conditions that surround it? And the echoes answer, "Do we?"

If this then is the condition among our professional zoologists (I believe entomologists are still regarded as zoologists by the layman, if not so regarded by his fellow zoologists), what is the condition among other scientists, and other folks in general,—that great class to which we scientists refer frequently, and not without condescension, as the lay minds, as something separate and entirely distinct from our minds which are denoted as academic minds. It is in the hope that I may be able to educate the lay mind that this paper has been prepared. And for fear that some of you may miss the drift of my remarks, I hasten to remind you that you are the lay mind, and to add that I am not exactly clear as to just why you are the lay mind or just what makes my mind, entomologically speaking, an academic mind, while from the standpoint of the chemist or the physicist or the botanist or what not my mind is removed from its temporary and somewhat insecure pedestal and is laid at the base and becomes perforce a lay mind. Perhaps I would feel just as well and you would have more respect for what I have to say if I did not inquire too closely into this phase of the subject but hasten on to tell you something about bugs, as I see that you are all sitting somewhat breathlessly with open mouths, if not with open minds, to learn something about this field that we call entomology and about this age that we call the age of insects.

Before I proceed, however, I must warn you that I am not an entomologist, let alone a zoologist, although I believe that is the title

that is conferred upon me by powers vested in the State of North Carolina and the government of these United States, but a specialist in an obscure group of insects. I tell you this to defend myself against the hordes of specialists in other groups who may hold up their hands in holy horror at some of the generalizations that I may make. Now the specialist is a sort of rare bird whose words are a law unto himself, at least, and who knows so much about his own pet field that he knows nothing about anything else and his final defense in all arguments about his field is, "Well, I am the specialist in this group." To which some of you, who are broadly academically minded if not lay minded, must feel like exclaiming, "We are thankful for that much at least." The difference in those things is of course one of degree. For instance a student of insects is, naturally, an entomologist but a student of fleas is a Professor of Suctoria, the student of the hind leg of a flea is a pulicidid morphologist and the student of the hairs on the second joint of the hind leg of a flea is a specialist and I say it reverently, "May the Lord help him!"

With this rambling and somewhat generalized introduction, you will pardon me if I turn your attention to some of the various aspects of the insect world in order that we may examine them more closely. Emerson said something to the effect that fools are amazed at the extraordinary and wise men wonder at the ordinary. I shall presume therefore on your wisdom and use only ordinary examples with which to paint my picture of the insect world.

THE NUMBER OF INSECTS IN THE WORLD

The possible number of insects in the world has always been a subject of very great interest to me. I, of course, refer to the number of kinds or species not to the number of individuals. No one has been foolhardy enough to make a personal census of insect individuals as yet, I believe. The nearest approach to this are the statements that misguided sanitarians and others make, sometimes, to the effect that starting with a single pair of houseflies we would have, by the end of summer, so many quintillions of flies. We all know this is not true, save perhaps on a summer afternoon when we are trying vainly to get our allotted forty winks and all but succeeding because of several of the above mentioned quintillions that persist in lighting just to the windward of an upturned nose. Or there is the statement that starting with a single plant louse, with all of her descendants surviving, we

would have, in a year or two, a mass of plant lice equal in volume to our earth. This may or may not be true, but if true a large proportion of the descendants must fly away to other worlds than ours because any species is lucky indeed if it ends its fiscal year and balances its books with a definite increase in numbers over the previous year.

The question of the number of species of insects is, however, another matter. We see, in our text books, estimates of the number of species of insects in the world, at anywhere from 250,000 to 500,000 and 1,000,000 and recently some one ventured to estimate that there must be at least 10,000,000 kinds of insects in the world, at the present time.

Obviously, in trying to generalize about a group of animals with such an enormous number of species, one finds himself handicapped not from lack of material but from its very superabundance.

General Physiology.

Typically, an insect is an arthropodous animal with its body divided into three parts; head, thorax and abdomen, and with three pairs of legs and usually two pairs of wings. Being an arthropod, an insect carries his skeleton on the outside of his body and as he grows this skin which is hard and chitinous must be cast off and a new skin produced to accommodate the larger sized individual. This skeleton is segmented to provide free movements. Thus various parts have been separated and since these parts are fairly constant they have been much used in taxonomy. But their phylogenetic relations are not always clear and thus a special nomenclature has grown up around each group which has served to discourage all but the most highly specialized of the specialists and has acted as a sort of natural selection, thus cutting down materially the crop of specialists, much to the general benefit of the world at large. With these special parts we need not concern ourselves here but the generalized parts will bear closer inspection. The head is largely sensory in function and bears the compound eyes, simple eyes and antennae. These will be discussed more in detail under sense organs. The head also bears the mouth parts which are among the most complicated structures found in the animal kingdom. Primitively, they consist of no less than three paired and three unpaired structures. We cannot inquire into the various morphological variations but the following classification of the mouth parts of insects based largely on functional grounds will

perhaps aid in conveying the complexity of the subject. We have, as our most generalized, the chewing insects which are fitted with a pair of mandibles which tear and masticate food.

A scraping type which lacerates the epidermis of plants and sucks up the exuding sap.

A piercing type in which the mouth parts are fitted for piercing the skin of an animal or the epidermis of a plant and sucking the blood or sap.

A rasping type fitted for rasping off solid particles and dissolving them in saliva and then sucking up the resultant liquid.

A sponging type in which the mouth parts are fitted for sponging up exposed liquids.

A siphoning type in which the mouth parts are formed into a long hollow tube which is usually used to suck up exposed nectar.

A lapping type in which the mandibles are well developed for working wax and paper or for portage and the other mouth parts are modified into a tongue which is used to lap up exposed liquids.

The thorax is largely given over to locomotion, which is carried on by the wings and legs. The insects were without doubt the first animals to conquer the air and of all animals, birds not even excepted, their mastery of the air is the most complete. The legs are fitted chiefly for walking, running, leaping and grasping. The speed of certain of our insects is indeed remarkable, as is their ability to make surprising leaps. The world's record for the broad jump is not held by a man but undoubtedly belongs to the flea. A leap of a hundred times his length would be no astounding feat for a flea, whereas for man five or six times his length would be wonderful indeed. In the same way the muscular strength of insects is almost beyond belief. The weakest insects according to Plateau can pull five times their own weight, while the average is more than twenty times, and one of the leaf beetles can pull forty-two times its own weight. In contrast man cannot pull his own weight and under the same conditions a horse could pull but three-quarters of his weight. Some of the insects are able to push one hundred times their own weight, while the honey bee can carry a load equal to three-fourths of its bodily weight. These remarkable feats are accounted for by the small size of the insects and by the greater advantage in leverage from an external skeleton.

Passing to the internal organs we find time for the discussion o two systems of organs only. The first of these is the respiratory or

gans or trachea. The insects differ from man in that their circulatory organs are very poorly developed and their respiratory organs are well developed to counterbalance this. The insects have no lungs but a system of trachea or tubes which open to the exterior through minute pores called spiracles. From the spiracles the trachea branch and rebranch until they reach all parts of the body. The oxygen is carried to the cells through these tubes and the carbon dioxide carried away through the same set.

The nervous system and sense organs of insects are so different from those of man that we are often at a loss to account for the sensory life of insects. There is in the insects no brain as we find it in the vertebrates but the nervous functions are distributed to a chain of ganglia along the ventral wall of the body. There is therefore more or less of local control for each region of the body. The psychic life of such animals is therefore rather low and in no way to be compared with that of man.

The sense organs of insects may be grouped into three classes (Comstock):

Mechanical sense organs.—Touch and hearing.

Chemical sense organs.—Taste and smell.

Organs of sight.

Touch organs are generally distributed over the body and need no special discussion. Organs of hearing are apparently not universally present. They occur among the singing orthoptera and in mosquitoes and perhaps in bees, but whether they occur in other forms is by no means clear. In the grasshopper the ears are located on the first segment of the abdomen, but in the katydids and crickets they occur on the tibia of the fore legs. In the mosquitoes they undoubtedly occur on the antennae, as the antennae are provided with whorls of setae which gradually decrease in length from the base of the antennae outward. It has been demonstrated that these setae vibrate to notes of different pitch and it is believed that the vibrations are transferred to the nerve endings. Most beekeepers believe that bees can hear because they make such different hums under different circumstances, and even an amateur can tell the difference between the busy hum, the swarming hum, and the angry hum of an outraged bee.

The chemical senses of insects are very poorly understood. This is due in part to the wide distribution of these organs over the body and to the fact that several different types of sense organs are frequently closely associated. We say that insects taste because we

know they make selections in foods, and we say bees smell because they seem to be able to distinguish members of their own colony from other bees, and they seem to be able to recognize their queen and to distinguish drones.

The sense of sight in insects is taken care of by two distinct types of eyes, the simple eyes and the compound eyes. The former we believe is used chiefly to distinguish light from darkness while the latter is used to give an image. The compound eyes of insects are composed of from a few to many hundreds of hexagonal prisms, called ommatidia. It is believed that each ommatidium forms a portion of the image just as tiles are put together to form a mosaic. Or, since the ommatidia are hexagonal in shape, perhaps we can best compare the image that insects receive to the image our eyes receive when we look through a piece of glass which has been laid down on poultry netting. Each mesh of the poultry netting would contribute its portion to the image just as each ommatidium of the insect's compound eye does. Obviously such an eye is better adapted to seeing motion than it is to seeing distinct images.

INSECT PSYCHOLOGY.

I wish I had the agile mind and the facile pen of a Fabre so that I would be able to unfold for you some of the beauties of the instincts of insects. We may see striking illustrations on every hand. Why do certain insects always lay their eggs in such situations that their young will find an abundance of food at hand? This question is of course easy to answer in the cases of those insects whose adults feed on the same plants as the young. It is simply a matter of placing them in the most convenient place; but we are confronted with the query, why do some of these insects take such elaborate pains to conceal their eggs by placing them in the stems of plants or imbedding them in the tissues of the leaves? On the other hand we are confronted by that vast host of adult insects which lay their eggs on food plants or animal hosts upon which they themselves do not feed. Or we are confronted by that complicated set of reactions, so well illustrated by our solitary wasp, where a nest is constructed and prey is searched out and stung in the precise spot to paralyze the individual but not cause its death. Then the prey is dragged back to the nest and stored with an egg and the nest closed and concealed. Or we see an insect like the cornfield ant taking the eggs of the corn and cotton root louse into its

nest and storing them through the winter, shifting their position in its tunnels with the changes of the temperature so that it will not be injured, then hatching the egg in the sun in the spring and placing the young nymph on the proper food plant. All this in order that the ants' descendants may have an abundant supply of honey dew for their nourishment. What are the mental processes of the eumenes wasp as it fashions the clay into pottery of the most charming design—a design so artistic that man has copied it as his very own. What are the mental processes of the tiny caterpillars as they weave their marvelous gossamer threads and become the earth's first aeronauts? What are the fungus ants thinking about as they prepare a fertile field and sow upon it the spores of a certain species of fungus in order that their children may have an abundance of food? What of the mental processes of the scarab as it rolls its ball of dung often many weary insect miles in order to provision its nest for its larva? Why does each species of scarab store its nest with the dung of certain animals only? What is the psychological process of the queen bee that causes her to lay only unfertilized eggs in drone cells? What are the slave-making ants "thinking about" when they make a raid on the nest of another species, kill the adults, kidnap the larvae and pupae, carrying them away to their nests where they are raised to adults to serve their captors?

We see these questions about us every day and we ask the question "Why?" and we reply very wisely with the magical word "instincts." Which is a very learned and very scientific way of saying that we know nothing about it.

In ordinary speech, the word "instinct" stands for all the hereditary and automatic revelations of activity, from simple tropisms to the most complicated outward manifestations of individual memory. Instinctive acts are stereotyped, being ever the same when responding to stimuli of the same nature, and almost always adapted to their object, although not resulting from previous experience on the part of the individual. To define them more precisely is impossible for they are varied and complex, overlapping one another and often becoming so confused as to render difficult the tracing of their limits. Nevertheless, we should not place them all on the same level and attribute to them all a common origin. Tropic reactions are due to the properties of living matter, rhythms presuppose an organic memory and hence a period of education, ancient or recent; but this apprenticeship is purely mechanical and dependent upon the stimuli that produce it.

Apprenticeship has its part also in those manifestations of memory belonging to the species which play such an important part in the behavior of arthropods. This kind of memory presents a character of distinct superiority, inasmuch as it was made effective for the race by the distant ancestors of the individual in the guise of a choice between the various possible responses of differential susceptibility. Choice, of a remarkably intellectual nature, is even more noticeable in the instinctive manifestations of individual memory. The animal, endowed with well-developed senses and nervous system, not only reacts to new necessities by new acts, but associates the stored impressions of new sensations and thereby appropriately directs its further activities. Thus, by an intelligent process, new habits are established which by heredity become part of the patrimony of instinct modifying the latter and constituting elements essential to its evolution. Of these instincts acquired through an intelligent apprenticeship Forel was led to say that they are reasoning made automatic and it is to them particularly that we may apply the idea of certain biologists that instincts are habits which have become hereditary and automatic. Probably all superior instincts at first had this intellectual quality. This certainly is true of all such as originated from more or less slowly acquired habits; it seems to be the rule as well with instincts due to mutations. It stands to reason that, whether they result from a sudden psychic change or from a sudden organic modification, these instincts must always be preceded by some intelligent period of education, during which they become perfected, in order to be handed on to posterity and to assume the character of true instincts.

Here, then, we are confronted with several classes of instinctive acts, which differ not only in origin but also in intellectual characteristics. No doubt they are linked together by many intermediate manifestations, and in the animals with which we are now concerned they often blend the one with the other or even with the reflexes, on account of the profound differentiation of nervous and sensorial centers. It is, nevertheless, very difficult to consider them as manifestations of a special faculty which we would fain place on the level of intelligence by calling it instinct. The name instinct justly applies to certain forms of activity which are innate and automatic, but these forms proceeded in diverse ways from the vital energy which is the source of all organic activity, and the highest of them, which are at the same time the most striking ones in the animals here studied, were originally acts more or less requiring the exercise of true intelligence on the part of

species and individuals. Intelligence has no part in the development of the instinct that draws nocturnal Lepidoptera toward the light, nor has it doubtless anything to do with the rhythms through which organic memory manifests itself. But intelligence it is that regulates by appropriate selection all manifestations of race memory; intelligence again in the sundry forms of association and individual memory, that puts together the most complicated mechanisms of instinct.

Instincts are of various kinds. If, by the word instinct we understand not any one special faculty but the complex of all the instincts, namely, the innate automatism regardless of its origin, we can say with Bergson that instinct and intelligence "are not things belonging to one and the same order," that they "diverge in direct ratio of their development," but that "they never become completely separate." They are both "opposites and complements" and they assist one another. "On the one hand, indeed, the most perfect instincts of the insects are accompanied by certain gleams of intelligence, be it only in the choice of place, time or material of construction. When by exception bees build their nest in the open they invent arrangements which are new and in the true sense intelligent to meet the new conditions. On the other hand, intelligence has still more use for instinct than instinct has for intelligence, since the ability to work up raw material presupposes in the animal a superior grade of organization, to which it could have arisen on the wings of instinct only." Before such evidence as this Fabre was forced to modify his theory of immutable instinct. "By itself, mere instinct," says he, "would leave the insect disarmed in the perpetual conflict of circumstances. A guide is needed in the midst of this bewildering mêlée. That the insect has such a guide is evident to a high degree. This is the second domain of its psychic powers. Here it is conscious and susceptible of perfecting by experience. As I dare not designate this rudimentary aptitude by the name of intelligence, a title too noble for it, I shall call it discernment." But is discernment in this sense not really a form of intelligence?

Such is the measure in which instinct and intelligence are combined in animals. If, following Bergson, we admit that consciousness "is proportional to the power of selection at the animal's disposal," it will be quite evident that consciousness must be particularly obscured in all purely instinctive acts, but that on the contrary it must accompany all intelligent acts. Bergson, however, regards consciousness in a peculiar light, since he considers it as "life projected

through matter," as the common source from which sprang in different directions both instinct and intelligence. This view leads us away from the commonly accepted theory that consciousness must be considered as that inmost luminary which enlightens our actions. It is possible, even probable, that this kind of consciousness exists to a greater or lesser extent in the animals. However, we can not know anything about it, and we believe with Ed. Claparede that "the science of animal psychology may and must scrutinize the problem of the greater or less intelligence of animals without being concerned about their consciousness."

We discern intelligence in its simplest expression wherever we notice a choice between the various alternatives offered by circumstances, and in one of its highest forms wherever we observe that power of invention which, according to Bergson, enables the human race to "manufacture artificial objects, more particularly to make tools with which to make other tools and to vary their fabrication indefinitely." These two extreme forms are naturally connected by a series of links, and we know that the one as well as the other plays a part in the behavior of arthropods. The latter of the two seems, however, to be rather exceptional in our group, showing itself only in the primitive state consisting of the use of foreign bodies as implements. The tool used by Ammophila is a small stone with which the female rams and packs the dirt that closes her burrow. With certain ants of India (*Oecophylla smaragdina*) and of Brazil (*Camponotus texter*) the instrument consists of the larva of the species itself. Held between the mandibles of the workers, these larvae, by means of their thread, glue and fasten edge to edge the leaves of which the nest is constructed. The implement of the crabs, of the genus Melia, in the Indo-Pacific seas, is supplied by a delicate sea-anemone. This is held between the pincers of the animal, which probably uses the nettling exudations to paralyze its prey.

Facts of this nature are rare in the world of arthropods, but they have an important significance. The use of the little stone is not yet a fixed habit with Ammophila, it belongs only to certain individuals more highly endowed than others and is perhaps only accidental even with them. Maybe it will finally pass into the instinctive habits of the species; for the present it belongs to the domain of individual intelligent acts. The crabs of the genus Melia are already farther advanced, all the species carry anemones and all exhibit a curious modification of the pincers, the fine teeth having become elongated and

needlelike so as to give them a better hold on their guest and tool. That they are adapted to the latter is evident, yet this adaptation is not such that the crab is likely to be in serious danger when it has not its Actinia. Many of the Melias brought back by explorers are not provided with anemones, and we may believe that the presence of this implement guest is not yet of vital importance to the species of this peculiar genus. The case of the ants which use their larvae as needles is quite different. With them this singular habit is innate and specific. Though probably acquired through intelligent acts, it now belongs entirely to the domain of instinct in the species among which it prevails. And thus we always come back to that predominating fact of the psychological history of arthropods, namely, the transformation of intelligent acts into instinctive acts. The following considerations formulated by Bergson eminently apply to this group:

Among animals, invention is never more than a variation on the theme of routine. Locked up as it is within the habits of its species, the animal succeeds no doubt in broadening these by individual initiative; but its escape from automatism is momentary only, just long enough to create a new automatism; the gates of its prison close as soon as they are opened; dragging the chain merely lengthens it. Only with man does consciousness break the chain.

Man occupies the topmost place in the scale of vertebrates, for, breaking the bonds of instinct he insures thereby the complete expansion of his intellect. Insects especially Hymenoptera hold the same dominating position in the scale of arthropods where they are the highest achievement of instinctive life. These two groups represent the actual extremes of the two paths followed by psychic evolution in the Animal Kingdom; the arthropods are going toward instinct, the vertebrates toward intelligence. These two courses are quite opposite, but why have they diverged? At the beginning of their evolution, during that far distant epoch when they were differentiating along four main lines (echinoderms, mollusks, arthropods, and vertebrates), animals were threatened by a great danger—"an obstacle" says Bergson, "that doubtless almost checked the progress of animal life. There is a peculiarity which we can not help being struck by when we glance at the Paleozoic fauna. The mollusks at that time were more universally provided with shells than those of today. The arthropods in general were provided with a carapace. The oldest fishes had a bony covering of extreme hardness." But "the animal which is shut in a fortress or in a coat of mail is condemned to an exist-

ence of half-sleep. It is in this torpor that the echinoderms and even the mollusks are living today. The arthropods and vertebrates escaped from it and on this happy circumstance depends the present development of the highest forms of life.

"In two directions, indeed, do we see the impulse of active life regaining the upper hand. The fishes exchange their ganoid armor for scales. Long before them the insects had made their appearance, having also rid themselves (of most) of the armor that once protected their ancestors. In both groups the inefficiency of the protective envelope was compensated for by a nimbleness that enabled them to escape their enemies and also to take the offensive and to select the place and time of the encounter."

These remarks rest on a solid foundation but they should be modified in one particular which is of paramount importance in the explanation of the structure and the special psychology of the arthropods. These animals have never lost the chitinous armor that protected their primitive ancestors. They have preserved it in its entirety and with greater or less thickness. Coleoptera, crabs, scorpions, and thousand-legs of our times are by no means inferior in this regard to the ancient forms from which they are descended.

As a matter of fact they are covered today, as in times of yore, with an external skeleton of chitin. That is why Edmund Perrier, in his desire to emphasize their dominant character, has called them Chitinophores. To escape imprisonment within their protective envelope, to acquire the flexibility and mobility necessary to their evolution, they underwent certain superficial modifications. These consisted in the division of the armor into several pieces by means of articular lines, along which the chitin is less thick than elsewhere, thus allowing the pieces to move one upon the other. This is the very way in which they became arthropods, at once acquiring agility without losing their protective cover. Naturally such joints were formed wherever the several segments, arranged in a row and constituting the body of the animal, came together. As a result, these segments acquire a certain independence and their uniformity is to a certain extent preserved. Indeed, we see that many arthropods possess a pair of appendages on each segment (Myriapods and the majority of Crustaceans) and that the insects most remote in this regard from the primitive types are still provided with seven pairs of appendages (one pair of antennae, three pairs of buccal appendages and three pairs of legs) not to speak of the modified or rudimentary organs to be seen on

the different parts of the abdomen. And the chitinous envelope of these appendages has broken into joints in the same manner in which the body itself became annulated. Hence the name of arthropods which is given to these animals.

What a difference from the vertebrates. Their skeleton becomes an internal framework. The organism is thus allowed to attain greater dimensions; the segments are able to fuse to a greater degree and to lose more or less their independence; all of which results in the reduction of the number of limbs to only two pairs.

Now, the relative independence of the segments and the multiplicity of the appendages have as a corollary the differentiation of these structures, each of which plays a special part in the organism. As Bergson remarks, the various appendages of arthropods are as it were natural implements, which differ from each other in structure as well as in function. Their specialization may be carried so far as to have each part of a single organ perform a separate function. This is clearly seen in the bee, in which the first tarsal joint of the hind legs is transformed into a brush, the tibia into a pollen basket, while the two joints, by the contact of their edges, act as pincers which take up the flakes of wax secreted under the abdomen. It is an admirable instrument wonderfully adapted to the performance of its particular tasks. As a general rule, apart from the changes which they may undergo in the course of specific evolution, the appendages of arthropods are unchangeable in the individual and are narrowly adapted to certain purposes; they are the tools for instinctive work, and in this they differ from the less specialized but more generally useful limbs which serve as implements to the vertebrates, at least to the higher vertebrates. With these latter, as Bergson expressed it, the two pairs of limbs "perform functions much less strictly dependent upon their forms," acquiring complete independence in man, whose hand can do any kind of work.

"It seems, then, that the extraordinary preponderance of instinctive activity among the arthropods has as its essential reason the differentiation and the multiplicity of the appendages, in other words, the chitinization of the integument and the formation of joint lines which results from it. From the beginning these animals were doomed to use organic instruments, and they made the best use possible of these. Their main psychical task consisted in engraving upon their memory and in instinctively repeating the acts to which these organs were adaptable." (Bouvier.)

Or we follow a bee as it leaves its hive and visits flower after flower and when it has gathered its load of sweets it takes a "bee line" for the apiary and when it gets there it goes directly to its own home without any mistakes and we talk very wisely and knowingly about the "homing instincts of the bee," but do not be led into believing that we really know anything about it. Because I am afraid that about all we know is to laugh at the poor Swiss peasant who paints the fronts of his hives in fantastic design so that his bees will find the right hive. Perhaps he laughs best who laughs last and the Swiss beekeeper may be right after all. Who knows?

When we contemplate the marvels of colonial life among the insects and the paucity of our knowledge of the warp and the woof of the intricate pattern that they make, we are filled with admiration of the blind Huber who taught us so much of the psychology of the bee. The intricacy of the problem is appalling but when we consider the benefits that might accrue to the beekeeper by their solution we are more inclined to buckle down to work and renew our efforts to solve them.

No wonder we feel like exclaiming with Maeterlinck: "The insect does not belong to our world." The other animals, even the plants, notwithstanding their mute existence and the great secrets which they jealously guard, do not seem wholly strangers to us. In spite of everything we have a certain feeling of terrestrial kinship with them. They may surprise, nay, astonish us, but they fail to upset the very foundations of our concepts. The insect, on the other hand, displays something that seems incongruous with the habits, the morals, the psychology of our globe. Apparently it comes from another planet, more monstrous, more vigorous, more demented, more atrocious, more infernal than ours. Vainly does it seize upon life with an authority and a fecundity unequaled here below; we can not accustom ourselves to the idea that it is part of the scheme of that nature of which we fondly believe ourselves to be the favorite children. With this amazement and this failure to understand is mingled, no doubt, a certain instinctive and profound feeling of dread imparted by these beings so incomparably better armed and equipped than ourselves, these containers as it were of compressed energy and activity which we vaguely feel to be our most mysterious enemies, our final competitors, and perhaps our survivors.

LIFE HISTORIES.

The general phases of the life histories of insects are usually well known but even here we find that there are many popular misconceptions. McCormack tells of a physician who laughed at the notion that house flies are but one stage of maggots for said he, "Have I not often seen little flies coming out of the ground in the spring." One of our largest potato growers believed that I was trying to fool him when I told him the "soft shelled potato bug" is but the grub of the "hard shelled potato bug" and he was not convinced until he had tried the thing out and carried the grubs through their changes to pupae and then to adults. Afterwards he said to me, "That is the most valuable lesson I have ever learned on the farm, for it has taught me that I have not seen what is about me every day."

We are inclined to smile at the ignorance of people in general as outlined by such examples as those quoted above but before we allow our smiles to become too broad perhaps it would be better to inquire into our own knowledge. We know or think we know the life histories of a few insects scattered from one end of the insect kingdom to the other but this knowledge is based chiefly on the study of a few economic forms. And too frequently these life histories have been worked out in our more northern states and apply only imperfectly or not at all to our southern conditions.

The wonders in the adaptations for carrying on the life cycle of insects are almost beyond belief and I wish that I had the space to recount many of them but time will permit citing only a very limited number. The time involved in completing a life cycle is apparently as varied as the species of insects themselves. I need only remind you of the cicada on the one hand, whose cycle covers seventeen years, while on the other hand we have the house fly with a complete cycle every nine to fourteen days, in the warmer parts of the year.

The complexity of the cycle is also very much involved. We have insects like the fish moth with no changes or metamorphosis on the one hand while on the other we have forms like the blister beetles with no less than eight distinct stages in its cycle. Between these two extremes are all grades of forms with almost every conceivable relation.

The following table will make these relations clearer than they would otherwise be:

THE LIFE-STAGES OF INSECTS

Group	Examples	Periods					
		Incubation		Growth*		Transformation	Reproduction
Ametabola (with no metamorphosis)	Silver fish	Egg	HATCHING	Young	SEVERAL MOULTS	Wanting	Adult
Paurometabola (with gradual metamorphosis)	Grasshopper Harlequin bug	Egg		Nymph		Wanting	Adult
Hemimetabola (with incomplete metamorphosis)	Dragonflies	Egg		Naiad		Wanting	Adult
Holometabola (with incomplete metamorphosis)	Butterflies	Egg		Larva		Pupa	MOULT Adult

* It should be emphasized that the number of moults during the growth period varies endlessly in different species though usually the same in any given species.

Yet I am sure that these dry as dust facts cannot impress you with the wonders of insects' life cycles. Neither do they answer the thousand and one questions that you might ask in regard to this subject. In the first place we might ask why is there any metamorphosis at all? And our answer is of course an indirect one as all that we can do is to point out its all but universal occurrence among insects and to call attention to the fact that the groups without metamorphosis are simply a small remnant of what was perhaps a mighty race,— a race not in the direct line of the ancestry of the higher insects but a branch from that ancient worm-like tracheated ancestor of the insects. The advantages of such a metamorphosis are many. It leaves the nymph, naiad or larva, the growing period free to assimilate food and store up energy while the adult is given excellent powers of locomotion so that it may roam far and wide searching for suitable feeding grounds for the next generation.

But why weary you further by recounting these thrice told tales when a few minutes spent in watching a butterfly emerge from its chrysalis or a larva change to a pupa will bring you closer to nature and impress you more with the wonders of metamorphosis than anything I might say.

THE TAX TO INSECTS.

Entomologists, especially economic entomologists, in our experiment stations and departments of agriculture, appreciate, in a vague way at least, the annual loss occasioned by insects but the figures are so startling and so beyond the realm of our ordinary everyday financial dealings that they make little or no impression. For instance I made recently a rather careful estimate of the loss to the farmers in North Carolina last year caused by insects and was somewhat startled myself to find that it totalled no less than $84,750,000.00, as shown by the following table:

Crop	1920 Value in N. C.	Per cent. Loss	Insect Damage
Corn	$110,480,000	10	$11,050,000
Tobacco	97,130,000	20	19,425,000
Cotton	68,750,000	10	6,875,000
Hay	35,000,000	10	3,500,000
Truck garden and crop	77,500,000	20	15,500,000
Wheat	20,000,000	5	1,000,000
Fruit	50,000,000	20	10,000,000
Forage	48,000,000	5	2,400,000
Animal and Animal Products	200,000,000	5	10,000,000
Forests	20,000,000	5	1,000,000
Stored Products	40,000,000	10	4,000,000
			$84,750,000

Enough to pay our $50,000,000 road bill and have enough left in one year to pay the ill fated $20,000,000 six year program for our institutions of higher education with a paltry $14,750,000 left. But I fear that most of us are not in the habit of dealing in millions of dollars and that these figures make very little impression on us. Perhaps it would be easier if we look at this as a tax. As a tax this means more than $40 for every man, woman and child in our state annually. Certainly more than the average tax for all purposes, state, city, county and town. Or let us look at it in another way. An observant entomologist will tell you that in the average year our crops suffer anywhere from 5 per cent to 30 per cent depreciation from the attacks of insects. Some crops suffering much more than others. This means that our farmers pay a tax each year of from five cents to thirty cents on each dollar's worth of crop value, a tax that would not be tolerated if it were levied by any political unit, national, state or county or for any purpose be it good roads, better schools or what not.

Yet this tax is levied so insidiously that we in the experiment station never hear about it and never know anything about it except by direct personal observation, save when insects destroy 75 per cent, 95 per cent or 100 per cent of the crop which happens time and time again sometimes to isolated farmers, sometimes to practically all of the farmers growing any given crop. I have frequently had tobacco farmers tell me that the flea beetle did no damage, while at the same time we were standing in the midst of tobacco beds covering three times the area that he would have had to have under cloth if it had not been for the flea beetle.

What of the labor of preparing the soil? What of the fertilizer used? What of the extra yards of tobacco cloth that he was required to purchase? What of the fact that he was raising here a hoard of flea beetles that would follow the plants when they were transplanted to the fields and seriously check their growth when they could least afford to have their growth checked? What of the fact that these insects continued to eat holes in the leaves throughout the growing season so that when the crop was placed on the market he was forced to sell at a lower price than he would otherwise have had to sell? What of the fact that careful experiments show that a flea beetle will eat more than fifty times its own weight in green tobacco every twenty four hours? Translate that into hay for an average cow or horse and think what it would mean if you had to feed them from two to three tons every day. I happen to be interested in a group of insects called leaf hoppers and in their efforts on pasture lands. Does it mean anything that we find as high as one hundred of these tiny insects per square foot? Our mountain farmer might answer no because the chances are that he has never seen a leaf hopper but is this the correct answer? Careful experiments show that these insects actually get more from our pastures than the animals that are being pastured on them.

With such enormous losses due to insects it might seem that entomologists were not keeping pace with the insects but I do not believe that this is true. A brief summary of some of the more important results of economic entomology might not be amiss. When we stop to consider the tons of arsenical poisons used in this country and reflect that this whole industry was initiated by the work of entomologists we get a glimpse of the importance of this phase of entomology.

In 1888 the fluted scale, which had been introduced into California from Australia, had practically ruined the citrus industry. However, the Department of Agriculture sent a representative to Australia where he found that the fluted scale was kept in check by a lady beetle. This lady beetle was introduced into California and in nine months time it had so checked the ravages of the fluted scale that the scale ceased to be a menace and the citrus industry of California was saved.

As you open your packages of predigested breakfast food, I wonder how many of you have noticed that they are carefully wrapped in oiled paper and I wonder how many people have tried to find the real reason for this. It is all done to control the grain weevils and was worked out by an entomologist who has by this simple means saved a great and growing industry.

These are but a few of the many illustrations that I might have drawn from the great field of applied entomology but they will perhaps serve to illustrate its many phases.

INSECT FRIENDS.

Entomologists lay so much stress upon the damage caused by insects that it is small wonder that the public is inclined to look upon insects as pests and nothing else. It was that eminent British Entomologist, Sir John Lubbock, I believe, who brought the opposite point of view to our attention forcibly by reminding us that he could make the world a place unfit for human habitation in less than a year's time if he had the power to remove certain insects from the world. Which is simply another way of saying that while we suffer much from the attacks of injurious insects we owe much to insects which are our friends and help to keep injurious insects in control.

Entomologists are having these matters forced upon their attention but apparently the general public misses the significance of the outbreaks of certain species of insects. The army worm is a case in point. Normally this insect is present every year but not in sufficient numbers to cause any appreciable loss to the farmer. Occasionally, however, the army worm becomes locally or generally abundant and causes wide spread destruction and alarm. Even a better illustration is offered by the soy bean worm. A year or two ago this insect threatened the destruction of the soy bean crop of this and adjoining states causing hundreds of thousands of dollar's worth of damage. Yet this insect is not even mentioned in standard textbooks of entomology and had never been a serious pest before. Why these sudden outbreaks of insect pests? The reply is that these destructive outbreaks represent what happens when the control exercised by their enemies is for any reason released. In other words it represents the condition that would prevail but for our insect friends.

"The following analysis of a typical outbreak of the army worm will show what usually happens. As is usual during such outbreaks, large numbers of Tachina flies were to be found in the fields laying eggs on the worms. With the intention of making a more careful study of these parasites 491 larvae were brought back and placed in cages. The following data gleaned from the records of these cages are presented as being of some interest. Of the 491 larvae, 442 were infested with the eggs of the dipterous parasite, leaving only 49 larvae,

or 10 per cent of the whole number, uninfested; yet 61 larvae were able to pupate. From these 61 pupae, however, only 7 adult moths emerged, showing a total mortality among the Army Worm from larva to adult of 98.6 per cent. And since 90 per cent of the larvae were infested with the eggs of this parasite, it would seem to indicate that, in this case at least, the parasitic fly was decidedly the most important factor in causing the high mortality of the Army Worm. In a few cases it was found that where only a single parasitic egg was attached to a larva, that the host was able to complete its transformations.

"The greatest number of parasitic eggs observed on a single larva was 12, with an average of 3 for the entire number (442) infested. The 442 infested larvae yielded 709 parasitic puparia, or an average of nearly two for each infested larva. The 709 puparia yielded 556 adult parasites. The greatest number of adult flies from a single Army Worm was four. These figures show that the mortality of the parasitic fly from egg to puparium was 52 per cent, and from puparium to adult 22 per cent, making a total mortality from egg to adult of 73 per cent.

"This shows that the tendency would be for the fly to continually gain in relative numbers, owing to the lighter mortality, and easily accounts for the complete subjugation of the Army Worm in normal years by this one natural enemy. No other parasites were found in the course of these experiments."

Since we are so dependent upon these insect friends perhaps it would not be amiss to inquire a little more closely into their life economy. For convenience we may divide the friends of man into two groups, predacious insects and parasitic insects but this is merely a matter of convenience and the line separating the two is by no means a sharp one. For example we might inquire whether the larvae of the solitary wasps mentioned in another connection were parasitic or predacious and while in general their behavior is that of a predacious insect there is little doubt that this is simply a further development of a strictly parasitic habit. Likewise the line separating the predacious insects from the plant feeding forms is not great. Some species seem to feed predaciously if insect hosts are abundant, but if not available they turn their attention to plants. Hence we feel safe in saying that the evolution of these habits have been from plant feeding to predacious insects and thence to parasitic insects.

Predacious insects are many and they have varied habits. Some are active and search far and wide for their prey like the ground bee-

tles and tiger beetles. Others are quiescent and construct traps for their prey like the ant lions. These curious fellows usually called doodle bugs construct funnel like traps in loose sandy soil and then take up their position at the neck of the funnel and wait for a luckless ant to tumble in. The ant thus starts a miniature land slide which the ant lion aids by throwing loose sand above the ant. Some are predacious only in the larval stage like the aphis lion or the aphis maggot, while others are predacious both in larval and adult condition like the lady beetles. The amount of food that these predacious insects will consume is often beyond belief.

"In order to determine something of the capacity of these insects for devouring plant lice and hence their degree of economic importance, I tried feeding the larvae of *Syrphus americanus* on cabbage aphids (*Aphis brassicae* Linn.) The aphids were touched to the mouth of a larva which had not been kept from food. A four-day-old larva devoured the first aphid in 4.5 minutes, a second, third, fourth and fifth, smaller than the first, in 2, 1, 1, and 0.5 minutes, respectively. The sixth, a larger one, was retained for 3.25 minutes. These were very thoroughly eaten, all the viscera and body fluids being picked and sucked out. After this the lice tendered were not eaten so closely, but killed, a seventh in 2 minutes, an eight in 1.75 minutes, and a ninth in 1.5 minutes." An average of less than 2 minutes for each plant louse or 240 per eight hour union day.

"It is, of course, not probable that any larva would ever normally devour aphids so rapidly. Yet when plenty are at hand the number eaten by a larva during its life of eight days to two weeks or more must be very considerable. It should be kept in mind also that it is not the actual individuals eaten, alone, that determine the amount of benefit from these insects; but the fact that in this way the production of enormous number of aphids is prevented. If, as Reaumour has calculated, and others have substantiated, one aphid may be the progenitor of over 5,000,000,000 individuals during her existence of a month or six weeks, we can see at once the important benefit that must arise from the destruction of one or two of these aphids early in the establishment of the colony. It is a fact that the eggs of Syrphidae are often deposited on the host-plant very early or even in anticipation of the arrival of the aphids." (C. L. Metcalf.)

On the other hand the small amount of food on which these insects seem to be able to survive is almost beyond belief. I shall never forget a deserted wagon road below Carolina Beech where both tracks

were crowded with the funnels of the aphis lion. These funnels averaged more than four to the foot in an open space about 150 feet long between a woods and a swamp. The chances of an ant traveling that road were certainly slim, but the chances of an ant lion getting very many full meals must have been correspondingly slim. Yet each one of these little fellows had moved nearly a cubic inch of earth in constructing his funnel.

As important as these predacious insects are, they are by no means as important as the parasitic insects. Allusion has been made to the Tachina fly and the army worm. In addition to these parasitic flies there is a large group of parasitic wasps which are among the most important of the parasitic insects. Many of these forms are so small that very little is known about them. And I think I would be justified in saying that they are perhaps the least known of all of the insects. Yet we are gradually accumulating knowledge of these forms and some of the more important points are perhaps worth reporting here. We have among the parasitic wasps many parasites of the egg, larval and pupal stages of insects, but cases of adult parasites are not so common. Sometimes the egg of the parasite is laid in one stage but does not emerge as a perfect insect until a later stage. Usually the parasitic stage is confined to the larva which feeds upon its host while living within the appropriate stage of the host, but sometimes the parasite really lives externally as is the case with certain parasites of the gloomy scale which we have under investigation. Here the adult parasite lays her egg or eggs under the scale covering of the host. The larval parasite attaches itself to the host and sucks it dry just as a predacious aphis maggot devours a plant louse. When it has completely destroyed the scale it changes to a pupa and thence to an adult. The adult cuts a neat circular hole through the scale covering and makes its escape. One of the most interesting points about this parasite is the apparent ability of the female to tell the scale insects that have been parasitized. Although I have watched upwards of 150 of these parasites under the high power binocular I have yet to find a case where one has made the mistake of ovipositing upon a scale insect that is parasitized. It is exceedingly interesting to watch the business-like way that these little fellows have as they pass from scale to scale tapping each one with their antennae until they find a suitable host, then slipping the delicate ovipositor under the scale covering depositing one or two or three eggs and passing on to the next victim.

Among the many interesting things about these parasites not the

least interesting is the small size of many of the forms. This is especially true of some of the egg parasites which are among the smallest known insects. Imagine an insect small enough to pass all of its stages in an insect egg not much larger than the period in ordinary newspaper print and you will have a proper conception of their size. Then when you remember that each adult is furnished with a pair of eyes and a pair of antennae, three pairs of legs and two pairs of wings, with mouth parts and a digestive system, with a nervous system and sense organs and is endowed with instincts enough to feed on the nectar of flowers and to mate and to lay eggs in the proper host at the proper time; and all this in an insect not over ¼ mm. long or so small that one hundred of them placed end to end just equal an inch; with these facts all before you you will have a proper conception of the marvelous ability of nature.

I cannot pass the subject of parasitism without mentioning two special phases of insect parasitism, polyembryony and hyperparasitism. Polyembryony is that condition in which one egg gives rise to more than one adult individual. It is known to occur in many groups of the animal kingdom, for example, the identical twins of man and other mammals, the quadruplets of the armadillo and others. But this condition reaches its greatest development among insects where Patterson reports not less than 395 individuals from a single parasitic egg.

Hyperparasitism is even more wonderful than this for here we have the case of one parasite preying upon another. We have not only the primary parasite which preys upon the host but a secondary parasite preying upon the primary parasite and a tertiary parasite upon the secondary parasite and apparently in rare cases a quarternary parasite preying upon the tertiary. Can anything more involved be imagined? And can man ever hope to unravel the intricacies of the relations that must exist in such elaborate cases of hyperparasitism?

ECOLOGICAL RELATIONS.

The realm of ecology is as broad as the sum total of all of the factors that touch an insect during its life. It is therefore not surprising that we know so little about the ecological relations of insects. The temperature relations are perhaps the only ones that have been investigated with any degree of thoroughness and here our firm ground consists of a series of critical high and low temperatures for a few economic

forms. These critical temperatures are of great economic importance in the control of insects of stored products and hundreds of thousands of dollars worth of furs are now held at low temperatures during the summer months thus avoiding attacks of moths. While, at the other end of the temperature scale, we find many of our largest flour mills provided with special heating apparatus so that the temperature of the mill may be raised beyond the critical point for mill insects. When it is remembered that temperature is intimately related to humidity and other factors it is perceived that the problem is an exceedingly complex one and one that will have to await better facilities for controlling these factors than any as yet available. Perhaps the most interesting single bit of information as yet gleaned from the many important ones relative to the temperature factor is the knowledge that certain species of plant lice will withstand a much lower temperature than their parasites. Hence they are able to survive and continue to breed in cool weather whereas the development of the parasites is checked, thus the plant lice gains the upperhand of their parasites and do widespread damage to crops during cool weather, but if the weather is warm the parasites gain the upper hand and keep the plant lice in check.

Humidity is perhaps next to temperature, the most important single factor in the ecological relations of insects. Here again we have practically an unexplored field and outside of the knowledge that many insects require a relatively high humidity for their best development, our knowledge is rather limited. The fact that air passed through certain strengths of various salt solutions and solutions of certain acids can be given almost any percentage of humidity required is of great service to the entomologist and opens up a fertile but practically untouched field.

In addition to the above problems of the ecological factors, which may be called laboratory ecology, there is another realm to which I desired to call your attention namely, field ecology. In field ecology we are not concerned with the individual factors but with the environment as a whole. In other words we take our selected area as we find it in nature and try to analyze it by determining the dominant species and then determine the reasons for their dominance. The whole of economic entomology may be said to belong to the field ecology of insects but field ecology of insects is broader than economic entomology for it is concerned not only with economic forms but with others as well.

For the past few years I have been giving some attention to a problem in field ecology that is very interesting to me and perhaps a statement of this problem will do more than anything else that I might say to make the whole matter clear. We have along our ocean front, our sounds, bays and rivers a narrow strip of land that is flooded twice each day by the rising tide. This strip of land may be known as the tidal zone. The part of the tidal zone lying along the ocean front where it is affected also by the direct action of the waves may be known as the strand. While that portion of the tidal zone along the sounds, rivers and bays where it is not much subjected to wave action may be known as tidal belt. While these two areas may be generically related yet they are very distinct. The strand is usually devoid of vegetation and is frequented by a group of animals that we will call beach combers. All of them are scavengers and they feed upon whatever the ocean may cast up before them. Their existence would seem to be a precarious one but when we note the abundance of beach fleas, sand scabs, ghost crabs and beach tiger beetles we are inclined to believe that nature must be very lavish with them after all.

The tidal belt is far more interesting to us, however, chiefly because it usually supports a luxuriant growth of sedges and grasses which in turn support a wealth of leaf hoppers and plant hoppers which are my special interest in all of the groups of insects. The ecological relations of some of these insects are most interesting. Here we have strictly terrestrial air-breathing arthropods living in an environment that is strictly aquatic for longer or shorter periods twice each day. Here we have strictly terrestrial forms living in close proximity to strictly aquatic forms like the sea snails and fiddler crabs. Naturally we wonder why these insects have adopted this habitat. Perhaps we can explain it by stating that these insects attached themselves to their host plant when it was a xerophyte and simply followed it into its half hydrophytic environment. This may be historically correct, but whatever is the past history of this peculiar relation we know that it is not simply a strict host relation at the present time but it seems rather a matter of fixity of environmental factors. This is borne out by the fact that one of the most abundant species of plant hoppers in the tidal belt region lives on no less than three species of grasses and one sedge. Another species was described originally from Long Island where it was secured from a species of the genus Spartina but on our coast where Spartina is replaced by the sea oats (Uniola) the same species of the plant hopper occurs on the Uniola and occupies

the same situations. So much we know but there remains a vast deal more to be found out. Are these species limited in their zones by the amount of submergence that they can withstand? What are the physiological characters that make it possible for these species to survive such an environment whereas their generic relatives are confined to xerophytic habitats? These and many other questions we might ask but only time and an unlimited amount of field work can give the answer.

There is another ecological relation that it seems to me would be worth pausing to consider and that is the relation of insects to their hosts. The relation of insects to their animal hosts I have discussed in another connection under parasitism so that there is left for our consideration at this point the relation between insects and their plant hosts. This is a broad subject in itself and one deserving of more consideration than I am able to give it here.

Some insects are so limited in the selection of their hosts that it is safe to identify the insect from the host on which you find it; while other insects apparently will eat anything that is green. We have in some cases whole families of insects limited to a narrow group of plants in their host relations, for example the Coleopterous family Bruchidae confines its attacks to the seeds of the Leguminosae. On the other hand we have species that are structurally closely related feeding on widely diverse plants. In fact these relations are so marked that they have been used to correct our phylogenetic notions. Thus the botanist may use insect species in determining the relationships of his plant forms and the entomologist frequently corrects his taxonomic concepts on a purely botanical basis. Naturally such relations cannot fail to impress the serious student and leave him with a vague feeling of dissatisfaction at his failure to answer them. Thus I have puzzled my mind for many hours in the hope that I might be able to answer the question, why does the gloomy scale occur on soft maples in destructive numbers yet be practically absent from hard maples? Is it simply a difference in the thickness of the bark in the two groups of maples, or is it a difference in the chemical composition of the sap? Whatever the answer, the selection is remarkably clear cut because we frequently see rows of hard maples with a few soft maples interspersed in which the hard maples are free from scale and thrifty whereas the soft maples are dead or dying.

There is another series of ecological relations that is deserving of more than passing attention. I have already referred to that com-

plex chain reflex which causes the adult female insect to deposit her eggs so that the newly hatched young will find an abundance of food close at hand for its sustenance. These relations are easy to understand in those insects where the young and the adults feed upon the same host but they become increasingly difficult to understand as we pass to those adults which either do not feed or feed upon an entirely different substance. For example the adults of the order Lepidoptera, the butterflies and moths, feed on the nectar of plants for the most part yet their larvae feed upon roots, stems, leaves or seeds of plants or on animal products. The eggs must be laid in close proximity to such food or the larvae would perish and the species would vanish from the earth. What is the mechanics that brings this very desirable conclusion? We may answer that this series has become hereditarily instinctive but when we do so we are merely clothing our ignorance in a mass of verbiage.

The climax in this series of complex reflexes is reached among the solitary wasps to which I have alluded in another connection. This complex may be pictured briefly and in a somewhat generalized way as follows. The female wasp digs a burrow in the soil. She goes away and searches until she finds the proper prey, be it cicada, horsefly, caterpillar or spider. She pounces upon it and stings it in the thoracic ganglia so that the prey will be paralyzed but not killed, for if the prey were killed it would decay before the egg hatched and the young larva would starve to death. She drags or carries the prey back to the burrow, often a considerable distance, and by means of some sense that is beyond human understanding she locates the burrow and deposits her prey; lays her egg; closes the burrow and, wonder of wonders, has the time and the patience to conceal the entrance of the burrow by making it look like the surrounding territory. If in hard ground she seeks out a small pebble and pounds the loose dirt down until it blends in with the surrounding territory, or if in a tidal flat with a crust of salt she finds a bit of crust to cover the entrance. Such in brief is the story, but who has the insight to unravel the maze of ecological factors that are woven into such a complex?

Another series of ecological adaptations that is so common that it causes no comment is the relation between pollination and insects. Here we are confronted with a case of parallel development that if it were not so common or if it existed only in the South Sea Islands would be one of the wonders of the age, but because we see it everywhere about us, because it is the rule rather than the exception, it arouses

no more comment than the rising of the sun. Yet the elaborate floral devices, the presence of artfully concealed nectaries on the one hand and the presence of long tongues and pollen baskets among the insects show an evolution that must have been carried on for untold ages. And how dependent one group is on the other and any failure of the one group must necessarily mean the extinction of the other. I wonder how many such cases of sad wrecks we might find if we could reconstruct the past geological ages.

The highest form of interdependence is found perhaps in the case of the Yucca and the Yucca moth.

"The flowers of the species of Yucca are absolutely incapable of self-or-wind-pollination, and the stigma is so situated that no ordinary insect visitor can reach it in a casual search for food. In some localities, it was observed that the common Yucca never produced seed and that wherever seed was produced, almost every pod was infested by a little caterpillar that destroyed a greater or less percentage of the seeds. The parent of this caterpillar is a small white moth, the Yucca moth, in which the mouth-parts are curiously modified and utterly unlike those of any other moth species that we know. At the sides of the ordinary tongue there are developed a pair of flexible processes set with little pegs and spines, and capable of being coiled like the tongue itself. When the female, which alone has these processes, is ready to lay an egg she enters a Yucca blossom, gathers a little mass of pollen, rolls it into a ball, carries it by means of the processes to the pistil, and rams it down so as to bring it into direct contact with the receptive surface. Not until this has been completed does she turn and then into the ovary or embryo seed pod, she forces an egg by means of a slender, sharp-pointed ovipositor. She is now ready to repeat the process on another flower and she does repeat it until her stock of eggs is exhausted. Here we have a deliberate pollination preceding oviposition, as if the insect knew that it would be useless to lay an egg until the possibility of development in the seed pod was assured.

"This peculiarity, though confined so far as we know to the genus Pronuba, is not confined to one species only. There are a number of Yuccas in the country, including the giant or tree Yuccas of the southwest, and for every species of Yucca there is a species of Pronuba. Surely a most wonderful adaptation of insect and plant, neither of which can exist without the other.

"And yet, while the adaptation is not so specific, nor the evidence of design so apparent, the dependence of red clover upon long-tongued

bees is not less absolute. Australia has no native bumble-bee, and red clover was unknown there until the colonists began to cultivate it. There was no difficulty in making crops of forage; but it would not seed. Importing seed annually was expensive, and, naturally, the Australians were anxious to raise their own. This led to a study of the reasons for the failure, in the course of which the dependence of the plant upon bumble-bees was established. The remedy was obvious, and now European bumble-bees disport themselves among the Australian red clover, seed is plentiful, and interference with bumble-bees is a crime—as it should be rated everywhere.

"There are many others among the Hymenoptera that are useful in the work of pollination because of their habit of feeding among the flowers, even if not on them; but all this is based on the same visits which the flower encourages and of which it takes advantage; but no account of this sort of relationship could be considered even passably complete without some reference to the complicated relationship existing between the Smyrna fig and the minute little Blastophaga, a species whose life relations have been beautifully worked out.

"The Smyrna fig of commerce depends for its edible quality upon the ripened seeds that it contains. The fig is not really a true fruit as that term is generally defined, but is a thick fleshy envelope within which the flowers are contained. In the Smyrna fig these flowers are all female and no pollen is produced anywhere on the tree. Left to themselves, such trees could never produce ripe fruit, and that was the condition of the Smyrna fig orchards in California, prior to 1900. In the Mediterrenean countries, whence our commercial supply is derived, there are found beside the cultivated also several varieties of wild or caprifigs, which produce three crops of fruit during the season. These fruits contain male flowers, producing an abundance of pollen; but this pollen is never naturally discharged from the envelope containing the florets.

"Yet it was recognized by the fig-growers in the Orient that to obtain fruit of the commercial edible varieties, it was necessary to bring to them when in bloom, branches containing fruit of the caprifig, which were usually hung up in the tree which it was intended to fructify. This work of pollination is accomplished by the Blastophaga already referred to, although, far from benefiting itself in the process, the insect dies without even being able to continue its kind.

"In the caprifigs the female flowers are replaced by little gall-like swellings in which the larvae of the Blastophaga develop. One gene

ration of figs, the so-called 'mammae,' remain on the trees during the winter and by the time they are ready to drop, there is already on the trees a new or spring crop of fruit, known as the 'profichi.' By the time that this crop is in proper condition, the insects that have hibernated in the 'mammae,' are fully developed, the wingless and almost blind male Blastophaga has fertilized the female before she is even out of her cell, and the latter, leaving the dried-up fig by the small anterior opening, makes its way into the new figs, to provide for a new generation. In the 'profichi' this generation matures at the time the commercial Smyrna fig is in proper condition and the females, emerging pollen covered from the 'profichi,' enter the small opening of this true female flower receptacle if they find themselves in a tree bearing them. But in this Smyrna covering all the female florets are fully developed, and the gall-like swellings that replace them in the caprifigs are absent. The insect therefore moves about over the entire interior surface of the pouch, seeking a place to oviposit, and in the process distributes its load of pollen everywhere. It eventually dies without reproducing, and usually without even being able to make its way out again. But though the insect has lost its life, the tree has gained; and the seed pouch that we know as the fig, comes to maturity and ripens seed.

"At the same time that the Smyrna fig which produces the edible commercial fruit is in bloom, there is also another crop developing on the caprifigs, and these are known as 'mammoni.' The Blastophaga issuing from the 'profichi' on the same tree, naturally enter these fruits which are of the same character as the preceding crops, and are able to continue their kind, coming to maturity when the third crop is ready for their reception. This third crop represents the 'mammae' or over-wintering form, from which the 'profichi' of the following season are again entered by the Blastophaga.

"Here we have an extremely complicated relationship which, reduced to its simplest terms, means that in order to produce the commercial Smyrna fig there must be suitable caprifigs producing 'profichi' infested by Blastophaga, at a period corresponding to the development of the female flower capsule. And as the insects are very small and very frail, the caprifigs must be either well distributed among the Smyrna trees, or the infested 'profichi' must be gathered and distributed among the trees to be pollenized.

"This account makes interesting reading and shows how, after many trials and much painstaking investigation, the Blastophaga and the necessary caprifigs were finally introduced into the fig-growing

districts of California, and how a new industry, absolutely depending for its continuance upon a minute hymenopterous insect, was finally established upon a firm and scientific basis.

"How many cases of this kind exist among plants having no present economic value it would be difficult to estimate, and how so complicated a relationship ever became established is not yet explainable even by a theory." (Smith).

Fearing that I may weary you I am nevertheless impelled to point out another ecological relation that borders upon the marvelous. I refer to the relation between gall insects and their galls. We have here another case of parallelism in evolution. The galls range from simple folds of the leaf or simple enlargements of the stem to most elaborate and wonderful structures and the insects themselves are scattered in many orders. The most wonderful phase of the whole subject of galls and gall makers is the fact that the galls are absolutely specific. It is much easier to determine the gall maker by the gall that it makes than it is by the insect itself. Just what are the factors that cause any given cynipid gall, for example, to have the same form regardless of what species of oak it is found on? Just what is the stimulus that causes some galls to develop their form completely before the egg hatches? In addition to these perplexing questions we have the whole problem overlaid with the problem of parthenogenesis and alternation of hosts we can appreciate that we have here a problem that demands the best that any biologist can give. And the biologist who tackles these problems may rest assured that the field is broad enough to demand the best efforts that he can put forth.

CONCLUSION

Having considered briefly the past accomplishments in entomology it may be worth our while to turn our attention in another direction and ask ourselves what of the future. I do this because we are somewhat prone to think that all that is good, all that is worth while lies behind us. Having lived through an age that has seen the development of the automobile, the telephone, the aeroplane, wireless and half a dozen other world astounding inventions we are inclined to think that all the great inventions and discoveries have been made and that there is little left to do. Which reminds me of a personal experience that will perhaps make the matter clearer than anything else that I might say. When I was a senior in high school I was told that for good and suf-

ficient political reasons I could have an appointment to West Point if I could pass the examinations. I was persuaded not to do this by the Superintendent because, said he, "All the great wars have been fought, and you are not the type of young man that would care to hang around an army barracks all your days." Needless to say I agree that I am hardly that type of man but I also imagine that very few of the graduates of West Point in the class of 1907 spent many days hanging around army barracks from April 1917 to November 1919. I remember telling this story to my old teacher of Zoology and he said that when he told his Professor of Natural Sciences that he expected to go into Zoology his teacher tried to discourage him. "For," said he, "now that Darwin has announced his theory of Natural Selection there is nothing left for the zoologist to do."

I cite these two instances because they illustrate so well an all too prevalent opinion in all fields, a feeling that is far too prevalent in a new field like entomology where the pioneers have been over the ground and harvested the first rich harvest not realizing that these same pioneers have left many corners untouched and have left abundant harvests yet to be garnered. That such a feeling should be still prevalent in applied entomology in the face of such enormous losses as have been pointed out above or in the face of the fact that tons of honey go to waste each year and bees are needed to gather it, is indeed hard to realize. That such a feeling should be prevalent in pure entomology when we realize how Morgan has advanced the science of genetics by breeding fruit flies, or when we consider what there is yet to learn about the anatomy, the physiology or the ecology of even our most common species is hard to understand. Except perhaps there is the notion that the pioneers had an easy time when we think that, no matter which way they turned, they were almost certain to stumble into unexplored fields. While if we want to be sure that our work is not simply a repetition of something that someone else has done much better we must wade through a mass of literature often mountain high to discover nothing at the bottom. Forgetting for the time being that they had no great laboratories fitted with the finest of microscopes, microtomes, ovens, cameras and utensils of all kinds, that they had no libraries, no collections and very little appreciation. While we have all of these things. Forgetting that most of the pioneers had to steal their time for research from their families or from their sleep. While all that it is necessary for us to do is to steal the time from our classes or other official duties.

With all of these things in mind, I cannot help but feel that in spite of the past brilliant record of entomology there are better things just ahead of us. That undiscovered laws of life are awaiting the searching eye of the worker in entomology. That as yet unheard of methods of control are about to be discovered, making it possible for us to reduce the tax we pay to insects to a negligible minimum, thus making possible an expansion in food production as yet undreamed. Feeling this way, I cannot help wondering if the world will be ready for these discoveries when they are made or will they lie buried as Mendel's work remained forgotten for nearly half a century? Will we accept them at their true value or will we cast them aside as worthless? The Hindoos have a legend that illustrates our present tendencies very well indeed. A young man had an iron bracelet placed on his wrist one morning and was told that on a certain beach there was a stone that would turn the bracelet into gold. So he hastened out in the morning light and commenced to pick up the pebbles one by one and touched them rapidly to the bracelet and observed the results with a critical eye. Thus he labored all through the long morning of his youth but as the sun climbed higher and higher, as the day got hotter and hotter, his speed slackened and he commenced to ask himself if it was really worth while. Wasn't the whole thing a hoax any way? Certainly no one but a fool would believe that you could turn an iron bracelet into gold. Thus he labored through the noon-time half persuaded to stop but as the day advanced and his shadow got longer to the east and as he realized that the day was fast slipping away, he commenced to work with renewed energy that gradually changed to frenzy as the shadows of evening began to creep up from the valleys. And then as he looked down in the half light he noticed that the bracelet had indeed turned to gold. But he also realized that in his haste and in his carelessness he did not know which was the magical stone.

RALEIGH, N. C.

THE GENUS RASPAILIA AND THE INDEPENDENT VARIABILITY OF DIAGNOSTIC FEATURES

By H. V. Wilson

The genus Raspailia (Nardo, 1833, 1847; O. Schmidt, 1862, p. 59) was classed by Ridley and Dendy, 1887, p. 188, in the Axinellidae but transferred by Topsent, 1894, to the Ectyoninae. In this Topsent has been generally followed, including Dendy, 1895 (p. 46), who here regards the genus as intermediate between the two groups. Dendy later (1905, p. 172) departs from this view and regards the resemblance of Raspailia to the Axinellidae as strong but superficial. Hentschel (1912, p. 413) brings out the skeletal resemblance between the Ectyonine genera centering round Raspailia and certain Axinellidae, and inclines to regard it as due to kinship and not to convergent evolution, thus maintaining the position of Dendy in 1895. Vosmaer, 1912, keeps Raspailia alongside of Axinella, Phakellia, Acanthella, and Phacanthina, thus indicating his belief in a relationship to these genera. George and Wilson, 1919, pp. 160–161, in describing *Axinella acanthifera* regard it as intermediate between typical Raspailias and Axinellas. In this species there are some acanthostyles and the dermal brushes include a few long slender styles, but the habitus is lamellate, and the skeletal framework of the same type as in *Axinella verrucosa* (Vosmaer, 1912).

In delimiting Raspailia more precisely, Vosmaer, 1912, p. 313, takes the Mediterranean *R. viminalis* (O. Schmidt, 1862, p. 59) as embodying the characteristics of the genus. The characters emphasized are: the axial skeleton is a funis (a reticular bundle composed of elementary fibres or funiculi) with wide meshes, component funiculi thin, spicules wholly or almost wholly imbedded in spongin; from this, slender and short extra-axial funiculi (radial fibres), composed of one, two, or three spicules cemented together by spongin, radiate to the surface, where each terminates in a single large style or subtylostyle, projecting far beyond the surface, surrounded at its base by a tuft of diverging small spicules, generally styles, sometimes oxea. Acanthostyles occur, dispersed in the parenchyma and echinating the funiculi. Skeletal megascleres, chiefly long, slender styles, occasionally tylo-

styles and strongyles, also generally oxea. Habitus cylindrical, long and slender, branching or not branching.

The long, slender, cylindrical habitus, with skeletal framework on the general axinellid plan, and the presence of acanthostyles have been regarded by many (Ridley, Ridley and Dendy, Dendy,) as the chief distinguishing characteristics of the genus. The acanthostyles may entirely disappear but the other characteristics remain, as in subgenus Syringella Ridley (1884, p. 460). Examples are: *Raspailia syringella* O. Schmidt (1868, p. 10) and the two species described by Ridley, loc. cit. In *R.*[*Syringella*]*falcifera* Topsent (1890, p. 12; 1892, p. 124) the habitus is fairly typical, and the dermal skeleton adheres to the *R. viminalis* type. In *R.* (*Syringella*) *rhaphidophora* Hentschel (1912, p. 371), the habitus is typical, save that the branches are generally compressed; instead of radial fibres, there are radial partitions (lamellae); dermal skeleton of the *R. viminalis* type; megascleres, styles, oxea, strongyles; microscleres present in shape of bundles of rhaphides. In *R.* (*Syringella*) *nuda* Hentschel (1911, p. 383) the habitus is typical; axial skeleton with radial fibres; dermal skeleton as in *R. viminalis.* All these forms make it plain that the general practice with respect to Syringella is correct and that such sponges are really members of the Raspailia group in which the acanthostyles have been lost, and should not be relegated on a technicality to the Axinellidae while Raspailia is referred to the Ectyonidae. Nevertheless Topsent (1904, p. 138) takes this position. Pick's position (1905, pp. 18–19) is different and is not opposed to the argumentation of this paper, for while assigning to the Syringella forms the dignity of a genus, he keeps the latter alongside of Raspailia.

A consideration of a number of the species usually assigned to Raspailia makes it plain that Vosmaer's generic concept cannot be applied in all of its details, especially in the matter of the dermal skeleton and the greatly reduced radial fibres. On the other hand the slender, elongated, cylindrical shape of body, sometimes branching, sometimes not, on which Ridley and Dendy (1887) laid chief emphasis, while common, is by no means constant. In fact, in this group of forms, as elsewhere, the characters have varied independently during the course of evolution, thus giving rise to several combinations. A generic concept of Raspailia, to be useful, must take into account the existence of these combinations, and cannot insist absolutely on the slender cylindrical habitus, dermal bunches of spicules such as occur in *R. viminalis,* monactinal character of the megascleres, or on the acantho-

styles. And yet this is what the recent definitions of the genus do, with the result that Dendy's definition (1905, p. 172) would exclude forms that are admissible on the definition of Vosmaer (loc. cit.) or of Hentschel (1911, p. 381), and *vice versa*. Of course the difficulty is well known. It is a difficulty offered everywhere by nature.

A considerable number of species, over thirty, have been referred to this genus. A good many of them are excluded by Pick in his essay on Raspailia (1905). He would delimit the genus somewhat more narrowly than is intended in this paper. Taking R. *viminalis* as a standard, some of the chief divergencies within the genus may be enumerated. It is to be regretted that in a number of the old species the data given do not permit a decision with regard to several of the features.

Habitus.

The long, slender, cylindrical habitus, "whip-like" in Ridley and Dendy's terminology, branching or not, is common. But it is departed from in a number of species. For example, while the habitus is branching and subcylindrical, the branches are comparatively short and stout in several of the Dictyocylindrus (Raspailia) species described in Bowerbank's British Sponges, in *R. ramosa* and *R. pumila* e. g. In *R. paradoxa* Hentschel (1911, p. 381), the habitus departs widely from the typical, the sponge consisting of several somewhat flattened lobe-like divisions, which arise together from a common base and expand above. Again in *R. irregularis* Hentschel (1914, p. 121) the habitus deviates markedly from the typical, the sponge being club-shaped.

Skeleton.

The axinellid type of skeletal framework consisting of an axial column and radiating fibres may be thought of as constant in Raspailia. Deviations from the precise form of skeletal framework found in *R. viminalis* are however common among the species that have been referred to this genus. Some of them may be enumerated as follows: In *R.* (*Syringella*) *clathrata* Ridley (1884, p. 461) the radial fibres are thick, not reduced as in *R. viminalis*. In *R.* (*Syringella*) *australiensis* Ridley (loc. cit. p. 460) also the radial fibres are thick and project at the surface, but the surface tufts are not said to be of the *R. viminalis* type. In *R.* (*Syringella*) *rhaphidophora* Hentschel (1912, p. 371), the radial fibres are represented by lamellae. In *R. bifurcata* Ridley (loc. cit. p. 459) a radial fibre and dermal tuft are together represented by a long style or a tuft of long styles which project at the surface (a more

reduced condition than in *R. viminalis*). In *R. hornelli* Dendy (1905, p. 172), the dermal tufts in which the radial fibres terminate include a few long styles, instead of one, surrounded by shorter ones; another deviation is made in the presence of connectives between the radial fibres. In *R. irregularis* Hentschel (1914, p. 121) the large dermal projecting spicules are in bunches and not singly as in *R. viminalis*.

In *R. flagelliformis* Ridley and Dendy (1887, p. 190), the radial fibres, apparently not especially slender, terminate in projecting tufts of small spicules; habitus is typical but if we lay stress on the dermal skeleton the species must be removed to Axinella. In *R. cacticutis* Carter (Dendy, 1895, p. 48), there are no surface tufts of spicules, and the species would best be assigned to some other genus, as Pick (loc. cit.) has done.

The *R. viminalis* type of dermal skeleton is known to occur in a number of species, and it may also occur in some of the older species for which the data are imperfectly given.

Spicules.

The skeletal spicules in the genus are smooth and in general styles, varying to tylostyles, but oxea and strongyles may occur intermingled with the styles (*R. viminalis* Schmidt, *R. bifurcata* Ridley, *R.* (*Syringella*) *rhaphidophora* Hentschel). A marked deviation is afforded by *R. vestigifera* Dendy (1895, p. 47; assigned by Pick, loc. cit., to the closely related genus, Echinodictyum), in which the skeletal spicules are oxea, except the small spicules of the dermal tufts which are inequiended and more or less stylote; in this species the radial fibres are stout, but the dermal tufts adhere in plan to the type of *R. viminalis*; acanthostyles are very rare and in this sense vestigial.

The acanthostyles may be almost (*R. vestigifera*) or quite absent, the species in which this loss has occurred being grouped together as a subgenus (Syringella). Microscleres in the form of bundles of rhaphides, may occur as in *R.* (*Syringella*) *rhaphidophora*; in general, absent.

The facts being so, it would seem advisable to recognize Raspailia as a comprehensive, heterogeneous genus, and to include in the diagnosis the chief lines of variation, about as follows:

Raspailia Nardo

Habitus often slender and cylindrical, branching or not; but the branches or unbranched stem may be comparatively short and stout, or the branches may even appear as flattened lobe-like divisions. The

skeleton is on the axinellid plan, including an axial dense aggregation of spiculo-fibres from which radial fibres pass outward. The radial fibres may be comparatively stout, sometimes expanded and forming lamellae, or may be reduced to one or a few spicules, or may even disappear as structures distinct from the dermal brushes in which they terminate. Connectives between the radial fibres generally absent, occurring only in a few species. The dermal brushes characteristically include one or a few long megascleres surrounded by numerous shorter ones, but the entire brush may be represented by one or a bunch of long megascleres, whereas in Axinella the radial fibres terminate "in tufts of diverging spicules slightly smaller than the bulk of the spicules" (Vosmaer). Skeletal spicules smooth and characteristically monactinal, but diactinal forms (to be looked on as variants of the type) are frequently intermingled, and in rare cases most of the spicules are diactinal. Acanthostyles characteristically occur, echinating the skeletal fibres and scattered, but in some species they are greatly reduced in number, in others absent (subgenus Syringella). Microscleres generally absent but may occur as bundles of rhaphides.

In considering a generic concept such as that just formulated one must remember that classification is no mere mechanical assorting, a putting of like with like. That much of it is easy and delightful, but the fact that the features used in the classification of a group are or may be independent variables, that is, may occur together or some may be absent or greatly modified, makes classification more dependent on argument than is generally recognized. Often, to be sure, no argument is conclusive, in the end there being several options about equally good. In such a case some consensus of opinion as to the best, most useful, practice is desirable. All this applies to the delimitation of such genera as Raspailia.

One other consideration must be kept in mind in considering such generic concepts, and that is that variation may have proceeded in such a way as to make it quite impossible, in the present state of our knowledge of diagnostic points, to recognize the relationship of a given species to the genus. If, for instance, the acanthostyles are lost, a typical habitus and dermal skeleton would still show the relationship, or even the peculiar dermal skeleton might be accepted, in the absence of acanthostyles and typical habitus, as a safe index. But the dermal bunches, as we have seen, may also vary from the type, and if habitus, peculiar dermal skeleton, and acanthostyles all go, nothing remains to show the relationship. I take it that such eventualities may have

actually happened, since, it would seem, we must recognize as a real i. e. natural, process the independent varying of characters. This consideration brings with it the conviction that classification in its details cannot be a completely satisfactory guide to relationship. Minor uncertainties will occur everywhere.

The only species of Raspailia recorded for our waters (North America and West Indies), are the following:

R. hamata O. Schmidt (1870, p. 62), West Indies. The diagnosis is very incomplete and Schmidt puts a query as to the genus. But the species, which is of typical habitus, is probably to be referred here. (*R. tenuis* Ridley and Dendy, 1887, p. 188, occurs off the Brazilian coast in shallow water to twenty fathoms).

R. acanthifera (George and Wilson), North Carolina coast (Fort Macon Beach). Somewhat reluctantly I conclude that this species originally referred to Axinella shoud be transferred to Raspailia, because of the presence of acanthostyles and the character of the dermal brushes, which consist of a bunch of ordinary styles together with one to a few long ones projecting far beyond the others. The species is to be regarded (cf. George and Wilson, 1919, p. 160), as a connecting link between Raspailia and Axinella.

When one speaks, as in this paper, of the independent variability of structures, it is not meant to imply that any part of a body is really an independent variable. It would rather seem from all that is known concerning racial differences, that where a race has varied from the ancestral type in one feature which is conspicuous from our present view-point, it has probably come to differ from the type in a great many other features, although these may become known to us only gradually as we become intimately familiar with the race in question. It is possible and convenient to refer, as I and others have pointed out, all this kind of variation in natural races to the gene theory, since in contemporary speculation a gene is a germinal unit which, like a molecule in a radical, may influence the organism (compound) in many different directions.

A good case of close correlation between specific characters in the matter of variability has been pointed out in recent years by Hentschel (1913 a, b), who has shown that in the silicious sponge Mycale (Esperella) a large number of characters ("character values" as Hentschel calls them, representing the concrete realizations of a schematic character, itself an abstraction drawn from a survey of the several

realizations) are co-dependent, all varying, or rather having varied in the same direction. They are, as Hentschel says, "functions of one another or of the same variable," the latter an environmental factor. We must of course suppose, since presumably we are dealing with germinal and not with somatogenic characters, that the environmental (external or internal) factor, as it increases in force, continues to modify the germ in the same detail of its constitution (same gene or gene complex) and in the same direction. This brings us well into the field of speculation, but without speculation no rational experimentation.

CHAPEL HILL, N. C.

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AN INTERESTING MAXIMAL CASE*

By Archibald Henderson and H. G. Baity

Plate 3

In lists of problems dealing with maxima and minima may commonly be encountered the following:

To find the dimensions of the rectangle of maximum area that can be inscribed in an ellipse of semi-axes a and b.

Various methods may be employed for the solution of this problem; but these ordinarily suffice to veil the characteristic features of the solution, as viewed in the present paper. An enumeration of the methods usually employed will bring this into prominence. The interesting feature of the problem, under the method here stressed, is the introduction of an auxiliary curve which plays a dominant role in the solution.

Method I

If we represent a critical value by A and Δx by h, the customary conditions for a maximum are

$$f(A-h) - f(a) = \text{positive quantity}$$
$$f(A) - f(A+h) = \text{positive quantity}$$

If we represent the sides of the rectangle, inscribed in the ellipse $\frac{x^2}{a^2} + \frac{y^2}{b^2} = 1$ by 2x and 2y, the area of the rectangle is given by

$$U = 4xy.$$

Since, from the equation of the ellipse, $y = \frac{b}{a}\sqrt{a^2-x^2}$,

$$\therefore U = \frac{4b}{a}x\sqrt{a^2-x^2} = \frac{4b}{a}\sqrt{a^2x^2-x^4}.$$

Let

$$f(x) = (a^2x^2-x^4)^{1/2} = x(a^2-x^2)^{1/2}.$$

To find the critical value, set $f'(x) = 0$

$$\therefore \tfrac{1}{2}(a^2x^2 - x^4) - \tfrac{1}{2}(2a^2x - 4x^3) = 0.$$

Hence

$$2x(a^2 - 2x^2) = 0;$$

which gives $\quad x = 0, \pm\frac{a}{\sqrt{2}}.$

* This investigation, which had been directed by Dr. Henderson, was presented by Mr. Baity before the Mathematics Club, University of North Carolina.

We exclude the value $x = 0$, since it obviously gives the minimum rectangle, of zero area. For the present, we may omit the value $x = -\frac{a}{\sqrt{2}}$ from consideration — primarily because a negative length would ordinarily be excluded in seeking a positive area. We shall revert to this case, however, in the latter part of the paper. Confining our attention to the value $+\frac{a}{\sqrt{2}}$, we have:

$$f(A) = \frac{a}{\sqrt{2}}\left(a^2 - \frac{a^2}{2}\right) = \frac{a^2}{2}$$

$$f(A-h) = \left(\frac{a}{\sqrt{2}} - h\right)\left(a^2 - \frac{a^2}{2} + a\sqrt{2}\,h - h^2\right)^{\frac{1}{2}}$$

$$= \left(\frac{a}{\sqrt{2}} - h\right)\left(\frac{a^2}{2} + ah\sqrt{2} - h^2\right)^{\frac{1}{2}} = \left(\frac{a}{\sqrt{2}} - h\right)\left\{\left(\frac{a}{\sqrt{2}} + h\right)^2 - 2h^2\right\}^{\frac{1}{2}}$$

$$= \frac{a}{\sqrt{2}} - h\left\{\frac{a}{\sqrt{2}} + h - \frac{h^2}{\frac{a}{\sqrt{2}} + h} + \text{-----}\right\}$$

$$= \frac{a^2}{2} - h^2 - \frac{\frac{a}{\sqrt{2}} - h}{\frac{a}{\sqrt{2}} + h}\,h^2 \text{-----}$$

$$\therefore f(A) - f(A-h) = +h^2 + \frac{\frac{a}{\sqrt{2}} - h}{\frac{a}{\sqrt{2}} + h}\,h^2$$

$$= h^2\left|1 + \frac{\frac{a}{\sqrt{2}} - h}{\frac{a}{\sqrt{2}} + h} \text{-----}\right|$$

This is a positive quantity, since as h approaches zero, h^2 remains positive, the first two terms are positive, and the remaining terms approach zero, since they all involve powers of h, and indeed h^2.

Proceeding in similar fashion, we derive

$$f(A) - f(A+h) = \frac{a^2}{2} - \left(\frac{a}{\sqrt{2}} + h\right)\left(a^2 - \frac{a^2}{2} - a\sqrt{2}\,h - h^2\right)^{1/2}$$

$$= \frac{a^2}{2} - \left(\frac{a}{\sqrt{2}} + h\right)\left\{\left(\frac{a}{\sqrt{2}} - h\right)^2 - 2h^2\right\}^{\frac{1}{2}}$$

$$= \frac{a^2}{2} - \left(\frac{a}{\sqrt{2}} + h\right)\left\{\frac{a}{\sqrt{2}} - h - \frac{h^2}{\frac{a}{\sqrt{2}} - h} + \text{-----}\right\}$$

$$= \frac{a^2}{2} - \frac{a^2}{2} + h^2 + \frac{\frac{a}{\sqrt{2}} + h}{\frac{a}{\sqrt{2}} - h} h^2 \text{------}$$

$$= h^2\left|1 + \frac{\frac{a}{\sqrt{2}} + h}{\frac{a}{\sqrt{2}} - h} \text{------}\right|$$

This is likewise a positive quantity, by similar reasoning to that given above. Hence $x = +\frac{a}{\sqrt{2}}$ is a critical value, which gives rise to a maximum. From the equation of the ellipse, the corresponding value of y is $+\frac{b}{\sqrt{2}}$ Rejecting the negative value as giving rise to a negative area, we have for the value of the maximum area $4\,\frac{a}{\sqrt{2}} \cdot \frac{b}{\sqrt{2}} = 2ab$.

METHOD II

Representing a critical value by A and Δx by h, the customary conditions for a maximum are

$$f'(A - h) = \text{positive quantity;}$$

$$f'(A + h) = \text{negative quantity.}$$

As before, let

$$f(x) = (a^2x^2 - x^4)^{1/2}$$

$$\therefore f'(x) = \frac{2a^2x - 4x^3}{2(a^2x^2 - x^4)^{1/2}} = \frac{a^2 - 2x^2}{\sqrt{a^2 - x^2}}$$

Since $A = +\frac{a}{\sqrt{2}}$ we have

$$f'\left(\frac{a}{\sqrt{2}}-h\right)=\frac{a^2-2\left(\frac{a^2}{2}-\frac{2a}{\sqrt{a}}h+h^2\right)}{\sqrt{a^2-\left(\frac{a^2}{2}-\frac{2a}{\sqrt{2}}h+h^2\right)}}$$

$$=\frac{\frac{4ah}{\sqrt{2}}-2h^2}{\sqrt{\frac{a^2}{2}+\frac{2a}{\sqrt{2}}h-h^2}}$$

$$=\frac{2h\,(a\sqrt{2}-h)}{\sqrt{\left(\frac{a}{\sqrt{2}}+h\right)^2-2h^2}}$$

which is a positive quantity.

Also

$$f'\left(\frac{a}{\sqrt{2}}+h\right)=\frac{a^2-\left(2\frac{a^2}{2}+\frac{2a}{\sqrt{2}}h+h^2\right)}{\sqrt{a^2-\left(\frac{a^2}{2}+\frac{2a}{\sqrt{2}}h+h^2\right)}}$$

$$=\frac{-\frac{4a}{\sqrt{2}}h-2h^2}{\sqrt{\frac{a^2}{2}-\frac{2a}{\sqrt{2}}h-h^2}}$$

$$=\frac{-2h\,(a\sqrt{2}+h)}{\sqrt{\left(\frac{a}{\sqrt{2}}-h\right)^2-2h^2}}$$

which is a negative quantity.

Hence $x=+\frac{a}{\sqrt{2}}$ is a critical value, which gives rise to a maximum. As before, we find for the value of the maximum area, 2ab.

METHOD III

We may deal with the function as an implicit function in the variables x and y, subject to the condition that the given point lie upon the required ellipse.

Thus

$$U \equiv F(x,y) = 4xy \quad . \quad . \quad . \ (1)$$

subject to the condition

$$\frac{x^2}{a^2} + \frac{y^2}{b^2} - 1 = 0 \quad . \quad . \quad . \ (2)$$

The critical values for maxima and minima are to be found by equating to zero the first derivative of U, and replacing $\frac{dy}{dx}$ by its specific value as derived from (2).

Thus

$$\frac{dU}{dx} = 4y + 4x\frac{dy}{dx} = 0 \text{ from (1)},$$

and

$$\frac{2x}{a^2} + \frac{2y}{b^2}\frac{dy}{dx} = 0, \text{ from (2)}$$

Hence

$$\frac{dy}{dx} = -\frac{b^2x}{a^2y}$$

which on substitution in the equation $\frac{dU}{dx} = 0$,

gives

$$4y + 4x\left(\frac{-b^2x}{a^2y}\right) = 0$$

and therefore

$$a^2y^2 = b^2x^2$$

Combining with (2), we have

$$2b^2x^2 = a^2b^2$$

giving

$$x = \pm\frac{a}{\sqrt{2}}, \text{ and therefore } y = \pm\frac{b}{\sqrt{2}}$$

The criterion for a maximum value is

$$\frac{d^2U}{dx^2} = \text{negative quantity.}$$

Now

$$\frac{d^2U}{dx^2} = 4\frac{dy}{dx} + 4x\frac{d^2y}{dx^2} + 4\frac{dy}{dx}$$

But

$$\frac{dy}{dx} = \frac{-b^2x}{a^2y}$$

and

$$\frac{d^2y}{bx^2} = \frac{-\left(a^2b^2y - a^2b^2x\frac{dy}{dx}\right)}{a^4y^2} = -\left(\frac{a^2b^2y^2 + b^2x^4}{a^4y^3}\right)$$

$$= \frac{-b^2(a^2b^2)}{a^4y^3} = \frac{-b^4}{a^2y^3}.$$

Hence

$$\frac{d^2U}{dx^2} = \frac{-8b^2x}{a^2y} - \frac{4b^4x}{a^2y^3},$$

which is negative certainly for the values

$$x = +\frac{a}{\sqrt{2}};\ y = +\frac{b}{\sqrt{2}}$$

Consideration of the other combinations of signs will be deferred until the last method is reached.

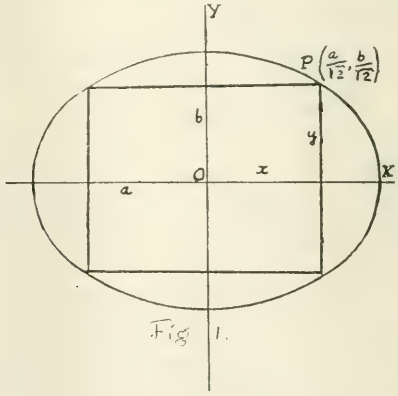


Fig 1.

METHOD IV

We may deal with the problem by expressing U as an explicit function in either x or y. Thus, solving (2) for y, we have

$$y = +\frac{b}{a}\sqrt{a^2 - x^2},$$

and hence

$$U = 4xy = \frac{4bx}{a}\sqrt{a^2 - x^2}$$

since we reject here the consideration of a negative area, a being always greater than x.

Let

$$f(x) = x\sqrt{a^2 - x^2} = (a^2x^2 - x^4)^{1/2}$$

Then

$$f'(x) = \frac{x(a^2 - 2x^2)}{(a^2x^2 - x^4)^{1/2}} = \frac{a^2 - 2x^2}{(a^2 - x^2)^{1/2}}$$

and

$$f''(x) = \frac{(a^2 - x^2)^{1/2}\ (-4x) - (a^2 - 2x^2).\ \dfrac{-2x}{2(a^2 - x^2)^{1/2}}}{(a^2 - x^2)}$$

$$= \frac{x(2x^2 - 3a^2)}{(a^2 - x^2)^{\frac{3}{2}}}$$

Setting $f'(x) = 0$, and solving we obtain

$$x = \pm\frac{a}{\sqrt{2}}$$

Since we have assumed that $\sqrt{a^2 - x^2}$ is to have the positive sign, in order to reject the consideration of negative areas, we obtain, on substituting $x = +\dfrac{a}{\sqrt{2}}$ in $f''(x)$

$$\frac{\dfrac{a}{\sqrt{2}}\ (a^2 - 3a)}{\sqrt{\dfrac{a^2}{2}}} = \frac{-2a^2}{\dfrac{a^2}{2}} = -4$$

which proves that $x = +\dfrac{a}{\sqrt{2}}$ gives a maximum value, as the condition for a maximum is that

$$f''(A) = \text{negative quantity.}$$

The same conclusion would have been reached had we expressed U as an explicit function of y, and followed a similar course of reason-

ing. In that case we would have found that $y = +\frac{b}{\sqrt{2}}$. In either case, the final value of U would have been the same, namely 2ab.

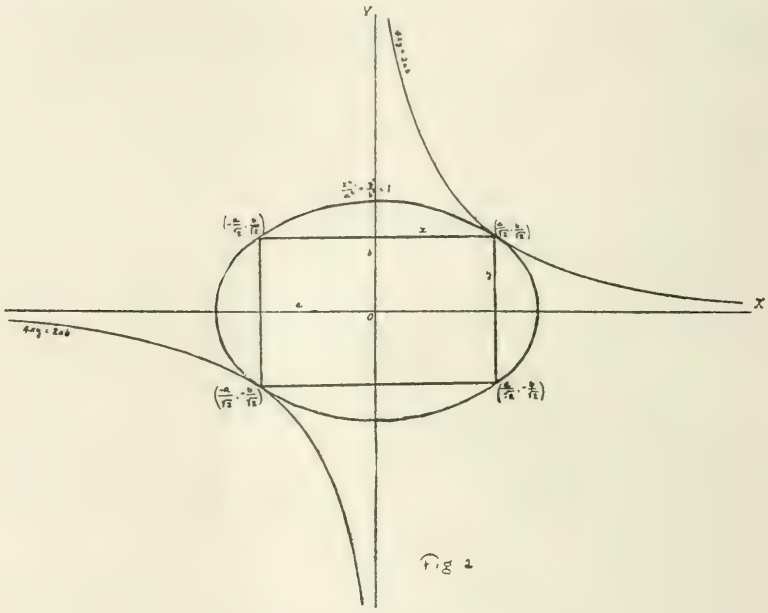


Fig 2

METHOD V

By employing the parametric representation for an ellipse, we readily obtain a very elegant solution of the problem. Any point on the ellipse $\frac{x^2}{a^2} + \frac{y^2}{b^2} = 1$ may be represented by

$$x = a \cos \phi$$
$$y = b \sin \phi$$

when ϕ is the eccentric angle of the point on the ellipse, namely the angle between the x - axis and the line joining the origin to the point of intersection of the line $y = b \sin \phi$ with the circle $x^2 + y^2 = a^2$.

Substituting the parametric values of x and y into the equation $U = 4xy$, we have

$$U = 4a \cos \phi . b \sin \phi = 2ab \sin 2\phi \quad . \quad . \quad . \quad . \ (1)$$

To find the critical value of ϕ for a maximum value of U, set the first derivative of U with respect to ϕ equal to zero:

$$\frac{dU}{d\phi} = 4ab \cos 2\phi = 0;$$

whence

$$2\phi = 90° \text{ or } 270°$$
$$\phi = 45° \text{ or } 135°$$

Accordingly

$$x = +\frac{a}{\sqrt{2}}, \ y = +\frac{b}{\sqrt{2}}.$$

Now

$$\frac{d^2U}{d\phi^2} = -8 \, ab \sin 2 \, \phi,$$

giving a negative value for $\phi = 45°$, but a positive value for $\phi = 135°$. Hence $\phi = 45°$ is the critical value for a maximum. Hence the only admissible values for giving a maximum are

$$x = +\frac{a}{\sqrt{2}}$$
$$y = +\frac{b}{\sqrt{2}}$$

Substituting these values in (1), we have

$$U = 4xy = 2ab,$$

from which

$$xy = \frac{ab}{2} \quad . \quad . \quad . \ (2)$$

The form in which this result presents itself, namely that of a rectangular hyperbole $xy = K$, excites interest at once, and prompts a further investigation. The introduction into the problem of an apparently extraneous curve, not invoked in the original statement, suggests that this locus must play a crucial role in connection with the ellipse in the solution of the problem.

The co-ordinates $+\frac{a}{\sqrt{2}}, \frac{+b}{\sqrt{2}}$ and $\frac{-a}{\sqrt{2}}, \frac{-b}{\sqrt{2}}$ of two of the

four corners of the maximum rectangle inscribed the ellipse satisfy the equation of the rectangular hyperbola $xy = \frac{ab}{2}$. Accordingly the ellipse and the rectangular hyperbola, having two points in common, must either intersect each other or be tangential at the given points.

The tangent to the ellipse at the point (x_1, y_1) has the form

$$\frac{x_1 x}{a^2} + \frac{y_1 y}{b^2} = 1;$$

and hence we have for the tangent to the ellipse at the point $\frac{+a}{\sqrt{2}}$, $\frac{+b}{\sqrt{2}}$

$$\frac{ax}{a^2\sqrt{2}} + \frac{by}{b^2\sqrt{2}} = 1$$

or

$$\frac{x}{a} + \frac{y}{b} = \sqrt{2} \quad . \; . \; . \; . (3)$$

The tangent to the rectangular hyperbola at the point (x_1, y_1) has the form

$$y_1 x + x_1 y = ab;$$

and hence we have for the tangent to the rectangular hyperbola at the point $\frac{+a}{\sqrt{2}}$, $\frac{+b}{\sqrt{2}}$

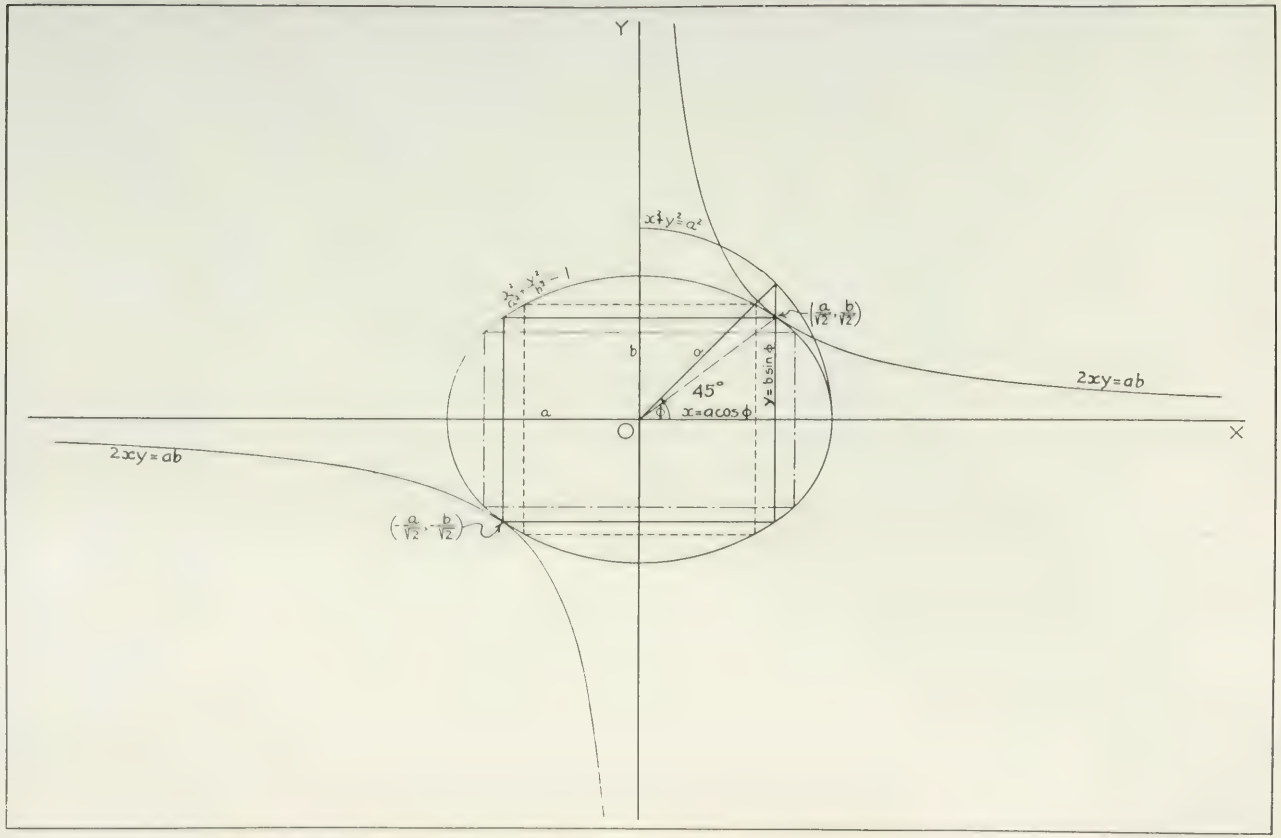
$$\frac{bx}{\sqrt{2}} + \frac{ay}{\sqrt{2}} = ab,$$

that is

$$\frac{x}{a} + \frac{y}{b} = \sqrt{2} \quad . \; . \; . (4)$$

As equations (3) and (4) are identical, it is clear that the ellipse and the rectangular hyperbola have a common tangent at the point $\frac{+a}{\sqrt{2}}$, $\frac{+b}{\sqrt{2}}$ It may be noted that, since the rectangular hyperbola consists of two branches lying respectively in the first and third quadrants, the ellipse and the rectangular hyperbola cannot intersect

PLATE 3


Y
X
O
$x^2+y^2=a^2$
$\frac{x^2}{a^2}+\frac{y^2}{b^2}=1$
$\left(\frac{a}{\sqrt{2}}, \frac{b}{\sqrt{2}}\right)$
$\left(-\frac{a}{\sqrt{2}}, -\frac{b}{\sqrt{2}}\right)$
$2xy=ab$
$2xy=ab$
45°
$x=a\cos\phi$
$y=b\sin\phi$
a
b
a
ϕ

each other in either quadrant, since only one corner of the maximum rectangle inscribed in the ellipse lies in either quadrant.

Since the ellipse and the rectangular hyperbola have a pair of common tangents at two corners of the maximum rectangle, it is clear that the critical values may be arrived at by solving the two equations simultaneously. Thus substituting $y = \frac{ab}{2x}$ in the equation of the ellipse we have

$$b^2x^2 + \frac{a^4b^2}{4x^2} = a^2b^2,$$

or

$$4x^4 - 4a^2x^2 + a^4 = 0,$$

i. e.

$$(2x^2 - a^2)^2 = 0,$$

giving

$$x = + \frac{a}{\sqrt{2}};$$

and accordingly

$$y = \frac{ab}{2 + \frac{a}{\sqrt{2}}} = + \frac{b}{\sqrt{2}}.$$

At this point, or at an earlier point, in the investigation, the inquiry may be raised why both rectangular hyperbolas:

$$xy = + \frac{ab}{2}$$

and

$$xy = - \frac{ab}{2}$$

do not enter into the problem.

Although the question has virtually been answered in the course of the treatment in Method V, in the rejection of the solution $\phi = 135°$, it may be pointed out that while $x = \frac{-a}{\sqrt{2}}$, $y = \frac{-b}{\sqrt{2}}$ formally satisfy the equation

$$xy = \frac{ab}{2}$$

and give a rectangle of positive area, they derive from the rejected value $\varphi = 135°$. The two points

$$x = \frac{+a}{\sqrt{2}}, \; y = \frac{-b}{\sqrt{2}}$$

and

$$x = \frac{-a}{\sqrt{2}}, \; y = \frac{+b}{\sqrt{2}}$$

neither formally satisfy the fundamental function

$$xy = \frac{ab}{\sqrt{2}},$$

nor derive together from either $\varphi = 45°$ on $\varphi = 135°$.

The association of the ellipse and the rectangular hyperbola in this problem suggests the query whether the maximum rectangle inscribed in the ellipse is at the same time the maximum rectangle which may be inscribed in the rectangular hyperbola. This question must obviously be answered in the negative, since the rectangular hyperbola $xy = \frac{ab}{2}$ at once furnishes the result

$$U = 4xy = 2ab;$$

which shows the invariance of the rectangle area for the rectangular hyperbola, as indicated by the nomenclature.

The superiority of Method V over those which precede is conspicuous in two respects—the brevity and elegance of the treatment, and the immediate identification of the critical values which give rise to a maximum value.

CHAPEL HILL, N. C.

KEY TO THE BUTTERFLIES OF NORTH CAROLINA

By C. S. Brimley

(Div. of Entomology N. C. Dept. of Agr.)

Butterflies may be distinguished from all other insects except the moths by the wings being covered with powdery scales which easily rub off, while from the moths they can be separated by having the antennae or feelers simple, and knobbed at tip, never hair-like, plume-like, comb-like, or even serrated. Furthermore all butterflies fly in the daytime, and most, but not all, moths at night.

The following key to the families of butterflies includes only six such, all the Nymphaline families or subfamilies, except the meadow browns, being lumped together, while our single species of the Erycinidae, or metal marks, is included in the Lycaenidae, which group it much resembles.

KEY TO THE FAMILIES OF BUTTERFLIES

1. Body stout, antennae hooked at tip (except in *Ancyloxipha*), species of medium or small size, mainly under two inches in spread of wings. Family VI. The Skippers (*Hesperidae*).
1. Body slender, antennae not hooked at tip.....2.
2. Front legs normal, fitted for walking, outer edge of forewing always evenly rounded or straight.....3.
2. Front legs brush-like, not fitted for walking.....5.
3. Spread of wings 2½ to 5 inches, hind wings with tail-like projections which are never thread-like...Family I. The Swallowtail Butterflies (*Papilionidae*)
3. Spread usually two inches or less.....4.
4. Ground color of wings white or yellow, hind wings never tailed. Family II. The Whites and Yellows (*Pieridae*).
4. Ground color of wings never white or yellow, hind wings often with thread-like tails..Family V. The Gossamer-winged Butterflies (*Lycaenidae*).
5. Size medium or large, colors usually bright, the prevailing shade being reddish brown.....Family III. The Nymphs (*Nymphalidae*)
5. Size medium or rather small, ground color of wings some shade of dull brown, with eye-like spots almost always present on one or both sides of one or both pairs of wings. ....Family IV. The Meadow Browns (*Agapetidae*)

Family I. The Swallowtails

1. Ground color light, striped with black.....2.
1. Ground color black, spotted with lighter.....3.

2. Black and white, striped.....Zebra Swallowtail (*Papilio ajax*)
2. Black and yellow, striped.....Tiger Swallowtail (*P. glaucus turnus*)
3. Underside mainly yellow, spread about 5 inches.
Giant Swallowtail (*P. thoas*). East.
3. Underside mainly black.....4.
4. Body striped with yellow, hind wings crossed above by an uninterrupted yellow band.....Palamedes Swallowtail (*P. palamedes*). East.
4. Body not striped with yellow, hind wings not crossed by an uninterrupted yellow band.....5.
5. Underside of hind wings with two rows of yellow spots.....6.
5. Underside of hind wings with one row of yellow spots.....7.
6. Upper side of wings with usually two rows of light spots, inner row of yellow spots on under side of hind wings complete...Black Swallowtail (*P. polyxenes*).
6. Upper side of wings usually with only one row of light spots, fifth spot of inner row on under side of hind wings missing, and replaced by a comet like dash of scales.....Green-clouded Swallowtail (*P. troilus*).
7. Wings glossy above, yellow spots on underside of hind wings enclosed in a glossy band.....Blue Swallowtail (*P. philenor*).
7. Wings not glossy, upper side of hind wings with a row of blue spots, under side of wings rather faintly striped with black.
Tiger Swallowtail (*P. glaucus*), melanistic female.

FAMILY II. THE WHITES AND YELLOWS

1. Ground color of wings white.....2.
1. Ground color of wings orange or yellow.....6.
2. Forewings falcate, sharp pointed at tip, underside of hind wings marbled with greenish, an orange patch at tip of forewing in male.
Falcate Orange-tip (*Anthocaris genutia*). Central Section, early spring.
2. Not as in *genutia*.....3.
3. Forewings broadly bordered outwardly with black, albinistic females of some species of *Terias* and *Colias*. See under 6.
3. Forewings not broadly bordered with black.....4.
4. Wings unmarked, hind wings not buffy beneath.
Gray-veined White (*Pontia oleracea*). Mountains, rare.
4. Wings with some dark markings above.....5.
5. Black markings on upper side of wings consisting of the tip, one or two spots on forewing and one on hind wing, these sometimes wanting in spring specimens, hind wings buffy beneath.....Cabbage Butterfly (*Pontia rapae*).
5. Forewings with more than two black spots, hind wings unmarked (male), or extensively marbled with dusky and white (female).
Checkered White (*Pontia protodice*).
6. Wings almost wholly yellow, except a row of brown spots along the outer edge in the female.....Cloudless Sulphur (*Catopsilia eubule*).
6. Wings broadly bordered outwardly with black.....7.
7. With one or two pearly spots on underside of hind wings.....8.
7. With no pearly spots on underside of hind wings.....10.

8. Forewings coming to a sharp angle at tip, yellow on upper side of forewings bearing a rough resemblance to an animal's head.
Yellow Dogface (*Colias caesonia*).
8. Forewings rounded at tip.....9.
9. Ground color of wings sulphur yellow...Clouded Sulphur (*Colias philodice*).
9. Ground color of wings orange.....Clouded Orange (*Colias eurytheme*)
10. Ground color of wings orange, spread over 1½ inches.
Bordered Orange (*Terias nicippe*).
10. Ground color of wings yellow, spread under 1½ inches.....11.
11. A black band across fore wings near the posterior border.....12.
11. No black band across forewings.....14.
12. Under side of hind wings white.....Banded Sulphur (*Terias jucunda*). East
12. Under side of hind wings rusty.....13.
13. Upper side of hind wings yellow.....Delia Sulphur (*Terias delia*). East
13. Upper side of hind wings white.....Elathea Sulphur (*T. elathea*). East.
14. Under side of hind wings yellow with brown spots..Little Sulphur (*Terias lisa*).
14. Under side of hind wings rusty.....Delia Sulphur, female.

FAMILY III. THE NYMPHS

1. Outer edge of both fore and hind wings strongly angled or jagged.....2.
1. Outer edge of hind wings evenly rounded or nearly so.....6.
2. Wings dark brown with cream colored borders.
Mourning Cloak (*Euvanessa antiopa*).
2. Wings reddish brown, the border darker.....3.
3. Silvery mark on under side of hind wings divided into a curved mark and a dot, round black spots on upper side of forewings normally six.
Question-mark (*Grapta interrogationis*)
3. Silvery mark on under side of hindwings undivided, round black spots on upper side of forewings normally five.....4.
4. Silvery mark on under side of hind wings tapered at both ends, under side of wings with grayish markings...Gray Comma (*Grapta progne*). Mountains.
4. Silvery mark on under side of hind wings expanded at both ends.....5.
5. Under side of hind wings with greenish markings, wings very much jagged on the outer edges..Green Comma Butterfly (*Grapta faunus*). Mountains.
5. Under side of hind wings without greenish markings, wings only moderately jagged.....Comma Butterfly (*Grapta comma*).
6. Wings with numerous silvery spots on the underside.....7.
6. Wings without silvery spots on the underside.....10.
7. Forewings long and narrow, silvery spots on under side of hind wings elongate.
Gulf Fritillary (*Agraulis vanillae*).
7. Fore wings broad, silvery spots on under side of wings round.....8.
8. Spread of wings 1½ inches...Myrina Fritillary (*Argynnis myrina*). Mountains.
8. Spread of wings 2½ to 3 inches.....9.
9. Under side of hind wings with a broad yellowish band.
Great Spangled Fritillary (*Argynnis cybele*). Mountains.
9. Under side of hind wings with a narrow yellowish band.
Silver Spotted Fritillary (*Argynnis aphrodite*). Mountains.

10. Ground color of upper side of wings black or blackish, usually with some white markings.....11.
10. Ground color of upper side of wings some shade of brown or reddish brown...14.
11. Wings black, transversely banded with white, forewings long and narrow.
Zebra Butterfly (*Heliconia charitonia*). South-east.
11. Wings not transversely banded with white.....12.
12. Upper side of forewings crossed by a bright red band.
Red Admiral (*Pyrameis atalanta*).
12. Upper side of forewings without red band.....13.
13. Under side with numerous red spots....Red-spotted Purple (*Limenitis ursula*).
13. Under side of wings without red spots.
Diana Fritillary (*Argynnis diana*), female. Mountains.
14. Upper side of wings without white markings.....15.
14. Upper side of wings with more or less white markings.....19.
15. Spread 3 to 4 inches, inner half of wings dark, the outer half orange in strong contrast.....Diana Fritillary, male.
15. Spread 2½ inches or less, colors not as in *diana*.....16.
16. Upper side of wings with 8 to 10 rounded black spots on each wing, spread about 1½ inches.....Bellona Fritillary (*Argynnis bellona*). Mountains.
16. Upper side of wings with not more than 4 or 5 rounded black spots on each wing, if more are present on the hind wings, there are none on the forewings.17.
17. Black spots as well as other markings present on upper side of forewings, color of wings mainly fulvous. Spread 2 to 2½ inches.
Variegated Fritillary (*Euptoieta claudia*).
17. No round black spots on upper side of forewings, spread of wings under 2 inches.....18.
18. The dark color predominating on upper side of forewings.
Silver Crescent (*Phyciodes nycteis*). Mountains.
18. The fulvous color predominating on upper side of forewings.
Pearl Crescent (*Phyciodes tharos*).
19. Palpi very long, snout-like; outer edge of forewing strongly angled, wings fulvous centrally, black externally...Beaked Butterfly (*Libythea bachmani*).
19. Palpi short as usual, outer edge of forewing not strongly angled, if at all....20.
20. Wing veins all edged with black, ground color of wings reddish brown or orange.....21.
21. Wing veins not edged with black.....22.
21. Spread 3½ inches or more, no black line across middle of hind wings, two rows of white spots near the outer edge of both pairs of wings.
Monarch Butterfly (*Danais plexippus*).
21. Spread under 3½ inches, a black band across middle of hind wings, one row of white dots near edge of wings.....Viceroy Butterfly (*Limenitis archippus*).
22. Wings with numerous white spots on the undersides of all wings, and at least on the upper side of the forewings also, but without any ringed eye-like spots.....23
22. Wings with few white spots on any one wing, but with eye-like spots on at least the under side of the hind wings.....25.
23. Spread about 3½ inches, the hind wings with very few, if any white spots on the upper side.....The Queen (*Danais berenice*). Eastern Section.

23. Spread 2 inches. Dark brown, the spots about equally numerous on all wings, above and below...The Baltimore (*Melitaea phaeton*). Mountains.
24. With one large eye-like spot on upper side of forewings, and two on the hind wings, the one on the forewings enclosed in the lower end of a whitish band, and repeated on the under side.....The Buckeye (*Junonia coenia*).
24. With no large eye-like spot on upper side of forewings.....25.
25. With two large eye-like spots on under side of hind wings.
Painted Beauty (*Pyrameis huntera*).
25. With not less than four small eye-like spots on under side of hind wings...26.
26. Ground color reddish brown, four or five small eye spots on under side of hind wings, spread 2¼ inches or more...Painted Lady (*Pyrameis cardui*). Local.
26. Ground color of wings dull brown, six or seven small eye spots on under side of hind wings, spread 2⅛ inches or less.
Gray Emperor (*Apatura celtis*). Central Section.

FAMILY IV. THE MEADOW BROWNS (*Agapetidae*)

1. Forewings with a large white or yellow patch.....2.
1. Forewings without any such patch.....3.
2. Two eye-like spots in white patch on forewings, spread of wings about 2. inches.....Blue-eyed Grayling (*Satyrus alope*). Mountains.
2. Often only one eye-like spot in patch on forewings, spread about 2½ inches.
Southern Grayling (*Satyrus pegala*).
3. Outer border of hind wings scalloped, spread about 2 inches.....4.
3. Outer border of hind wings not scalloped.....5.
4. Veins of outer part of forewings of male are noticeably pale and the round black spots between them have light wedge-shaped marks on their inner side, female with only two well developed black spots on upper side of forewings.....Southern Pearly-wing (*Debis creola*). Wake county
4. Veins on forewings not pale and without wedge-shaped light spots on their inner side. Three or four well developed black spots on upper side of forewings in both sexes.....Pearly-wing (*Debis portlandia*).
5. Upper side of wings with eye spots.....6.
5. Upper side of wings without eye-spots, spread less than 1½ inches.....7.
6. Forewings with two eye-spots above, spread about 1½ inches.
Little Wood Satyr (*Neonympha eurytus*).
6. Forewings with a row of black spots above, spread about 2 inches.
Eyed Brown (*Neonympha canthus*). Mountains.
7. Hind wings with a pearly or metallic patch on under side of hind wings but with no eye like spots.....Gemmed Brown (*Neonympha gemma*).
7. Hind wings with eye-like spots on under side.....8.
8. Eye spots on under side of hind wings round.
Carolinian Satyr (*Neonympha sosybius*).
8. Eye spots on under side of hind wings elliptical.
Georgian Satyr (*Neonympha phocion*).

FAMILY V. THE GOSSAMER-WINGED BUTTERFLIES (*Lycaenidae*)

1. Wings reddish brown above with black spots or many fine black lines.....2.

1. Wings not spotted above with black, nor with many fine black lines on the upper side.....4.
2. Wings with four or five irregular black lines, extending across both pairs of wings on both surfaces.
Little Metal-mark (*Calephelis caenius*). Cumberland Co.
2. Wings spotted above with black.....3.
3. Under side of hind wings with many small crescentic and circular fine white lines.....The Wanderer (*Feniseca tarquinius*).
3. Under side of hind wings with small black dots.
American Copper (*Chrysophanus hypophleas*).
4. Wings with more or less blue on the upper side.....5.
4. Wings without blue.....10.
5. Hind wings evenly rounded, without thread-like tails.....6.
5. Hind wings with thread-like tails.....7.
6. Under side of hind wings with a row of orange crescents near the outer border.....Scudder's Blue (*Lycaena scudderi*). Mountains.
6. Under side of hind wings without any orange markings.
Spring Azure (*Lycaena pseudargiolus*).
7. Hind wings evenly rounded with a single thread-like tail, color of upper surface of wings not bordered with black.....Tailed Blue (*Lycaena comyntas*).
7. Hind wings with two tails or at least a second projection.....8.
8. Blue little if at all evident on upper side of forewings, a red band on under side of wings.....Least Purple Hairstreak (*Thecla cecrops*).
8. Blue largely present on both pairs of wings above, no red band on under side of wings.....9.
9. Under side of abdomen orange, no white line on under side of wings.
Great Purple Hairstreak (*Thecla halesus*).
9. Under side of abdomen not orange, a white line on under side of wings.
White M Hairstreak (*Thecla M-album*).
10. Hind wings with thread-like tails.....11.
10. Hind wings without tails, but often scalloped or uneven.....15.
11. Under side of wings bright green, marked with brown and white.
Green Hairstreak (*Thecla damon*).
11. Under side of wings not green.....12.
12. Under side of wings with a red band near outer edge.
Least Purple Hairstreak (*Thecla cecrops*), female.
12. Under side of wings without red band.....13.
13. Under side of wings pearly gray with a single irregular white line on under side of hind wings.....Gray Hairstreak (*Thecla melinus*).
13. Under side of wings dark brown with two or more series of broken white lines or series of lines.....14.
14. Outer white lines on under side of hind wings continuous.
Banded Hairstreak (*Thecla calanus*).
14. Outer white lines on under side of hind wings broken.
Edward's Hairstreak (*Thecla edwardsi*). Polk Co.
15. Underside of hind wings with a row of orange spots.
Coral-banded Elfin (*Thecla titus*). Wake and Polk Cos.
15. Under side of wings without orange spots.....16.

16. Under side of wings with numerous irregular black cross bars.
Banded Elfin (*Thecla niphon*).
16. Under side of wings not as in *niphon*.....17.
17. Under side of wings uniform rust red on its outer half.
Brown Elfin (*Thecla augustus*). Polk Co.
17. Under side of hind wings with pale scales on its outer half giving it a hoary appearance.....18.
18. Upper side of forewings grayish brown, under side of hind wings fairly uniform in color.....Hoary Elfin (*Thecla irus*). Mountains.
18. Upper side of forewings reddish brown on its outer portion, under side of hind wings with a pale outer portion and a dark inner portion, these sharply defined from one another.
Henry's Elfin (*Thecla henrici*). Polk and Wake Counties.

Note. In the preceding keys no distribution is given except of those species which are apparently confined to a part of the state, the others are known to be at least fairly well distributed throughout the state.

The sixth family of butterflies, the *Hesperidae* or Skippers, is left for another paper, the species being both numerous and hard to discriminate.

RALEIGH, N. C.

A THEOREM ON DOUBLE POINTS IN INVOLUTION

By J. W. Lasley, Jr.

A bilinear relation

$$axx' + bx + cx' + d = 0 \ldots\ldots\ldots\ldots (1)$$

between x and x', in which a, b, c, d are known, may be regarded as a projective transformation of the points x of a line into the points x' of that line. Thus

$$5xx' + 2x + 3x' + 6 = 0 \ldots\ldots\ldots\ldots (2)$$

sends the point $x = 1$ into the point $x' = -1$ and the point $x = -1$ into the point $x = 2$.

We ask ourselves can it happen that if $x = h$ is sent into $x' = k$, that $x = k$ is sent into $x' = h$. Such transformations are said to be of period two. They are called involutions. For example

$$xx' + 3(x + x') - 7 = 0 \ldots\ldots\ldots\ldots (3)$$

sends $x = -2$ into $x' = 13$ and $x' = 13$ into $x = -2$.

One can convince himself that the noticeable difference between (3) and (2), namely that in (3) the coefficients of x and x' are alike, is a property which characterizes an involution. From this point of view an involution is given analytically by

$$axx' + b(x + x') + d = 0 \ldots\ldots\ldots\ldots (4)$$

When for $x = \mathrm{h}$ the relation (1) demands $x' = k$, k is said to correspond to h. Ordinarily to k will not correspond h again. This will be so when, and only when, the projective transformation is an involution. In this event we may say that h and k correspond. The points -2 and 13 are seen to correspond in (3).

Consider now the involution

$$xx' - 7(x + x') + 33 = 0 \ldots\ldots\ldots\ldots (5)$$

different from (3). Let us see whether (3) and (5) have a common pair of corresponding points. If so, x and x' must satisfy both (3) and (5). We have, then, xx', $-(x + x')$, 1 proportional to the two-rowed determinants obtained from the matrix

$$\begin{Vmatrix} 1 & 3 & -7 \\ 1 & -7 & 33 \end{Vmatrix} \qquad \ldots\ldots\ldots\ldots (6)$$

by deleting in turn the first, second and third columns, that is

$$xx' : x + x' : 1 = -5 : 4 : 1 \ldots\ldots\ldots\ldots (7)$$

Consequently x and x' are given by

$$x^2 - 4x - 5 = 0 \ldots\ldots\ldots\ldots (8)$$

and are -1 and 5. We find upon testing these in (3) and (5) that they correspond in both involutions.

Let us inquire whether in an involution, like (3), there are points which correspond to themselves. If so, these are given by

$$x^2 + 6x - 7 = 0 \ldots\ldots\ldots\ldots (9)$$

obtained from (3) by putting $x = x'$. These are here -7 and 1, and are called the double points of the involution. Similarly the double points of (5) are 3 and 11.

The question naturally arises as to what extent a choice of corresponding points determines an involution. Equation (4) appears to have three arbitrary constants, but it will become evident upon reflection that only the ratios of these are important. Clearly, if we knew two pairs of corresponding points, they would by (4) give us two homogeneous linear equations, which are usually just adequate for determining the ratios $a : b : d$. For instance, let us arbitrarily assign -7, 1 and 3, 11 as two pairs of corresponding points, and ask for the involution determined by them. The pair -7, 1 in (4) gives

$$7a + 6b - d = 0 \ldots\ldots\ldots\ldots (10);$$

the pair 3, 11 in (4) gives

$$33a + 14b + d = 0 \ldots\ldots\ldots\ldots (11).$$

From (10) and (11) we have $a : -b : d$ as the second order determinants obtained from the matrix

$$\left\| \begin{matrix} 7 & 6 & -1 \\ 33 & 14 & 1 \end{matrix} \right\| \qquad \ldots\ldots\ldots\ldots (12).$$

by deleting in turn the first, second and third columns. In this way we obtain $a : b : d = 1 : 2 : -5$. Consequently, the involution determined is

$$xx' - 2(x + x') - 5 = 0 \ldots\ldots\ldots\ldots (13).$$

whose double points are -1 and 5.

We have seen that the involutions (3) and (5) have just one pair of corresponding points in common, the pair -1, 5 given by (8). The double points of (3), namely -7, 1 and of (5), namely 3, 11, taken as two pairs of corresponding points determined (13), and involution different from (3) or (5). The common pair -1, 5 of corresponding points in (3) and (5) turned out to be the same as the double points of (13). We shall now show that this is not an accident of the particular involutions chosen, but follows from the nature of involutions.

In the two involutions (4) and

$$a'xx' + b'(x + x') + d' = 0 \ldots\ldots\ldots\ldots (14).$$

the common pair of corresponding points are such that xx', $x + x'$, 1 are proportional to their cofactors in

$$\begin{vmatrix} xx' & x + x' & 1 \\ a & b & d \\ a' & b' & d' \end{vmatrix} \qquad \ldots\ldots\ldots\ldots (15),$$

that is,

$$xx' : x + x' : 1 = (bd' - b'd) : (a'd - ad') : (ab' - a'b).$$

Consequently x and x' are given by

$$(ab' - a'b)\, x^2 + (ad' - a'd)x + (bd' - b'd) = 0 \ldots\ldots\ldots (16).$$

The double points of (4) are given by

$$ax^2 + 2bx + d = 0 \ldots\ldots\ldots\ldots (17),$$

those of (14) by

$$a'x^2 + 2b'x + d' = 0 \ldots\ldots\ldots\ldots (18).$$

The involution determined by the two pairs of points in (17) and (18) is

$$\begin{vmatrix} xx' & x + x' & 1 \\ d & -2b & a \\ d' & -2b' & a' \end{vmatrix} = 0 \qquad \ldots\ldots\ldots\ldots (19).$$

Its double points are given by

$$\begin{vmatrix} x^2 & x & 1 \\ d & -b & a \\ d' & -b' & a' \end{vmatrix} = 0 \qquad \ldots\ldots\ldots\ldots (20),$$

or

$$(ab' - a'b)x^2 + (ad' - a'd)x + (bd' - b'd) = 0 \ldots\ldots\ldots\ldots (21)$$

which is identical with (16). We have, then, established the theorem that *the common corresponding points in two involutions is the pair of double points in the involution determined by the double points of the given involutions.*

CHAPEL HILL, N. C.

THE COLLYBIAS OF NORTH CAROLINA

By W. C. Coker and H. C. Beardslee

Plates 1 and 4–23

Cap slightly fleshy and in most species drooping soon after maturity, often thin, expanded or rounded at maturity; margin even, at first incurved. Gills sinuate, adnate, adnexed, or free. Stem hollow or stuffed, cartilaginous, rooting. Spores white when fresh, smooth, in most species small. Volva and veil lacking. None is known to be poisonous and all the best known larger ones are valued edibles.

The Genus *Collybia* will be found fairly easy to distinguish among the white spored agarics. It is a little difficult to understand at first what is meant by "cartilaginous stem," and as is usual, some species referred to this genus are not clearly typical and might easily be referred to other genera. These will trouble the beginner. The largest of the genus, *C. platyphylla*, for example, has a thick fleshy stem and may well be looked for in *Tricholoma*. *Collybia confluens*, *C. stipitaria* and *C. zonata* might easily be referred to *Marasmius* at the start and they have in fact been transferred to that genus by some authors (see Atkinson, in N. Y. State Mus. Bull. 205–206: 61. 1919). Kauffman, in his *Agaricaceae of Michigan*, retains them in *Collybia*.

The key which has been arranged has purposely been made as simple as possible, and will, it is hoped, be found practical. It covers the common species of the state, though more will probably be found as our fungous flora is better known. One species which is common in northern woods may be looked for in the mountains. It is *Collybia succosa* Pk. (*C. nigrescens* Quél., *C. atramentosa* Kalch., and *C. fuliginaria* Weinm.). It will be at once recognized from the watery drops which exude from the lamellae when cut and from the black hues which the flesh assumes when injured. *Collybia tenacella* (Pers.) Quél., *C. ventricosa* and *C. clavus* (L.) Quél., were reported from this state by Schweinitz or by Curtis. They are noted as doubtfully American by Murrill (N. Am. Flora 9: 374–6. 1916). *Collybia detersibilis* B. & C., also reported by Curtis, is probably the same as *Clitocybe compressipes* Pk.

It will be noted that two species have been referred to European species not before reported from America. It may be said that this

has been done only after careful comparisons and correspondence with the best European authorities.

Unless otherwise stated all numbered collections are from Chapel Hill, N. C.

IMPORTANT AMERICAN LITERATURE:

PECK. N. Y. St. Cab. Rept. **23**: 78. 1872. Bot. ed.; also N. Y. St. Mus. Rept. **49**: 32. 1896. Bot. ed.

MURRILL. N. Am. Flora **9**: 352. 1916 (as *Gymnopus*); and **9**: 287. 1915 (as *crinipellis*).

LLOYD. *Collybias of Cincinnati.* Mycological Notes No. 5. Dec., 1900.

KAUFFMAN, C. H. *Collybia.* Mich. Geol. and Biol. Survey Publication, Biological Series **5**. 1918; also *Agaricaceae of Michigan*, p. 749. 1918.

MORGAN. Journ. Cincinnati Soc. Nat. Hist. **6**: 70. 1883.

Besides the well known works of the older mycologists see the recent important monograph by Sartory and Maire, *Synopsis du genre Collybia*, Paris, 1918. Also see Ricken, Die Blatterpilze **2**: 400, pls. 106-9. 1915; Lange, Studies in the Agarics of Denmark--III. Dansk Bot. Ark. **2**, No. 7: 10, 3 pls. 1917.

KEY TO THE SPECIES

Stem stout, striate, in a few cases stuffed, not velvety 1
Stem more slender, glabrous or pruinose, not distinctly striate or velvety 5
Stem distinctly velvety 11
1. Cap white or nearly so ..... *C. maculata* (1)
1. Cap red or chestnut brown, or reddish ochraceous 2
1. Cap gray, grayish brown or olive 3
2. Gills pure white; stem stout and enlarging downwards ..... *C. butyracea* (2)
2. Gills pure white; stem not stout and nearly equal ..... *C. dryophila* (3)
2. Gills spotted with red ..... *C. distorta* (7)
3. Cap viscid; stem with a long root ..... *C. radicata* (8)
3. Cap not viscid 4
4. Gills blackening when injured ..... *C. semitalis* (9)
4. Gills not blackening when injured ..... *C. platyphylla* (10)
5. Growing on decaying fungi, small, buffy tan ..... *C. cirrata* (12)
5. Growing on pine cones, small, threads at base white ..... *C. conigena* (13)
5. Growing on magnolia cones, threads at base buff ..... *C. conigenoides* (14)
5. Growing on thick beds of moss, small, brown ..... *C. clusilis* (22)
5. Not growing on cones or fungi 6
6. Cap less than 12 mm. broad; plant white all over ..... *C. alba* (15)
6. Cap larger; plant not pure white 7
7. Gills white or nearly so 8
7. Gills distinctly yellow ..... *C. exsculpta* (11)
7. Gills buff color, no tint of lilac ..... *C. exsculpta* (a form) (11a)
7. Gills brownish-lilac, or tan with tints of brownish-lilac 9
8. Growing on damp earth; plant small, the stem base with a mat of tawny

PLATE 4

COLLYBIA MACULATA. No. 1298.

hairs, color of cap dark brown.....*C. Earleae* (4)
8. Growing on earth, leaves or wood.....10
9. Growing on logs; gills crowded.....*C. myriadophylla* (6)
9. Growing on earth; gills not crowded and with spiny cystidia..*C. lilacina* (21)
10. Usually on leaves; cap center often rugose and always rugose on drying, color yellowish tan with center reddish; spores pip-shaped, about 3.5 – 4.5 x 6 – 9μ.....*C. nummularia* (5)
10. On earth, wood or leaves; cap center smooth and usually drying smooth; color pinkish tan or yellowish brown, the center darker; spores elliptic, about 3–3.8 x 5–7μ.....*C. dryophila* (3)
11. Cap distinctly viscid.....*C. velutipes* (16)
11. Cap rough-pubescent or squamulose.....12
11. Not as above.....13
12. Cap gray or brownish-gray, not zonate.....*C. stipitaria* (20)
12. Cap rich tawny color, zonate.....*C. zonata* (19)
13. Cap hygrophanous.....*C. confluens* (18)
13. Cap not hygrophanous.....*C. hariolorum* (17)

1. Collybia maculata A. & S.

PLATES 4 AND 23

Cap up to 8.5 cm. wide, usually 4–6 cm., convex, slightly viscid, smooth, even, dull or faintly shining, not at all striate, color nearly white or a light flesh-pink with darker areas and stains of pinkish-brick color which seem to be the result of rubbing. Center usually not darker than the margin. Flesh white or slightly pinkish, 1 cm. thick in center, thinner towards margin, dense and pliable, odor decidedly woody, taste bitterish and distinctly astringent, sometimes tardily so.

Gills colored like the cap and staining pinkish-brick on bruising; crowded, sinuate attached, narrow, 2–3.5 mm. deep, many short ones, none branched, margin eroded.

Stem 5–10 cm. long usually rather deeply rooted, white, even or slightly larger at either end, tough, elastic, fibrous, with a central cylinder that is lightly stuffed or hollow; surface minutely tomentose except at base where it is decidedly hairy; the hairs white or a very light cream color.

Spores (of No. 1298) cream color, elliptic, 2.9–3.8 × 4.2–5 μ. Easily distinguished from *C. dryophila* (which is nearest) by the brick-colored stains.

131. Low dense woods, Glen Burnie Farm, October 4, 1908.
594. Along branch below Howell's Spring, October 18, 1912. Spores cream color, elliptic, smooth, 3–3.7 × 4.7μ.

1298. On rotting pine log in woods south of athletic field, October 1, 1914. Photo.
1884. Under pines near old iron mine, October 3, 1915.
1939. In damp pine woods just south of athletic field, October 27, 1915. Spores smooth, subspherical, 3.6–4μ thick.
2370. Woods near Meeting of the Waters branch, June 5, 1916. Spores 3–4 $\times$ 4.5–7μ.
3011. Battle's Park just below Outdoor Theatre, April 19, 1918.
3187. Under pines by branch toward Meeting of Waters, October 5, 1918.

Asheville, on or around well decayed wood in mountain woods; rather rare. Beardslee.
Middle district (Schw.), woods. Curtis.

2. **Collybia butyracea** Bull.

PLATES 5, 6, AND 23

Cap up to 6 cm. wide, convex, sometimes umbonate, smooth, shining, color pinkish-buff, darkest in center. Flesh 2. 5 mm. thick at stem, very thin towards margin, soft.

Gills deeply depressed and angled at stem, nearly free, close, none forked, many short, up to 5.5 mm. wide near stem; white, margin strongly eroded.

Stem up to 6 cm. long, usually flattened and channelled, up to 5 mm. thick at cap, enlarging downward, smooth except near base which is incrassated with white mycelium, more or less obviously marked all over with longitudinal striations, color of cap, darkest below, flesh firm, elastic, fibro-cartilaginous, quite hollow.

Spores (of No. 1902) *not* white, exactly light buff of Ridgway, subpip-shaped, smooth, 3–3.7 $\times$ 5–6 μ.

On earth in woods, rare. There is a greasy look to the cap, which gives the plant its name.

I cannot find any quality that will hold good between this and all the forms of *C. dryophila*. In Chapel Hill forms occur with greasy-looking caps and slender equal stems, and Beardslee's photo. of *C. dryophila* on earth shows the stem enlarged below just as in *C. butyracea*. Also the slender stemmed plants of *C. dryophila* often show the stem distinctly lined when a lens is used. The spores of the two species as we have distinguished them here are identical.

1902. In pine and oak woods near Brockwell's, Battle's Park, October 17, 1915.
2431. Under shrubs in Mr. Woollen's yard, July 25, 1916. Spores elliptic, smooth, pointed at one end, 3–3.7 $\times$ 5.5–7.4μ.

PLATE 5

COLLYBIA BUTYRACEA. No. 1902.

PLATE 6

COLLYBIA BUTYRACEA. Photo by B.

Asheville, rather rare. Beardslee.
Middle district, rotten trunks. Curtis.

3. **Collybia dryophila** Fr.
Collybia subdryophila Atk.

PLATES 7, 8, AND 23

Plants solitary, gregarious or cespitose with the enlarged bases densely crowded.

Cap about 2.5–5.3 cm. broad, convex then expanded and uneven, usually a little depressed in or around the center, smooth, hygrophanous; in damp weather translucent and greasy looking, in dry weather opaque and dull or faintly shining, not greasy; color pinkish-tan or dull yellowish-brown, the center darker or with a lighter "eye." Flesh thin, 1.5–2 mm. thick near center, soft, color of cap or whitish, taste and odor like rotten wood (fungoid), not farinaceous.

Gills very thin, nearly or quite free, crowded, sinuate, the edges uneven, pure white or in age faintly creamy or pinkish-creamy; when bruised turning slowly to ochraceous. Looking at gills when fresh the color of the pileus showing through in some forms gives the effect of wine color.

Stem 4–7.5 cm. long, 2–4 mm. thick, equal (typically) except for a sudden enlargement at the very base, but often varying towards the enlarged base of *C. butyracea*, damp, smooth, white-tomentose near base, and with several string-like rhizomorphs; color like that of cap or lighter, pithy then hollow. If examined with a lens the stem may be seen to be distinctly striate with inherent lines of color, especially below.

Spores (of No. 80) deep cream, elliptic, smooth, 3–3.7 $\times$ 4.8–7 μ., most about 3.3 $\times$ 5.5 μ.

I can find no character that will sharply separate this from *C. butyracea*, and plants combining the characters of the two are often found. I am satisfied that these supposed species are forms of only one.

This is the commonest and most variable of our Collybias. In old plants the pileus is often pale, and it presents many variations in size and habit. It is, however, soon learned and recognized in all its

* There is a peculiar growth that has been often found on the cap and stem surface in America (not in Europe) that was named by Peck *Tremella mycetophila*. It is in the form of rather small pale globules or cushions of various size, that are plicate and soft. They are not, however, a *Tremella* as the basidia are club-shaped as in an agaric. Burt now thinks it an abnormal growth of the *Collybia* itself, but Miss Hone thinks it a true parasite. See Mycological Notes No. 47, p. 662. 1917.

disguises. One photograph is of the cespitose form on old wood, but it should be noted that it is often solitary or gregarious.

Collybia subdryophila was described by Dr. Atkinson from plants sent him from Chapel Hill by us. It seems to me to be one of the numerous forms of this variable species. His description is as follows (Ann. Myc. 7: 367. 1909):

"Plants dry, 5–9 cm. high, pileus 2–3 cm. broad, stem 5 mm., stout. Pileus smooth, purplish or pinkish-brown. Gills white, adnexed. Spores oval to subglobose, granular, then usually with a small oil drop, 3–4 μ, in diameter, rarely 5 μ, long. Stem cartilaginous, tough, hollow, equal. Belongs to Levipedes section, resembles somewhat *C. dryophila*, but differs especially in the spores. C. U. herb., No. 22634, mixed woods on hillside by Fern Walk near Sparrow's Pond, Chapel Hill, N. C., W. C. Coker, October 2, 1908."

For good illustrations see Mycologia 3: 101, pl. 40, fig. 8, 1911, and 4: 164, pl. 68, fig. 3. 1912.

80. On side of hill east of Tenney's, October 23, 1911.
1012. Among leaves in woods in Battle's Park, October 28, 1912. Spores cream color, 3.3–3.8 × 5–7.5μ.
1745. On trunk of red maple among growth of Porella, at foot of Lone Pine Hill, September 12, 1915. A depauperate form. Spores about 3.7 × 7μ.
2493. Gregarious to subcespitose in humus, grove at "The Rocks," May 9, 1917. Photo. Intermediate in character between *C. butyracea* and *C. dryophila*. Spores white at first, 3–3.3 × 5.5–6.7μ, exactly like those of *C. butyracea* No. 1902.
3049. Dense deciduous and also pine and deciduous woods, foot of Lone Pine Hill, May 18, 1918. Spores ovate-elliptic, white, smooth, 2.8–3.9 × 5.2–6.5μ.
3066. Strowd's lowground woods, on decaying stump, May 22, 1918.
3310. On a black gum log, June 7, 1919. One plant has on it a specimen of the growth called by Peck *Tremella mycocephala*. Painting.
3542. Mixed woods, Battle's Park, October 28, 1919. Cap very pale buff, center slightly darker. Gills and top of stem pale yellow, darker buff below.

Blowing Rock. Atkinson.
Asheville, "In scattered colonies on old leaf mould and old wood. Often in dense clusters." Beardslee.
Middle district, in woods. Curtis.

3a. **Collybia dryophila** Bull. A form.

We have a small, squat form of bare soil in shade that would hardly at first sight be referred to this species. It is single or cespitose;

COLLYBIA DRYOPHILA. Photo fly B.

COLLYBIA DRYOPHILA. No. 2492-

the cap up to 2.5 cm., usually about 1.5 cm. broad, nearly plane or irregular, glabrous, not viscid, hygrophanous, brownish-leather color when wet, leather color or buffy leather when dry. Flesh concolorous; taste oily-woody, strong, odor same or slight. Gills rather close, sinuate, color of cap, 1–2 mm. wide. Stem 1.5–2.4 cm. long, 1–2 mm. thick, smooth, concolorous, tough, solid, firmly attached in the soil and bringing up a ball of earth. Spores (of No. 3237) white, elliptic, 2.9–3.7 × 4.1–5.5 μ, identical with those of the typical form.

2500. In humus soil under shrubs in Arboretum, May 11, 1917.

3237. In sparse weeds and grass under oaks, roadside home near Mebane, N. C. May 20, 1919.

3236. Bare soil, road in front of Dr. Battle's, May 15, 1919. This is just like No. 3237, except that it is abnormally squat and irregular and more cespitose; cap margin strongly recurved in most; odor and taste the same.

3240. On nearly bare soil under oak, hillside on Glen Burnie farm, May 21, 1919. Spores 3 × 4.2–5.5μ.

4. **Collybia Earleae** (Murrill) n. comb.
Gymnopus Earleae Murrill.

PLATES 9 AND 23

Cap 6 mm. to 3.3 cm. broad, convex, then plane or concave, smooth, dull, margin incurved until near maturity, sometimes striate; color pinkish buff or dark brown then wood brown; surface minutely puberulent all over when young. Flesh concolorous, tough; taste rankly moldy; odor faintly similar.

Gills not crowded, notched at stem, narrowly adnexed, becoming practically free at full maturity, narrow, 1–3 mm. wide, pale then nearly color of cap, with tint of pink.

Stem 1.5–3.3 cm. long, 1–4 mm. thick, tough and cartilaginous, hollow, granular-pulverulent, then smooth, color of cap or a darker reddish buff; attached to soil by a decided clump of tangled, tawny hairs which come up with it, bringing a ball of earth.

Spores (of No. 3052) white, smooth, pip-shaped, 2.3–3 × 5.2–6 μ.

This seems certainly *C. Earleae*, which is known only from the type locality—a creek bottom near Auburn, Alabama. The small size, dark color, growth on damp earth, pinkish-brown gills and particularly the dense clump of tawny hairs easily distinguish it.

3046. On damp ground, Strowd's lowground woods, May 5, 1918.
3052. Same locality as No. 3046, May 7, 1918.
3128. Same locality as No. 3046, May 18, 1918. Spores 3–3.8 × 5.8–7μ.
3130. Same locality as No. 3046, May 22, 1918.

5. **Collybia nummularia** Fr.
Collybia strictipes Pk.

PLATES 10 AND 23

This medium-sized plant grows generally in small tufts on rotting leaves in low woods. Cap up to 5.5 cm. broad, convex, then expanded, sometimes slightly depressed on one side, somewhat striate on margin, barely umbonate, yellowish-tan in color, often with tint of pink, the center almost brick red and usually a little rugose, often appearing water-soaked. The pileus sometimes shows concentric circles near the margin, evidently due to the plants being water soaked and drying in stages.

Gills close, and not very narrow, white or light flesh-colored, sinuate-attached, or sometimes free, not quite reaching the outer edge of the cap, many short ones.

Stem 3.5–7 cm. long, 3–7 mm. thick, cartilaginous, hollow, smooth, flesh-colored or whitish, darker at base, nearly equal, connected with extensive cream-colored mycelium that runs among the leaves.

Spores long, pip-shaped, white, smooth, 3.7 × 7.4–8 μ, characteristically pointed and bent at the mucro end.

Peck says of *C. strictipes* (Rep. 49: 44. 1896): "From small unspotted forms of *C. maculata* this species may be distinguished by its even stem, less crowded lamellae and by the shape of its spores." From *C. dryophila* it is distinguished by the more yellowish cap with reddish, more or less rugose center, the more equal, paler, and more translucent stem, and by the longer, more pip-shaped spores. It is a common species and easily recognized. Kauffman has developed this species (as *C. strictipes*) from mycelium in leaf-mold brought into the laboratory and kept in a partially covered dish (Mich. Acad. Sci. Rept. **22**: 203. 1920).

82. On leaves near Howell's Branch, October 4, 1911.
83. Among leaves, Battle's Park, October 28, 1911.
354. On rotting leaves near Howell's Branch, October 11, 1911. Spores pip-shaped, mostly pointed and slightly bent at one end, 4 × 9μ.
584. Near Howell's Branch, October 18, 1912. Spores 3.5–4.5 × 6–9.5μ.

COLLYBIA EARLEAE. No. 3128.

PLATE 10

COLLYBIA NUMMULARIA. No. 628.

589. On leaves, below Howell's Spring, October 18, 1912. Spores 3.3–4 × 6–8.5μ, with mucro end pointed and bent.

628. On leaves near Battle's Branch back of Dr. Wilson's house, October 24, 1912.

Blowing Rock, Atkinson.

Asheville, abundant. Beardslee.

6. **Collybia myriadophylla** Peck.

Cap 2–5 cm. broad, thin and tough, broadly convex to plane and slightly depressed at the center, hygrophanous, brownish or grayish brown with a distinct lilac tinge when moist, paler when dry, minutely fibrillose.

Gills very crowded and narrow, adnexed, brownish lilac.

Stem slender, tough, 2–4 cm. long 1–2 mm. thick, colored like the cap, often compressed silky pruinose especially toward the rooting base.

Spores ellipsoid, 2 ×3-4 μ.

Growing on old logs. Rare.

This seems more common farther to the north. It is quite common in the coniferous woods of upper Canada. It is very distinct in its very crowded and narrow lilac gills. The texture of the plant is suggestive of *Marasmius*.

Asheville. Beardslee.

7. **Collybia distorta** A. & S.

PLATE 11

Cap 2.6–8 cm. broad, campanulate, then expanded, and in age with the irregular and contorted margin upturned; glabrous, hygrophanous, deep reddish brown, paler when dry, not viscid. Flesh toughish, pale-concolorous; taste of rotten wood; odor none.

Gills crowded, up to 6 mm. wide, mostly narrower, several times branched toward the margin; edges pubescent, thick; color a dilute tan, then strongly stained and blotched with reddish brown.

Stem short in ours, 2–4 cm. long, 5–10 mm. thick, often flattened; strongly channelled, inherently fibrous, the base whitish with mycelium and connected with stout white strands which run in the rotten wood.

Spores white, smooth, oval, 3.3–4.2 × 4.4–6 μ. (rather few in this collection).

3519. On a rotten log, October 26, 1919.

8. **Collybia radicata** Rehl.

PLATES 12 AND 23

Cap 3–10 cm. broad, expanded, usually umbonate and rugose, in center sometimes nearly plane; surface viscid, glabrous, varying from pale yellowish-brown or gray to deep blackish-brown, the margin lighter. Flesh thin, white, toughish, taste pleasant.

Gills white, rather distant, broad, adnexed to nearly free.

Stem very variable in length and thickness, often most slender when longest, 5–20 cm. long above ground, 3–13 mm. thick at stem, tapering upward, and extending deeply into the earth with a smaller root; surface glabrous or furfuraceous, striated and often grooved, about color of cap or lighter, darkest below; texture firm, stuffed.

Spores (of No. 1844) white, smooth, elliptic, 8–10.8 × 14.4–19 μ.

A very variable plant both in size and color, but always easily recognized by the long rooting extension of the stem. It is common in open woods, groves and shrubby borders through the summer and fall, and is edible. McIlvaine says it is sweet, pleasing in texture and delicately flavored. For a good illustration see Krieger in Nat. Geog. Mag. **37**: 398, 1920.

130. Campus in front of Alumni Building, September 21, 1908.
372. Open place west of athletic field, October 18, 1911.
472. Steep hillside on ground and on rotting tree roots in Battle's Park, September 30, 1912. Spores 11.8 × 15.2μ.
478. In open space back of South Building, October 2, 1912. Spores 11 × 18.5μ.
495. On steep hillside around rotting tree in Battle's Park, October 4, 1912.
1844. Battle's Park, north of Piney Prospect, September 20, 1915.

Asheville. Beardslee.
Blowing Rock. Atkinson.
Common in woods. Curtis.

9. **Collybia semitalis** Fr.

PLATES 14 AND 23

Cap convex, 2.5–5.5 cm. broad, convex except for a low umbo or nearly plane, hygrophanous, not viscid, rather silky-shining, inherently fibrous radially, at times minutely squamulose between center and margin, dark brown with a tawny tint, the center blackish and the margin soon so on withering or touching. Flesh 1.5 mm.

COLLYBIA DISTORTA. No. 3519

PLATE 12

COLLYBIA RADICATA. No. 478.

thick near stem, pale brown, toughish, fibrous, taste and odor of raw meal.

Gills crowded, 4–5 mm. wide, broadly adnate and a little decurrent, not notched; brownish drab, the margins soon darker, black when bruised.

Stem 1.5–3 cm. long, 5–6 mm. thick, subequal, color and surface of the cap but rather darker; flesh concolorous, tough, firm, fibrous, stuffed and paler in center.

Spores (of No. 3869) white, smooth, oval, slightly pointed at each end, 3.7–4.2 × 7.4–8.5 μ.

Recognized by the rather small size; dark, smooth, inherently fibrous cap; dark, crowded, slightly decurrent gills, which change color when bruised, and by the farinaceous taste and odor.

Added below is Beardslee's description of this plant from Asheville:

Cap 1.5–6 cm. broad, hygrophanous, gray to deep smoky gray when moist, dingy gray to isabelline when dry, surface with darker fibrils giving it a streaked appearance, convex with the thinner margin incurved, then expanded and plane, flesh white, thin at the margin.

Gills white, quickly becoming yellow and then black when bruised, moderately close.

Stem 2–4 cm. long, 5–15 mm. thick, tough, white, changing color like the gills, stuffed but often hollow with age.

Odor rancid and unpleasant.

Spores usually ellipsoid, 7–9 × 5–6 μ.

Growing along paths, in bare ground in woods. This is a curious but altogether unattractive plant. I have found it only in wet weather after rains. Usually the plants are short stemmed and close to the ground, and dirty and sordid in appearance. They agree well with Bresadola's figure and description of *C. semitalis* to which I refer them. All my specimens agree in the quick change to yellow and then black, and all of them have the same disagreeable odor. Both of these characters are brought out in Bresadola's diagnosis.

It will be remembered that Bresadola has separated his plants into three closely related species, all of which were included by Fries under the one name. The spores of the Asheville plants are typically like those of his *C. semitalis* and the change of color and odor are as he describes. It is interesting, however, that some specimens had a few spores which were triangular as in his variety *trigonospora*, and in one plant they showed a tendency to become spindle shaped. In none was

there a change to blue, and then black. Some specimens were more like *Tricholoma* than *Collybia*.

It is hoped that more work can be done on these forms and their status definitely determined.

887. In pine and oak woods east of graded school house, October 4, 1913. Spores 3.7–4.6 × 7.4–9μ.

890. In pine and oak woods, sandy soil by edge of road, about 250 yards southeast of cemetery in woods, October 6, 1913.

3869. Mixed woods, back of athletic field, December 11, 1919.

3880. Mixed woods, Strowd's lowgrounds, December 13, 1919.

Asheville. Beardslee.

10. **Collybia platyphylla** Fr.

PLATES 1, 13, AND 23

Cap large, up to 12.5 cm. broad, plane and regular or considerably crimped, lobed and uneven, sometimes depressed in center; surface smooth, finely punctate under a lens, not viscid, a rich bay brown (about warm sepia, Ridgway) in center, fading to snuff brown on the margin. Flesh white, extraordinarily thin for the size of the plant, only 3 mm. thick near the cap, and fading to a mere transparent membrane near the margin.

Gills deeply sinuate, barely reaching the stem at top, distant, sometimes much crumpled and ridged on faces, varying greatly in width in the same plant, some 2 cm. wide in the center, while other narrow ones running between are only a few mm. wide; color nearly white or with a slight flesh tint.

Stem stout, about 5–10 cm. long, 1.5 to 2.3 cm. thick at top, somewhat larger below, stuffed, then usually hollow; surface even and smooth, striate, white at top, brownish below; flesh white, firm.

Spores white, smooth, oval to short-elliptic, 6.8–7.6 × 7.6–8.5 μ.

Edible, but not so good as many others.

1263. In grass just east of Old West Building, campus, U. N. C., September 25, 1914. Painting.

1833. In humus, woods by branch southwest of Rocky Ridge Farm, April 20, 1915. Spores creamy in bulk, subspherical to ovate, smooth, 4. 3–5. 8 × 6.3–8μ. Surface of cap brownish-gray, with whitish flecks from the cracking superficial layer.

2045. In grass near oak tree north of Alumni Building, June 9, 1916. Also occurs near stump north of President's house.

2509. In same spot as No. 2045, June 8, 1917.

COLLYBIA PLATYPHYLLA. No. 1833.

3276. On a rotting oak stump in Battle's Park, June 1, 1919. A remarkable form of *C. platyphylla*. Cap drooping with the margin crimped inward, about 11 cm. across below, and hanging down about 10 cm., glabrous, but cracked into inherent scales over all but margined half or third. Stem very long, 24 cm., 1.7 cm. thick; fibrous, tough. Spores smooth, ovate, 5.9–6.6 × 7.7–8.1μ.

Blowing Rock. Atkinson.
Asheville. Beardslee.
Low and middle districts, on rotten wood. Curtis.

11. **Collybia exsculpta** Fr.
Collybia colorea Pk.

PLATE 14.

Cap 2–4 cm. broad, rounded convex to broadly campanulate, with the center a little prominent; hygrophanous, yellow, with the disk often reddish or brownish, minutely fibrillose; margin thin, exceeding the gills, even.

Gills yellow, close, narrow, sinuate adnexed, usually turning red in drying.

Stem slender, 2–4 cm. long, 3–5 mm. thick, colored like the cap, hollow, glabrous.

Spores ellipsoid, 4–6 × 3–3.5 μ.

On old logs; not rare.

This is without question Peck's *C. colorea*. Our specimens have been submitted to Bresadola and approved as *C. exsculpta*, which is said to be rare in Europe. The gills usually change to red in drying, but I have had undoubted specimens in which this is not the case. Occasionally I have found specimens in which the growing plant were red. This, I take it, is Peck's var. *rubescentifolia*. From the peculiar color and its habit of growing on logs this species would be taken at first sight for *Flammula*.

Asheville. Beardslee.

11a. **Collybia exculpta** (a form)

PLATES 15 AND 23

Cap 1. 6–2. 6 cm. broad, convex with a depressed center, then expanded with depressed center, glabrous, hygrophanous, not viscid, very faintly striatulate near the margin when soaked, color about ochraceous tawny when soaked, a paler cream-buff to chamois when

not soaked, the center at times a little darker, the thin margin soon withering to nearly black. Flesh very thin, about 0.6 mm. thick near stem, taste woody and a little bitter, odorless, concolorous.

Gills crowded, color of unsoaked cap, in places becoming distinctly lilac in drying, sinuate, about 2–3 mm. wide.

Stem concolorous, 2.3–3 cm. long, 1.3–3.5 mm. thick, nearly equal, base with white mycelium; mostly glabrous, a large hollow, toughish (cap rather tender).

Spores (of No. 4543) white, smooth, subspherical, 3.5–4 × 3.7–5.5 μ, no cystidia. Basidia long-clavate, about 6 μ, thick, 4-spored. Hymenium about 29–33 μ, thick. Threads of the gill trama parallel, narrow toward the margin, more swollen toward the cap.

I am considering this a form of *C. exsculpta*, but the color is buff, not yellow or reddish-yellow and the gills are not bright suphur yellow. Also it does not grow on decaying wood but on the ground.

1735. In earth by path west of Meeting of Waters, September 10, 1915.
4543. On very rotten pine log, Strowd's lowgrounds, July 26, 1920.
4597. On rotting oak wood, swamp of Bowlin's Creek, July 30, 1920. Spores 3.7–4.5 × 4.5–7.4μ.

12. **Collybia cirrata** Fr.
Agaricus cirratus Pers. Abs. Myc. 2: 53. 1799.

PLATES 1, 16, AND 23

Cap 7–15 mm. broad, slightly umbonate, depressed-umbonate, or only depressed, expanded; the margin curved; glabrous, hygrophanous, not viscid, buffy tan, the margin pale, and center darker. Flesh about 0.5 mm. thick, toughish, concolorous, almost odorless, tasteless.

Gills crowded, less than 1 mm. wide, linear, slightly notched at stem, nearly white or concolorous.

Stem 0.8–2.5 cm. long and up to 2 mm. thick, narrowed above, or equal, about color of cap or darker, covered below with a conspicuous dense mat of long, cottony, white or whitish, more or less radicating fibers which may extend with reduced length nearly to the top if well protected; usually only scurfy above.

Spores (of No. 3491) white, smooth, oblong-ovate, 2.2–2.5 × 3.7–4 μ.

This is certainly *C. cirrata*, agreeing in all respects with Persoon's original description which is as follows (translation):

PLATE 14

COLLYBIA EXSCULPTA. Photo by B. [upper left].
COLLYBIA ALBA. Photo by B. [upper right].
COLLYBIA SEMITALIS. Nos. 3869 & 3880 [below].

PLATE 15

COLLYBIA EXCULPTA, A form. No. 1735.

PLATE 16

COLLYBIA HARIOLORUM. Photo by B. [above].
COLLYBIA CIRRATA No. 3941 [below].

"Small, gregarious, cap subpapillate, plane, whitish; disk subrufescent, gills crowded, white; stem rather long, slender, rufescent covered with long fibrillose rootlets.

"Habitat. Among dead leaves in autumn, truly a parasite, especially on dying Agarics.

"Stems 1½ inches long, ½ line thick at base and sending out sparingly from the sides fibrillose rootlets sometimes 1½ inches long Gills narrow, even, subdecurrent. Cap about 2–3 lines broad, plane to convex, subumbilicate, ½ line thick."

Murrill thinks this the same as *C. tuberosa* (N. Am. Flora **9**: 374. 1916) and he may very well be right. This form, however, has no tuber and the dense mat of hairs is not mentioned for *C. tuberosa*. *Agaricus* (*Collybia*) *tuberigenus* B. & C. is probably this. There is a collection from Hillsboro, N. C., in the Curtis Herbarium. It is hairy at the base like our plants and also has small tubers. It seems to be growing from earth rich in humus "under cedars."

Beardslee's notes on the Asheville plant are as follows:

This species and its close relative *C. tuberosa* seem to need further study. True *C. cirrata* was found at Asheville answering well to the common description. The more common form, however, grew in masses from old decaying fungi arising in almost every case from yellowish sclerotia, but also having a dense mass of white fibrillose roots. If the presence of a sclerotium is decisive our plant is *C. tuberosa*. Bresadola considers this plant *C. cirrata* and writes that the differences are "exactly as shown in Cooke." The main difference in Cooke's figure is in the sclerotia which are deep brown or black in *C. tuberosa* and yellow in *C. cirrata*. According to this view our Asheville plants are the latter species. It seemed possible that the color of the sclerotia might depend upon their age, the yellow color being characteristic of the newly formed sclerotia and the dark brown or black indicating older ones. Some attempts were made to test this theory but no decisive results secured.

3491. On a dead and black, but still firm and tough, Thelephora, on earth near north branch of Meeting of the Waters, October 16, 1919.

3743. On a dead agaric in pine woods north of Meeting of Waters, November 12, 1919.

Asheville. Beardslee.

13. Collybia conigena Fr.

PLATES 17 AND 23

Cap about 1.5–20 mm. broad, about 270 μ thick, very nearly plane, but with a slight depression in the center, the edge turned up slightly in older specimens, surface glabrous, light brownish-tan, or the center pinkish, minutely pubescent. Threads of flesh very irregular and knotty.

Gills almost white with a brownish tinge, nearly or quite free, some branched, quite narrow toward the margin. Threads of gill flesh 3.7 μ thick.

Stem about 2.5–5 cm. long, very pale, lighter in color than the cap or gills, minutely pubescent (velvety) at maturity above and with long white hairs at the base which attach it to the cone. These threads are very long and conspicuous rhizomorphs that look like stiff cotton threads and are very peculiar. They may extend from as much as the lower third of the stem.

Spores (of No. 3503) white, extremely minute, oblong, about 1.5–2 × 3–4 μ. Basidia about 3.7 μ thick and 13 μ long. Cystidia only on margin of gills, 6.6–9.3 μ at thickest part, about 15–25 μ long.

Easily recognized from its habit of growth on pine cones. While *C. esculenta* and *C. conigena* are said by Bresadola to have much larger spores, this is not borne out by the more recent European monographs. Lange (l. c. p. 18), Ricken (l. c. p. 414), and Sartory and Maire (l. c. p. 176) all describe the spores to be substantially as in our American plants. Their creeping stems which are hairy on the rooting portion could not separate our plants. It is only in the spores that a marked difference appears. *Collybia esculenta* is listed by Schweinitz from this state. For comparison of this and *C. conigenoides*, see the latter species.

84. On pine cone, October 20, 1911.
2948. On cone of *Pinus echinata*, October 15, 1917.
3503. On decaying pine cones, October 25, 1919.

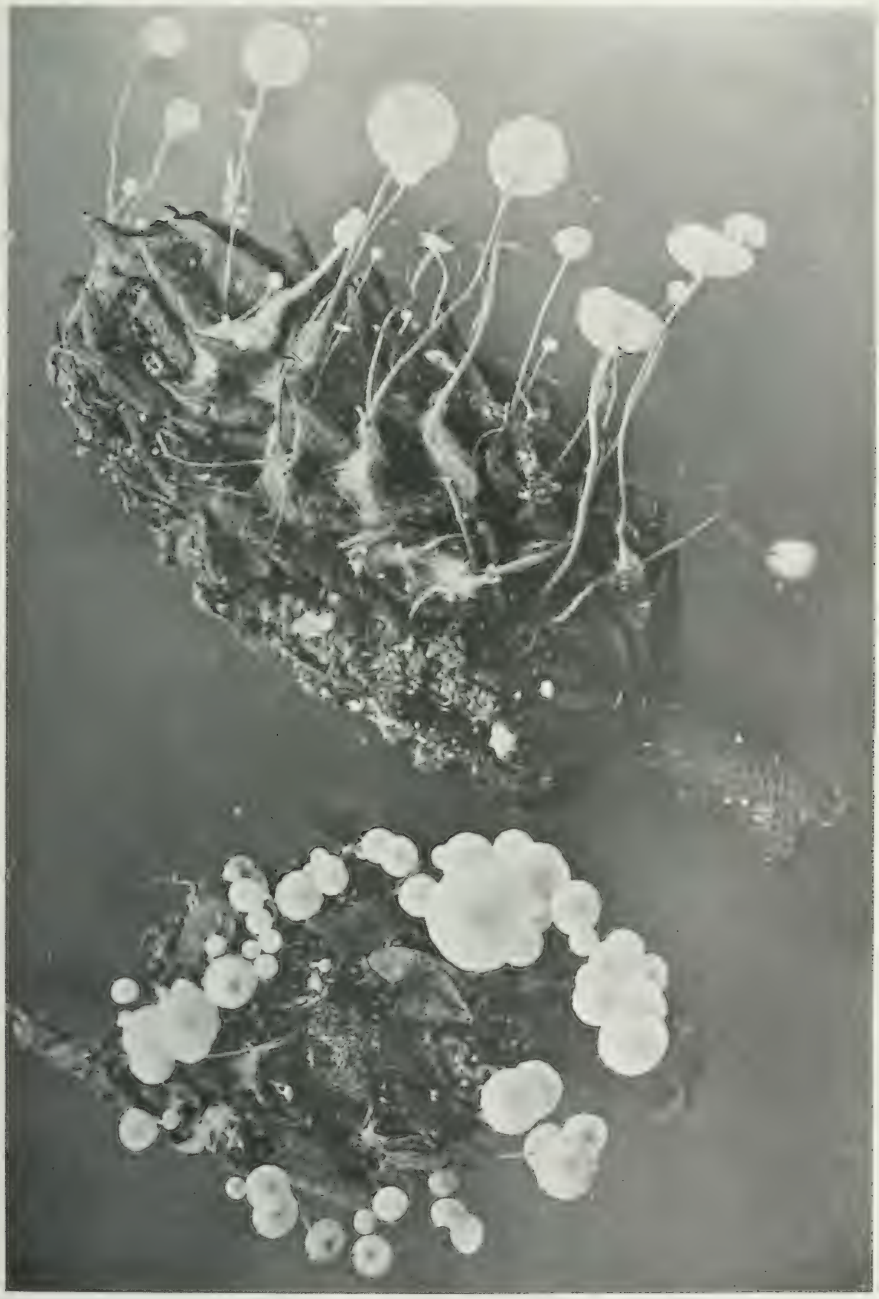
Asheville. Beardslee.
Low district, rotting pine cones. Curtis.

14. Collybia conigenoides Ellis.

PLATES 18 AND 23

Cap 3–15 mm. broad, convex then nearly plane, at times depressed in center, striatulate, very finely pubescent, a little viscid, buff in center, paler toward margin; the cap surface composed of large swollen cells through which project the short hairs which are about

PLATE 18



COLLYBIA CONIGENOIDES. No. 3545.

6–7.5 μ thick at base and of variable length up to 55 μ. Flesh less than 0.5 mm. thick, nearly tasteless and odorless, toughish; threads of flesh about 3.7 μ thick.

Gills white or palely concolorous, rather close, ventricose, 1.5 mm. wide in center, rounded at stem and slightly adnexed, not veined or branched.

Stem 1.5–4 cm. long, 0.5–0.9 mm. thick, finely puberulent all over like the cap, except in the basal region which is covered for some distance by long, woven, fine buff hairs which bind the stems together; color a clear ochraceous buff all over except for the abruptly whitish tip; tough, hollow.

Spores minute, smooth, elliptic, pointed at one end, 2.2–2.9 x 5–6.3 μ. Basidia 4-spored, about 4.4 μ thick and 18 μ long. Cystidia present, contracted above the swollen body.

Mostly cespitose, but some single. It approaches very closely to *Marasmius*, reviving quite well in water.

This is certainly *C. conigenoides*, every character agreeing with the original description (Bull. T. B. C. **6**: 76. 1876). We have examined a collection determined by Ellis and distributed as No. 3503 in Ellis and Everhart North American Fungi on cone of *Magnolia Fraseri* from Nuttallburg, W. Va. (Herb. Dept. Agr., Washington). Although in bad condition this specimen is without doubt the same as ours, with the long buff hairs conspicuous around the stem. The species is different from our plant on pine cones which we are calling *C. conigena*. The latter has smaller spores and basidia, gills branched in part, a paler stem, with white, not buff threads below, and no bladder-like cells on the cap surface.

The plant from Michigan on pine cones referred by Kauffman to *C. conigenoides* cannot be our species on magnolia cones as the former has a white stem with white hairs at the base and shorter spores.

3545. By path in Arboretum on fallen magnolia cones, October 28, 1919. Photo.

15. **Collybia alba** Pk.

PLATE. 14

Cap 6.5–11 mm. broad, rounded-convex, white, glabrous.
Stem 1.7–2.6 cm. long, 2 mm. thick, pure white, glabrous.
Gills broad, ventricose, nearly free.
Spores 4–5 × 3 μ.
Growing on old mossy logs and stumps. This small white species

is found frequently in the summer, and has been referred to Peck's species with which it seems to agree. The dried plants become dingy as they dry, as noted by Peck.

Asheville. Beardslee.

16. **Collybia velutipes** (Curt.) Fr.

PLATES 19 AND 23

Plants densely crowded and imbricated or somewhat scattered, growing on logs.

Cap up to 4.5 cm. broad, very irregular in shape and surface, ridged and often deeply pitted, general outline rounded or nearly plane; surface very glutinous and viscid, smooth, color a strong dull red (about burnt sienna) in center, shading out to a yellowish-red on margin; in old wet plants a deeper blackish-red. Flesh light reddish-yellow (about color of gills), about 3 mm. thick near stem, quickly thinning to less than 1 mm., tasteless or sweetish.

Gills moderately close, sinuate attached, with a broad, deep tooth near stem, about 8 mm. wide at the tooth and 4 mm. wide beyond; color a light reddish-yellow, about pale yellow-orange of Ridgway, lighter when young.

Stem central or somewhat lateral, about 2. 5 to 5 cm. long, usually strongly flattened at top or to full extent, about 5 to 8 mm. wide at cap, tapering downwards, and usually fused with others at base into a dense clump, surface densely short-tomentose, almost velvety; color of gills at top, dark reddish-brown elsewhere, texture tough, almost cartilaginous at surface, more fibrous inside; solid or partly hollow.

Spores (of No. 1507) white, very abundant, elliptic, smooth, 3.4 × 5.1–8.5 μ.

This is one of the good edible mushrooms and it may be had often in any of the winter months. We find it in Chapel Hill only in cool weather. For an elaborate account of the plant with ten plates see Stewart in Bull. No. 448, N. Y. Ag. Exp. Sta., Geneva, Feb.1918; also Biffen in Journ. Linn. Soc. **34**: 147. 1899.

For other illustrations see Mycologia 1: 39, pl 3. 1909; Krieger. Nat. Geog, Mag. **37**: 398. 1920.

1507. On end of hickory log in grove behind Memorial Hall, December 9, 1914.
2013. On a charred oak stump, southwest of athletic field, December 18, 1915. Spores elliptic, smooth, 3.2–4 × 5.5–8μ.

COLLYBIA VELUTIPES. Photo by B.

Asheville. Beardslee.
Middle and upper districts, on rotting logs. Curtis.

17. **Collybia hariolorum** Fr.

PLATE 16

Cap 2–5 cm. broad, broadly campanulate, becoming expanded, and at length nearly plane with the center a little prominent, pale tan or pale rufescent at first, becoming white with age, glabrous, striate on the margin when moist; flesh white, thin, especially on the margin; odor when crushed strong and unpleasant. Taste disagreeable.

Gills white, narrow, closely crowded, adnate with a distinct sinus.

Stem 2–4 cm. long, 2–4 mm. thick, hollow, slightly enlarged at the base, everywhere covered with white villous down, which is longer and more marked at the base, the extreme base usually curved and attached by an abundant white mycelium to the leaves in which it grows.

Spores 4–6 × 2.5–3 μ.

Somewhat gregarious, on old leaves in woods.

This species appeared quite frequently in late summer at Asheville. It is suggestive of *C. confluens*, and may easily be taken for it. As found at Asheville it is more nearly white than *C. confluens*, has a shorter stem, and is not inclined to occur in the dense clusters which are characteristic of *C. confluens*. The rather disagreeable odor is also a mark of distinction.

Asheville. Beardslee.

18. **Collybia confluens** Fr.

Marasmius confluens in N. Am. Flora **9**: 269. 1915.

PLATES 20 AND 23

Cap 1.3–4.6 cm. broad, convex then expanded, the center broadly compressed, the margin curved and striatulate when moist; hygrophanous, reddish-brown and viscid when wet, leather color when dry. Flesh toughish, concolorous, about 1 mm. thick in center; taste and odor slight.

Gills moderately close, up to 4 mm. broad, rounded at stem and adnexed, color of dry cap.

Stem 4–6 cm. long, finely white pubescent above, the threads longer and more cottony below and often binding several together,

color of cap when shown through the pubescence; tough, often compressed; hollow.

Spores white, smooth, elliptic, pointed, 2.5–3.7 × 6.2–7.4 μ.

3533. Mixed woods back of cemetery, October 26, 1919.

Blowing Rock. Atkinson.
Asheville. Beardslee.
Middle and upper districts, among rotten leaves. Curtis.

19. **Collybia zonata** Pk.

PLATES 21 AND 23

Cap up to 3. 6 cm. broad, convex, or nearly flat with a broad umbo, a sharp depression in the center (umbilicate) at all ages, flatly hemispheric when young, with the margin strongly incurved; surface conspicuously clothed with roughish hairs of a rich tawny color, the hairs usually pinched into groups and flattened. Flesh thin, tough, white, taste sweetish, of a disagreeable, fishy nature, odor strong and of the same nature, and persisting long after drying. Occasionally the odor is absent, as in No. 2658.

Gills white, rather close, narrow, about 1.5 mm. wide, quickly rounded at the stem and barely reaching it at the upper angle.

Stem slender, even, up to 5 cm. long, about 1.5 to 2 mm. thick, tough and strong, with a small irregular hollow about the size of a needle; surface covered with similar hairs as the cap and of the same color.

Spores white, elliptic, smooth, 4.5–5.4 × 6.4–7.2 μ.

The plants are cespitose from decaying bits of twigs, etc., on the ground and are remarkable for their penetrating odor, somewhat resembling the fishy smell around old wharves, only more acid. This is not mentioned by others.

Not found at Asheville by Beardslee and apparently new to the state. For a discussion of this and related species see Atkinson N. Y. State Mus. Bull. **205-206**: 61. 1919. For other illustration see Mycologia **4**: pl. 56, fig. 8. 1912.

1577. From twigs, rootlets, old beech fruits, etc., on ground, New Hope Swamp, June 26, 1915.
1899. On a rotten root, woods at foot of Lone Pine Hill, October 17, 1915.
2241. On hull of *Hicoria ovata*, swamp of New Hope Creek, June 24, 1916.
2568. By path in woods along Battle's branch, July 2, 1917.

PLATE 20

COLLYBIA CONFLUENS. No. 3533.

COLLYBIA ZONATA. No. 1577.

2658. On rotten oak log, low damp woods by Battle's branch, July 12, 1917. The characteristic odor of the type was absent when fresh, but was slightly noticeable when dry. Taste faint, but unmistakably that of type. Other plants with very strong characteristic taste and odor were growing on the same log with this, but several feet away.

3112. New Hope Swamp on decaying bark, June 23, 1918.

20. Collybia stipitaria Fr.

Marasmius stipitarius (Fr.) Atk. and House.

Agaricus scabellus Alb. and Schw.

PLATE 23

Cap 5–12 mm. broad, convex, depressed a little around the center which is itself concave, roughly fibrous, that is, the inherent fibers forming irregular elevated ridges and near the margin pinched into squamules, pale tan to gray or brownish-gray, the center (in No. 3370) abruptly a much deeper gray-brown; texture of cap and stem tough and persistent; taste and odor none.

Gills rather distant, about 1 mm. broad, abruptly sinuate at the stem and nearly or quite free, pale-creamy white, the margins toothed.

Stem 2–5 cm. long, 0.5–1 cm. thick, equal, spongy-scurfy all over, inserted, i. e. disappearing into the substratum and not arising from superficial mycelium; about color of cap center, the tip shading to tawny.

Spores smooth, oval to elliptic, 5.1–6.2 × 8.9–10.4 μ. Cystidia acute to mucronate, simple.

Easily recognized by the fibrous-squamulose cap, dark center, nearly free gills and spongy stem surface. It is distinguished from *C. zonata*, which is near, by the smaller size, absence of fishy smell and longer spores. For discussion of this and related species see Atkinson in Bull. N. Y. St. Mus. **205–206**: 61. 1919. Massee gives measurements of *C. stipitaria* as: cap 4–11 mm. across and stem 1–2 in. long. For other illustration see Lloyd, Mycological Notes **1**, No. 5: 42, fig. 15, 1900.

3370. On herbaceous debris, grove in front of Gimghoul Lodge, June 26, 1919.

Asheville. Beardslee.

Middle and upper districts, on decaying trunks. Curtis.

21. Collybia lilacina n. sp.

PLATES 1, 22, AND 23

Solitary or gregarious and at times subcespitose, rather often with little undeveloped ones attached to the stem bases of mature ones. Cap up to 7.5 cm. usually about 4–5.5 cm. wide, hygrophanous, decidedly or very slightly umbonate, somewhat uneven, expanded, margin striatulate when moist, even or nearly so when dry, flat or bent down; surface smooth, like fine leather in appearance, the marginal third often rugose in youth, the wrinkles disappearing; color tan with the center decidedly deeper and usually with a tint of lilac at maturity. Flesh thin, only 1. 8 mm. thick at stem, whitish except at center, which is brownish-lilac, tough, almost tasteless.

Gills rather distant, variable in attachment just as in *Clitocybe compressipes*, sometimes deeply sinuate, most of them barely attached and not at all decurrent, again squarely adnate in part and sinuate in part and some slightly decurrent by a tooth, very easily separating from the stem when attached, about .5–8.5 mm. wide, broadest near stem, color a pallid tan or bright tan, then darker with brownish-lilac tints and smoky on drying, many short, none branched. The surface of the gills is set with spiny cystidia which project about 20–25 μ.

Stem very variable in length even in plants of the same size, up to 11 cm. long and 6.5 mm. thick at cap, nearly equal, usually twisting in drying and becoming lined from top to bottom, tough and semi-cartilaginous, firm, elastic; surface pruinose and often lined above, smooth below, the very base enlarged and tomentose with the fine white mycelium; color of cap, lilac tinted at maturity especially above white at base; flesh strongly brownish-lilac, deepest colored within, a large hollow cylinder in center from top to bottom.

Spores (of No. 1818) white, elliptic, smooth, 5.2 × 7.8 μ.

Very young plants are nearly black, but soon become paler. The lilac tints do not appear until maturity and deepen afterwards. This change is peculiar and constant. Smaller specimens of the species have very much the general appearance of *Marasmius oreades*, but differ in the smooth hollow stem, tendency to lilac tints in all parts at and after maturity, in not reviving well when moistened and in the much larger size attained at times. The habit also is different, our plants being solitary or sparsely gregarious, and growing in woods and shrubbery and on bare earth, not in open grassy places. It also

PLATE 22

COLLYBIA LILACINA. No. 3288. Photo of drawing, to show size.

seems near *C. nigrodiscus* Pk. I am inclined to think this is the plant listed by Curtis as *M. plancus*, Fr., which has a similar habit and size and has a hollow stem, but *M. plancus* differs in its narrower gills and downy stem, and in absence of lilac tints. In size, shape, and thickness of flesh, *Mycena Zamurensis* Pat. and Gail. from Venezuela (Bull. Soc. Myc. Fr. **3**: pl. 8. 1887) recalls our plant, but is excluded by the absence of lilac tints and differently shaped spores. I have looked through the Curtis herbarium under *Marasmius* and *Collybia* but could find nothing like this.

1752. In damp shaded spot in soil among weeds and grass, woods at foot of Lone Pine Hill, September 12, 1915.

1818. One plant. On dry shaded path in Arboretum, northeast side, September 17, 1915. Stem eccentric; gills almost triangular, wide in center, pointed at stem and just reaching it, distant, veined at cap, rather light brownish-drab with a tint of lilac. Stem granular-pruinose above, smooth elsewhere, tough, 2.5 cm. long, hollow; cap 3.5 cm. wide.

2193. Woods below rock wall, south of Peabody building, June 21, 1916. Cap about 3 cm. broad, strongly convex, umbonate, smooth, appearing slightly tomentose under a lens, hygrophanous, fleshy-buff color, darker in center; margin thin, even, becoming brownish-lilac. Spores white, smooth, elliptic, pointed at one end, 3.7–4.4 × 5.5–8μ.

2810. Among shrubs near wall, east side of Arboretum.

3288. Under *Magnolia* in Arboretum, June 4, 1919.

3290. Under *Magnolia soulangeana* in Arboretum, June 4, 1919. Fine plants, up to 6.5 cm. in diameter. Painting.

4331. Under shrubs in Arboretum, June 24, 1920. Spores variable, smooth, elliptic, 4–5.5 × 6–9μ.

22. **Collybia clusilis** Fr. (sense of Schroeter)
Mycena palustris (Pk.) Sacc.

Cap up to 1 cm. broad, very smooth, convex, not umbonate or umbilicate, brownish-olive or buffy-brown (Ridgway), paler when young, very thin and delicate but not striate.

Gills pale yellowish-brown, distant, slightly decurrent, not sinuate, less than 1 mm. wide, only about 20 to 25 in number and a few short ones.

Stem slender, about 3 cm. long, color of gills, smooth, hollow, extending deeply into the moss and there covered with mycelial strands.

Spores white, subspherical to elliptic, smooth, 3.5–6 × 4–9 μ.

This very pretty little plant seems to be confined to thick beds of moss.

Notes by Beardslee follow:

Cap 0.5 cm. to 2 cm. broad, rounded convex, at times slightly raised at the center, becoming more expanded with age and somewhat depressed, hygrophanous, pale brown or brownish-olive, paler when dry, and becoming opaque, and with a slight silky luster, margin thin, striatulate when moist, even when dry; flesh thin.

Stem slender, weak, 3–6 cm. long, a little lighter in color than the cap, attached by abundant white mycelium to the mosses in which the plant grows, smooth, and hollow.

Gills grayish brown, rather distant, adnate, rather narrow, venous connected.

Spores elliptic, 7–9 by 4–5 μ.

Odorless when fresh, but developing a slight disagreeable odor. Growing in beds of sphagnum.

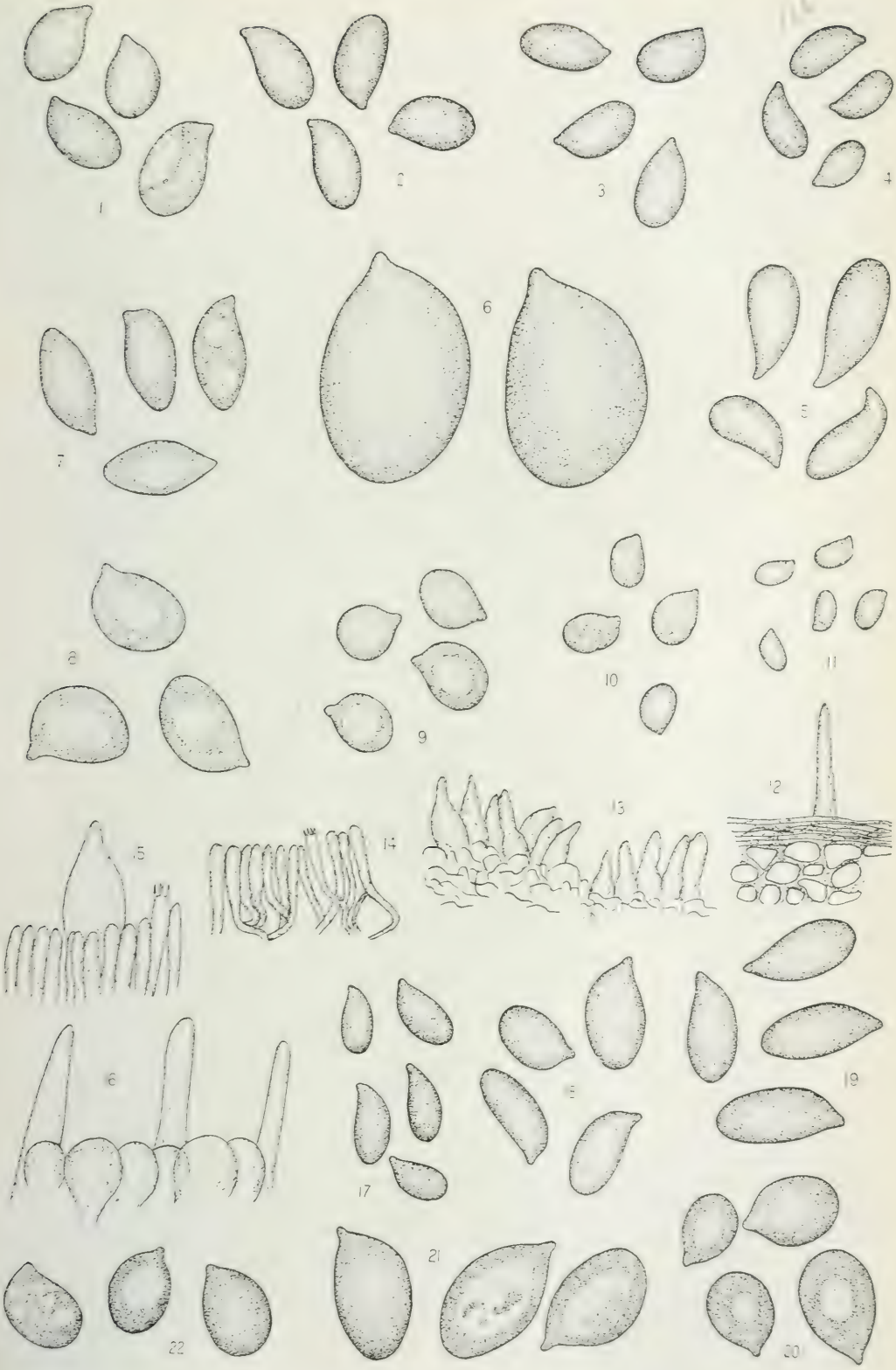
This interesting plant was found in abundance in Sweden in 1905. I have since seen it in similar places in Maine. When first found it could not be determined with certainty, though its abundance in one of Fries' collecting grounds indicated that it could not have escaped him, especially as it is more than usually striking. Lange's excellent notes on *Collybia* made it possible to identify it as above. Schroeter has an excellent description as Lange points out in Pilze Schlesiens, page 642, which exactly fits our plant. Fries' description does not fit as well. Cooke's figure is not a good representation of our plant. Ricken's description presents some difficulties. There seems little doubt that our plant is *C. clusilis* in the sense of Lange and Schroeter.

As it occurred in Sweden good opportunities for studying it were given. Successive crops of specimens appeared after rains in the same moss patches and its variations could be observed. The shape of the cap seemed to vary considerably. What seemed to be the typical form uniformly showed a slight umbo, or papilla. Other plants were rounded or even depressed at the center, though scarcely so as to be called umbilicate. The type material of *Mycena palustris* (Pk.) Sacc. has been carefully compared with our specimens and found to be identical, though the description seems to indicate a discrepancy in regard to the gills.

1532. In a thick, dense bed of a large moss (*Dicranum scoparium*), woods south of cemetery, December 4, 1913. It has also appeared in a similar bed of the same moss near the sphagnum bed east of athletic field.

Chapel Hill, N. C.
Perry, Ohio.

PLATE 23



EXPLANATION OF PLATE 23.

Collybia maculata. No. 594. Fig. 1.
Collybia butyracea. No. 1902. Fig. 2.
Collybia dryophila. No. 3049. Fig. 3.
Collybia Earleae. No. 3052. Fig. 4.
Collybia nummularia. No. 584. Fig. 5.
Collybia radicata. No. 372. Fig. 6.
Collybia semitalis. No. 3869. Fig. 7.
Collybia platyphilla. No. 3276. Fig. 8.
Collybia exsculpta. No. 4543. Fig. 9.
Collybia cirrata. No. 3491. Fig. 10.
Collybia conigena No. 3503. Fig. 11, spores; fig. 12, hair on cap; fig. 13, cystidia on gill margin; fig. 14, basidium.
Collybia conigenoides. No. 3545. Fig. 15, basidium and cystidium; fig. 16, hairs and swollen cells on cap surface; fig. 17, spores.
Collybia velutipes. No. 2013. Fig. 18.
Collybia confluens. No. 3533. Fig. 19.
Collybia zonata. No. 1577. Fig. 20.
Collybia stipitaria. No. 3370. Fig. 21.
Collybia lilacina. No. 3290. Fig. 22.

Figs. 12–16 × 670; others × 2160.

Effect of the Relative Length of Day and Night and Other Factors of the Environment on Growth and Reproduction in Plants. By W. W. Garner and H. A. Allard.

(Note: The authors have furnished by request the following abstract of their work. Mr. Allard was assistant in Botany in the University of North Carolina in 1904–05. Both authors are now in the Department of Agriculture, Washington. Their paper under the above title was published in Journ. Agr. Research **18**, No. 11, 1920.)

Although the intensity of the light and the quality as regards wavelength of radiation are recognized as important factors in the development of plants, the present paper deals mainly with the behavior of the plant in response to the daily duration of the period of light. This phase of the subject of light effects upon plants appears to have received little attention in the past but in the present paper sufficient evidence has been accumulated to show that it has an extremely important bearing on the expression of plants as regards growth, stature, and specialization in the direction of sexual reproduction.

The main feature of the present paper is a demonstration of the fact that with many plants, sexual reproduction in some manner is a function of the relative length of the day and night. In other words, by artificially shortening the summer daily illumination period by keeping certain plants in a dark house for suitable periods of the day, sexual reproduction or flowering is initiated. Thus, the plants may be made to bloom at will, weeks or months in advance of controls responding to the normal seasonal length of day. Thus, certain late varieties of soy beans, namely Biloxi and Tokio, in particular, and the variety of tobacco known as Maryland Mammoth, have shown themselves very responsive to such conditions. The wild aster, *Aster linariifolius*, and other species also blossomed precociously, so to speak, when the length of day was reduced to 12 hours or 7 hours, respectively. Plants of this class may be considered short day plants, since sexual reproduction has been initiated by a length of day considerably shorter than the normal summer day which tends to promote vegetative growth, until the shorter days of late summer and autumn intervene to initiate flower and seed production.

On the other hand, certain plants have consistently shown a different behavior, and have failed to bloom in response to a day length of 7 hours, as obtained by the use of the dark house. Climbing Hemp

weed (*Mikania scandens*), wild Hibiscus (*Hibiscus Moscheutos*) and the common garden variety of radish (Scarlet Globe) are members of this class. For the sake of convenience these plants have been termed long day plants, indicating that they attain sexual reproduction successfully when the days are relatively long.

By the use of electric light of low intensity to increase the relatively short duration of illumination of the winter days, results in line with those obtained when the summer day has been shortened, were secured. Thus, soy beans and cosmos blossomed weeks and months after the controls enjoying the normal duration of illumination of the winter days.

It is evident that the duration of the daily illumination in itself is of primary significance in controlling the course of development toward or away from the flowering stage or sexual reproduction.

Experiments with several so-called late varieties of soy beans in the field, planted at intervals from April to August, have shown that the shortening of the period from planting till the first appearance of blossoms, is dependent upon the seasonal length of day to which the successive plantings have been subjected.

In the light of these results it is believed that the natural distribution of plants is governed more or less directly by the seasonal length of day which obtains for the different latitudes of the earth from the equator to the poles.

From the evidence at hand it will be seen that the stature and season of flowering of certain plants is dependent upon a favorable length of day, and this may actually be a most important limiting factor in determining crop yields in many instances. In other words, the time for propitious seeding to obtain maximum yields may be governed very largely by the length of day to which the crop will be exposed.

Since it has been shown that certain plants respond with a definite behavior to certain day lengths, the term "photoperiodism" is suggested to designate this response.

TEACHING OF GEOMETRY. By Archibald Henderson, Professor of Pure Mathematics, University of North Carolina.

If this paper (a pamphlet of 49 pages, Univ. N. C. Extension Series No. 33) simply followed the usual treatment of books on "The Teaching of Geometry," it would not call for special mention; but, as it strikes a distinct note, and gives many fresh discussions not found

in our geometries, it seems appropriate to call attention to it as an original work of high scientific value that should prove not only helpful, but stimulating to teachers and students in geometry.

In the Introduction, Dr. Henderson properly calls attention to the lessons of the world war as to the prime necessity of Mathematics relative to the scientific progress, welfare and preservation of a nation, which naturally recalls the saying of Napoleon that, "The advancement, the perfecting of mathematics, are bound up with the prosperity of the state."

In discussing "The Aims and Results of Geometrical Study," the author emphasizes the fact that the true purpose of instruction in geometry is to develop the faculty of independent thinking in geometry, to acquire facility in working problems—"originals," as they are happily called—in other words, to train the student as an investigator —a research worker. There can be no question as to the correctness of this point of view. Students so trained, take an increasing interest in the study—they "make good—" whereas, those neglecting this discipline, soon lose their mental self-reliance and intellectual courage to tackle new problems and difficulties, become discouraged, resort to mere memorizing, and thus, ultimately fail.

The author next takes up "The Problem of Instruction," and advocates the natural method of instruction, even when it is longer than the usual synthetic method. The usual text-books, following almost exclusively the synthetic method, are models of "Compression, elegance and rigor;" but they, too often, leave the student puzzled as to what the author is driving at, until the end is reached; when, presto, a conclusion is reached which comes as a distinct surprise to the reader, who has not been prepared for the denouement by being given the reasons for the successive steps of the demonstration.

By the synthetical method, whether for the demonstration of theorems or the solution of problems, we start from known theorems or problems and endeavor to effect a solution; but, as it is often difficult to know from what known theorems or problems to start, a series of fruitless essays may be made before hitting upon the proper solution.

On the contrary, by the natural method—that of the "old analysis" of Plato—we have the advantage of a starting point, the thing to be proved; and from that, an endeavor is made, by logical processes, to reach a known result. When this is attained, then if the successive

results are reciprocal, or each can be obtained from the one that follows, the theorems or problem posited in the beginning is true; since it can be proved by the synthetical method, by reversing the steps and working from the first conclusion or known results.*

The method of analysis is generally that of research and discovery; and because of its importance to the investigator and because of the slight attention accorded it in existing texts, Dr. Henderson has, purposely, given a number of illustrations of its working in solutions of theorems and problems. In fact, the treatment by the analytical method of problems and theorems is one distinctive feature of the paper, which should appeal particularly to the eager student who aims at any research in geometry.

"The Basic Problems of Construction" are treated by the author in an interesting manner. Most of the constructions are simple; some are complex, and are given as stimulating problems, since one object of the paper is to give new and instructive points of view.

This is especially noted in the section entitled "The Problem of Research," where the various modes of approach to the solution of geometrical problems are indicated, and numbers of illustrations are given with a completeness and elegance of demonstration that causes one to regard this section as the most interesting part of the essay.

The scope of this section can be judged from the following subheadings:

1. The Method of Analysis,
2. The Method of Successive Substitutions,
3. The Method of Reductis Ad Absurdum,
4. The Method of Intersection of Loci,
5. The Method of Construction of Loci by Points,
6. The Method of Transformation; Construction of Auxiliary Figures,
7. The Method of Parallel Translation,
8. The Method of Rotation Symmetry,
9. The Algebraic Method,
10. The Method of Similarity.

The final sections on "Procedure in Attacking Geometrical Problems" and a Biographical Note complete the subject.

The paper is illustrated with 26 figures, and is written in the attractive style one has come to associate with the author. It is plainly intended for teachers and research workers, for the author is a firm

* See Duhausel's "Des Méthodes dans les Science de Raisonnement," vols. 1 and 2; also, Cain's "Symbolic Algebra and Notes on Geometry" (D. Van Nostrand Co., New York) for a full discussion of the analytic method, including the cases of "lost" solutions and of those "strange" to the questions.

believer in that method of instruction which constantly calls for the working of "originals", and this brochure should prove especially helpful and inspiring to both teacher and student in pursuing this plan.

WM. CAIN

The following three abstracts were published in the University of North Carolina Record No. 179, Graduate School Series No. 2, August 1920.

IN REGARD TO SPECIES AND SPONGES. By H. V. Wilson. *The Scientific Monthly,* October, 1919.

A comparative study of sponge species indicates that hereditary characters are independently subject to variation such that in respect to any one of them individuals and races occur which form close series between far distant extremes. Such series are doubtless in many cases phylogenetic ones in which the terms bear to one another the relation of ancestral species and descendant. In other cases it would seem that the terms of the series represent only different degrees in the environmental stimuli which related protoplasms have made independently of one another.

It is recognized that the gene theory which assumes the existence in the germ cell of minute units, representative of the hereditary characters, is applicable to the facts stated above, as well as to the facts of Mendelian inheritance in particular, if only we assume enough units in the germ cell. In thus extending the theory to cover all forms of heritable differences between organisms, it may be questioned whether it retains any practical (pragmatic) value. Nevertheless it would seem that symbolism of this sort does contribute to precision of thinking, if it be recognized for what it is, viz., conceptual symbolism.

It is called to mind that many today would remove the gene from the conceptual world and give it a perceptible body, that is, they would identify it with a chromatin granule. The known facts however do not necessitate, according to some even contradict, this view as to the nature of chromatin and chromosomes.

SPONGES OF BEAUFORT (N. C.) HARBOR AND VICINITY. By W. C. George and H. V. Wilson. *Bulletin U. S. Bureau of Fisheries,* XXXVI, Document 876. 1919. (Body of the paper accepted as a thesis for the Ph. D. degree awarded to W. C. George, 1918).

The paper includes a description of sponges present and in any de-

gree conspicuous in the Beaufort area. Seventeen species are described, most of them new. Of these the "Fishing Bank," a bank of coralline nature with a West Indian fauna, to seaward of Beaufort Inlet, has yielded four. Collecting on the sea-beaches was incidental, most material so collected being unfit for precise study. The bulk of the sponges are harbor forms, at least eight sufficiently abundant to be available for investigations of an experimental nature. The occurrence of a minute horny sponge of very simple character, designated *Pleraplysilla latens*, is noteworthy, both because horny sponges as a group inhabit more southern waters and because of the morphological simplicity of the form.

The families, subfamilies, and genera represented are defined, and the paper may thus be used for purposes of identification. A considerable amount of comparative data falling under the general head of variation is recorded, and in the case of a number of the genera there is discussion of the facts on which they rest. The illustrations, of entire sponges and microscopic preparations, are for the most part photographic.

ASYMMETRICAL REGULATION IN ANURAN EMBRYOS WITH *Spina bifida* DEFECT. By H. V. Wilson and Blackwell Markham. *Journal Experimental Zoology*, XXX. 1920. (Body of the paper accepted as a thesis for the M. A. degree awarded to Blackwell Markham, 1918.)

Abnormal embryos and larvae of the frog and toad are described, the developmental processes in which add to our knowledge of what is called the regulatory power of organisms. This is the power which enables an organism, lower adult or embryo of higher form, to restore or develop the typical form of body, after the destruction or amputation of a part of the whole, or after some interference in development which blocks the normal course of differentiation. In the particular cases described the normal backward growth of the axial structures of the embryonic body, such as notochord and spinal cord, is prevented. In a well-known type of embryo of this sort the tissue of the blastopore lips, two stripes which diverge from the posterior end of the embryonic body, becomes organized, each stripe forming a half spinal cord, half notochord, etc., the half structures gradually coming together (process of 'concrescence') in the median line to form a complete spinal cord, complete notochord, etc. But in the embryos here described a different and asymmetrical kind of regulation is employed. Instead of both streaks (blastopore lips) organizing and fusing, only one streak

organizes. It organizes however in such a way as to produce not a half but the whole, that is, both right and left halves of the trunk of the body. Thus the end result, the production of a typical form, may be reached by very different paths. This variety in the fundamental formative processes of which an embryo is capable makes it impossible to think of development as at bottom a deterministic process, viz., as one in which the embryo is a machine composed of (self-propagative) parts each the material cause and origin of a particular portion of the body.

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ISOTOPES

By Francis P. Venable

The fundamental conception in chemistry is that of the atom. The atomic theory is the basis of all explanations offered as to the constitution of matter and such reactions and other changes as may occur in matter. The atom is possessed of certain characteristics or properties that distinguish it. It has even been suggested that an atom is a bundle of properties. The mass or weight of the atom has been assumed to be an unvarying property and hence to be classed as a constant of nature.

The determination of one of these constants, which after all means an attempt at measuring the attraction exerted by other masses of matter upon it, is of course relative in its results and beset by many difficulties and chances for error. At first the methods used were too crude and the results obtained too inaccurate to justify any conclusions as to the unvarying nature of these so-called constants, but with the improvements in apparatus, methods, and manipulation there was reached a degree of confidence which caused some investigators to question the constancy of the atomic weights. Schützenberger, Boutlerow, and others raised this question but no satisfactory conclusion could be reached so long as the possibility of error in such determinations was unavoidable. There was, however, a persistent suspicion that changes in the atomic weights might occur in the course of chemical reactions. To refute this we have the well-known experiment of Landolt which proved that within the limits of experimental accuracy no change in the sum of the total interacting weights of matter can be detected when chemical action takes place. For the usual routine work of the chemist, then, it can be taken for granted that the weight

of the atom is an invariable or constant quantity. It is to be noted however, that the proof is not absolute, and furthermore that while the sum total weight might have been found to be the same the possibility of change in single atoms was not excluded.

As explanatory of some of his results Crookes, in his classical investigation of the rare earths, threw out the suggestion that in the course of reactions, and such have taken place throughout untold periods of time, changes might be wrought in certain of the atoms under the stresses to which they had been subjected. These he called "worn atoms." If this were so, then the determinations, in which vast numbers of atoms are dealt with, could give only the average of all atoms concerned as the weight of one. It is manifest that chemical methods alone could not give a satisfactory answer to such a question as this, but after nearly half a century the same conclusion has been practically reached through the use of modern methods, largely physical. It would seem that in a number of cases at least our accepted atomic weights represent an average weight only.

The announcement of the Periodic System by Mendeleeff induced a renewed and increased interest in the atomic weights and their determination. This system showed that when the elements were arranged in an ascending series according to the increase in their atomic weights they fell into certain periods and groupings which brought out remarkable relations as to chemical and physical properties. By means of this system Mendeleeff was enabled to predict the existence of certain elements at that time unknown, and to give a fairly accurate description of them and their properties. These predictions were, for the most part, confirmed soon afterwards and the system took its place in science as a natural system.

It is important to note, however, that in drawing up his ascending series Mendeleeff relied more upon the properties of the elements than upon the atomic weights. His boldness in pointing out places to be filled by yet undiscovered elements testifies to this, and still more the fact that in certain cases where there was conflict between the physical properties and the atomic weight in deciding the position of an element in the series he unhesitatingly adopted the properties as the deciding factor so that so far as these elements are concerned it is not a strictly ascending series of atomic weights. This transposition was quite allowable at a time when most of the atomic weights had been only inadequately investigated. In the cases where this liberty was

taken the atomic weights fell very close together and it was within reason to think that the probable error lay there. The two chief instances were those of Te and I; Co and Ni. During the following years many determinations were made to settle this discrepancy. The differences between them were under one-half of a unit but they were real and persistent. Some suggested the existence of companion elements which could not be separated. Indeed Krüss announced the discovery and separation of such a companion element with nickel which, if removed, would leave the atomic weight of nickel greater than that of cobalt and thus justify Mendeleeff in so placing it in the series. Krüss died shortly afterwards and his supposed discovery has never been confirmed. The proof that Mendeleeff was right in placing these elements as he did was finally brought about through the revelations of radioactivity. This much was evident from the first, however, namely, that each element had its definite position in a series, or place in a system not artificially arranged but forming a natural order. In this orderly arrangement two factors decide the position of the element. These are the mass and the electrical content. That the elements were electrically charged was recognized by Davy within a few years after the announcement of the atomic theory.

The clear exposition of the inter-relationship of the elements and their arrangement in a definite order practically placed their composite nature beyond question and their genesis became a subject of speculation. Of course Prout had been the first to enter this field, but so far as he was concerned it was a sheer guess without foundation in fact or logic and should never have received the attention given it. So, too, the later hypotheses lacked fundamental data, though some of the guesses were shrewdly near the developments of these latter years.

While it was definitely settled that each known element had its definite place in the series, no especial import was placed upon the relative number of this position. This is now known as the atomic number and can be determined accurately by physical means. It was first accomplished by radioactive methods but Moseley's marvelous application of the defining power of quartz crystal to the definition of the x-rays emitted by each element under a bombardment by negative elections has superseded all other methods. The spectra so obtained reveal an orderly shifting of certain groups of lines. Beginning with any one element, the position of all others in the series can

be determined. In other words, the atomic number of any element can be found in this way.

Radioactivity has solved the constitution of the atom. Rutherford's disintegration theory and his demonstration of the building up of the helium atom have finally settled that problem. We now know that the atom is built up of positive and negative electricity—according to Rutherford's conception, a positive nucleus of alpha particles surrounded by a field of negative electrons. The discussion of this or other atomic models is apart from the object of this paper.

The Periodic System represented the place occupied by an element in the series as primarily a function of its mass, but in reality mass is secondary and the electrical content is the chief factor. As already stated there are two variables in the structure of each atom—mass and electrical content. The former decides the position of the element in the vertical columns of the Periodic Table and the latter decides the position in the horizontal columns. In consequence of the influence of the electrical content, Soddy reasons that a chemical element is not necessarily homogeneous and its atomic weight may be, and possibly is generally, a mean value rather than a natural constant. The fact that some elements are known to be radio-active—that is, with some of their atoms undergoing disintegration—that even such elements as potassium and rubidium are subject to a slow disintegration of their atoms which involves the formation of atoms of lesser mass, brings the thought near that possibly all elements are subject to the same process of change except that the rate is too slow to admit of detection by such instrumentalities as have hitherto been used. Quite recently the statement has been made that by means of a new device it has been found possible to detect and register the expulsion of one alpha particle from zinc in every nine and a half hours. So far as I know, this has not been confirmed. But enough is definitely known to bring us back to the worn atoms of Crookes.

The addition of some thirty or forty new elements known as radioactive elements but having valid claims to recognition as real elements puts too severe a strain upon the Periodic Table as conceived and constructed. This is far in excess of the number of vacant places, especially when one reflects that the rare earths which have been shifted from place to place are still dissatisfied with their accommodations. Making use of the two variables named above, it was found that a few of these radioactive elements—as, for instance, radium emanation,

which belongs to the group of the monatomic gases—found lodgment in some of these vacant places; but the great majority fall in places already occupied by well-known elements. Thus seven fall in the place occupied by lead. This necessitates the use of the same atomic number for eight elements. These radioactive elements possess identical chemical characteristics with lead and can not be separated by chemical means. The minute amount of the radioactive elements available renders a comparison of the spectra difficult. In a number of cases they are known to be identical and according to Soddy's theory should be, but certain generalizations (as that of Hicks) are opposed to this view.

The name isotope was adopted by Soddy to designate these elements. The word means same place. Thus RaG is an isotope of lead; RaC is an isotope of bismuth. No strictly chemical means for separating these elements is known. In the same way ionium and thorium are isotopes and there are three other isotopes in that place in the Periodic System.

As these isotopes have different physical properties, they can be separated sometimes by means of these. The question then arises as to whether in case the atoms of an element are not homogeneous they can be separated or detected by physical methods. J. J. Thompson in 1913 devised a method involving the use of the deflecting influence upon the trajectory of an ion by the simultaneous application of electric and magnetic fields and thus obtained evidence of the existence of heterogeneous particles. In some cases further examinations show these to be different molecular aggregations rather than new elements. Thus in hydrogen besides H_2 the presence of H_3 was proved and there was a possibility of other hydrogen molecules being there. The atomic weight of hydrogen is 1.008. The fractional portion can now be safely regarded as due to an admixture of these heavier molecules. To call such molecular aggregations isotopes would be a serious departure from the original definition of the term. They are not distinct and different elements. The term is sometimes carelessly used in the case of molecular aggregations of hydrogen, and other elements and this must lead to needless confusion of ideas.

An examination of the monatomic gas neon, whose atomic weight is given as 20.2 reveals the presence of a companion gas having an atomic weight of 22. This corresponds with no known element and the new element is called meta-neon. A physical investigation of at-

mospheric neon was then undertaken by Aston. Fractionations by charcoal absorption yielded no results, but fractional diffusion resulted in a partial separation of the two gases. They showed the same properties and gave identical spectra, differing only in atomic weight. More recently the possible existence of another isotope with the atomic weight 21 has been shown.

It would seem that heterogeneity has been proved in more than twenty of the common non-radioactive elements. The investigations have been carried on chiefly by the method of Thomson in which the negative electrons were separated and differentiated, and that of Aston in which the positive particles were examined by the application of similar means to the canal rays. Diffusion methods have also been applied with partial success. From the results obtained by either the Thomson or the Aston method the atomic weights can be accurately calculated. It is interesting to note that the results from the Aston method give as whole numbers the atomic weights of all the elements examined.

From the examination of chlorine it was found that there were present two distinct elements having the atomic weights of 35 and 37 respectively. There was a possibility of another in much smaller amount with the weight 39. The atomic weight of ordinary chlorine is 35.47 and this is correct to the second decimal place. It is composed mainly of chlorine 35 plus chlorine 37. The relative amounts of these present have been determined and the atomic weight confirmed.

In argon a companion element was found in very small amount and this had the atomic weight 36. Krypton gives definite evidence of being a mixture of five isotopes and possibly six. The atomic weights are 84, 86, 82, 83, 80, 78. Xenon also shows the presence of five isotopes with possibilities of two more.

The remaining ten in the list of Aston are homogeneous as to atoms but heterogeneous as to molecules. These are H, He, C, N, O, F, P, S, As, and I. In these cases only two variants were found in each mixture.

There is a very striking fact regarding the isotope of helium which was discovered by Rutherford and found to have the mass 3. Aston gives it the atomic weight 4, the same as helium, and that means from his calculations some multiple of 4. It is proper to state that Rutherford has questioned the correctness of Aston's deductions. If Rutherford is right, this coincides with the mass of the hydrogen isotope

H_3, which was discovered by Thomson, confirmed by Aston, and directly prepared by the activation of H by Wendt and Landauer (Amer. Chem. Soc. 1920. 42: 920). Thus we have the two with the same mass—one an isotope of helium and the other a molecular aggregation of hydrogen. They are entirely different in properties.

Soddy (Lond. Chem. Soc. Ann. Rep. XVII. 221) writes as follows concerning the Aston methods:

> The methods depend on the same general principles as those (of Thomson) which sufficed to detect the presence of meta-neon, of atomic mass 22, in atmospheric neon but the electromagnetic and electrostatic deviating fields are rearranged in such a way as to secure an effect precisely analogous to focussing in optics. The trajectories of the positive ions in a slightly divergent beam are brought to a focus in a plane containing the photographic plate. All those for which the mass divided by the charge is the same are brought to the same point in the plane, those with greater or less values, respectively, being on either side. The complex pencil is resolved into a "mass spectrum" in every respect analogous to a light spectrum produced by a prism or grating. The terms "first-order and second-order mass spectrum" are used to denote spectra produced by ions singly and doubly charged respectively. The existence of ions with more than one unit of charge introduces a complication but fortunately these are experimental peculiarities which enable the two orders usually to be distinguished without uncertainty. The relative mass of the ion causing any line in the spectrum can so be evaluated to an accuracy of one part in a thousand and the atomic mass determined to a degree of accuracy comparable with that attained in the best determinations of the atomic weight by chemical means. Incidentally, the complete agreement between the two in many cases affords much the most important evidence of the constancy between mass and weight for different elements. . . . .
>
> Apart from a possible uncertainty, already alluded to, as to the orders of spectrum to which any line belongs, the photographs published reveal the great power and accuracy of the new method. Unfortunately, only non-metallic elements have so far been included. The difficulties in the way of examining metallic elements by this means have not yet been overcome. In every case, except hydrogen, the atomic mass of each homogeneous component proves to be an exact integer in terms of that of oxygen as 16, within the error of measurement already stated. For hydrogen, however, the chemical value 1.008 is exactly confirmed and its homogeneity proved.

In the year or two that have elapsed since the above citation was written by Soddy several new isotopic elements have been discovered, among them those accompanying certain metals as K, Rb, Mg, and Zn, so some of the difficulties which impeded progress have been overcome. Likewise certain of the atomic weights as determined by chemical means have been very exactly confirmed. Furthermore, Harkins has

recently drawn attention to the inadequacy of the designation "atomic number." He suggests as a substitute "element number" but this seems equally inadequate. The truth is, it is merely a position number and no longer represents either single atoms or simple elements.

In his address as president before the recent meeting of the British Association, Thorpe says:

> The term atomic weight has thus acquired for the chemist an altogether new and much wider significance. It has long been recognized that it has a much deeper import than as a constant useful in chemical arithmetic. For the ordinary purposes of quantitative analysis, of technology, and of trade these constants may be said to be now known with sufficient accuracy. But in view of their bearing on the great problem of the essential nature of matter and on the superlatively grand question, "What is the inner mechanism of the atom?" they become of supreme importance. Their determination and study must now be approached from entirely new standpoints and by the conjoint action of chemists and physicists.

In conclusion, I ask you and myself the question: How shall we now define the element in the light of these new and wonderful revelations? Years ago in an address before the American Association I pointed out how often in the history of science we had been forced to change the definition because of new developments and how shifting were the sands upon which it was based. The homogeneity so fervently relied upon in our textbooks must be abandoned as the heterogeneity of their component particles has been made manifest. One stand is left to us and it has the appearance of permanence. However heterogeneous physically, these component particles are homogeneous chemically. In fact, the sole difference seems to be that of mass. For the present, then, the definition may safely run: The masses of all elements are composed of chemically similar particles. So long as this is true the chemist at least need not disturb himself. Of course, there always looms before us the fact of atomic disintegration.

CHAPEL HILL, N. C.

SOME CONSIDERATIONS IN DEFENSE OF THE GENERAL BIOLOGY COURSE

By J. P. Givler

In the teaching of elementary courses in the biological sciences in America two main policies have been developed during the past half century. In one, the beginning student is introduced to plant biology or animal biology through the medium of a course in Botany or Zoology as a distinct entity. The other method, originating with Huxley, is to organize into a single elementary course forms from both plant and animal "kingdoms" to show their essential agreements or to bring out their contrasts.

The history of the two policies is well known. The separate course system had its origin in systematic Botany and Zoology since Linnaeus and before his time, through Cuvier and others in Europe and into America principally through the elder Agassiz and Asa Gray at Harvard. The animus of the General Biology Course, on the other hand, came up from Greek thought, with the viewpoint of the naturalist, out of which the selection theory gained expression through Darwin and Wallace.

Parallel with this naturalistic expression developed the generalizations based upon the discovery of the meaning of the cell and of protoplasm which generalizations have become incorporated with the Doctrine of Organic Evolution.

About sixty years ago Huxley seized the essential features of this cell-protoplasm-evolution complex and, with rare educational genius, framed it in clear outline for the beginner and layman. In this he doubtless secured assistance from Foster and Dyer and inspiration from Darwin.

Each of these systems of elementary instruction has its peculiar virtues. That involving separate courses has the advantage of a more restricted field and, further, clings mainly to *fact* through the disciplines of morphology and taxonomy, while the General Biology Course is animated mainly by ideas and principles from the spirit of the generalizations which gave it birth.

As is commonly known the teaching of General Biology entered this country with H. Newell Martin, the physiologist, an early student of Huxley's, and radiated out from Johns Hopkins into a great many institutions in the East and West. During the forty-odd years which

have elapsed since that time many changes have taken place. The number of colleges and universities including some kind of Biology in their curricula, then small, has multiplied into the hundreds. With this has come about a vast increase in the number and viewpoints of teachers, their leaders primarily interested, as investigators, in extending our knowledge into new fields of an ever broadening and deepening science.

Along with this must also be reckoned the profound influence of German science upon that of America. As complained of by Professor Carmichael* our science has become practically an appendage of that of Europe (and especially of Germany) as witnessed by the character of the research in most departments of American universities. These various exhaustive and extensive research programs pursued by leading professors and the "schools" which they represent demand distinct limitation in the scientific interests of the workers which, unfortunately, spells the extinction of the general point of view.

The General Biology Course, on the other hand, was born out of a more generalized condition and in a day of more limited knowledge. Uniting the genius of interpreter with that of investigator, Huxley was able to organize out of simple materials a course of great suggestiveness and value which undoubtedly stimulated many students. The pedagogical theory underlying the course was that each type is both broadly suggestive in itself and also that, through their sequence, evolutionary progress is epitomized. The inclusion of both plant and animal types was defended on the ground "that the study of living bodies is really one discipline, which is divided into Zoology and Botany simply as a matter of convenience."

In the second edition of their textbook Huxley and Martin reversed the order of animal forms, beginning with the frog, running down to the Protozoa and then up on the plant side to the Angiosperm.

From that day to this we have had an unending series of experiments in the pedagogy of General Biology among writers in English recalled by the names of Parker, Gibson, Dodge, Boyer, Wells, Needham, Hamaker, Sedgwick and Wilson, Abbott, Conn, Calkins and others. Each of these books seems to be the embodiment of a sincere attempt to frame "a general biology" for the beginner in somewhat the spirit of one writing an introduction to philosophy.

They disclose many influences. The book by Sedgwick and Wilson,

* Carmichael, R. D., Science, Apr. 1, 1921.

really an unfinished task, apparently attempts to combine the Huxleyan unified view of nature with a strong leaning toward the typically German love of multitudinous details in its rather exhaustive treatment of the fern and the earthworm. Continual experimentation in the order or sequence of presentation of types characterizes these many elementary textbooks.

The earlier, and we believe the better, of these works developed directly out of Huxley's influence and, like that of their master, were based solidly on the idea of comparative general morphology and physiology. An example of these, and in our judgment, the best that has ever been written, both from a biological as well as from a literary standpoint, is Jeffrey Parker's "Lessons in Elementary Biology." This book embodies the virtuous realization that the student knows only the types presented which must serve as the tangible and material embodiment of the principles drawn therefrom.

Unfortunately this fine common sense is nearly absent from many later works in which both author and reader seem to struggle vainly to get feet on solid ground. Many such works embody the results of recent and unconfirmed research, talk much about enzyme action or accessory chromosomes, and give the student the notion that he must reach up and pluck general principles out of thin air.

Much poor teaching has been done in the name of "General Biology," and I revoice some of the criticisms of Professor Nichols* of the Yale Sheffield Scientific School, who not long ago published a detailed attack upon the value of this type of course. While believing that his views result, in the main, from bias, many of his points are well taken.

Many courses, printed and unprinted, have been futile primarily because their builders fail to recognize the basic principle of any type course—that the types presented embody the realities from which both wider knowledge must spring and on which principles must rest. If this be true for distinct courses in Zoology and Botany, where subject-matter is more limited, it is much more the case in General Biology where the student's thinking may range over a wider field.

In our view the essential principle of a course in General Biology is that it be a series of elementary lessons upon a logically arranged series of suggestive type forms. The course should be conducted by a broadly-trained biologist with a view to developing in the student

* Nichols, G. E., Science, Dec. 5, 1919.

the attitude of the appeal to nature for facts, upon which accurate thinking is based, as well as that liberation of the spirit which comes from reflection upon their broader meaning.

From the standpoint of the student there are two considerations of importance. First, which method will give him the best scientific training in Biology while providing a single view of the entire field of living things, granted that he may find time for no further work in Biology? Second, which method would be preferable in case he decides to go further or finally become a specialist? These complex questions are, in a measure, bound up with the nature of the curriculum for, after all, a college exists largely for the purpose of sampling the stock knowledges which have come down to us with our social inheritance. Biology purports to give an interpretation of the living world. This is a large order, so the student rightfully expects a clear panorama and a guide thereto. In our judgment this is best supplied by a course in General Biology whether he elects to go farther or not.

The study of plants and animals together in their agreements and contrasts seems to us especially desirable. In our daily lives we deal with complex situations which have little in common beside the fact of their complexity. We learn more about these situations by contrasting them, the learning process, in life, progressing with the ability to drop out unessential factors. For this the training offered by work in General Biology may afford some practice. Moreover, biologically, the essential characters of organisms as plants, on the one hand, or as animals, on the other, are best brought out by comparison and contrast. As, in a course in General Biology, this is done on material common to the several biological fields, it seems to us that a course of this character forms the best possible introduction for either the future botanist or zoologist.

But we are not usually teaching for the benefit of the future specialist. Our task, mainly, is to feed the prospective citizen with food meet for his symmetrical development. For him, especially, do we see in the well-organized course in General Biology the best possible introduction to a balanced view of the facts of life as it not only epitomizes living nature but also the nature of things throughout time out of which man was evolved. Here we do not find plants by themselves nor animal life apart but rather that symbiotic relationship for the appreciation of which, in one balanced view, General Biology should stand.

That this is not more often satisfactorily done seems to us to be due both to lack of pedagogical sense and judgment and also to the restrictions imposed by too special an early training. Sometimes, also, a very conscientious instructor makes the mistake of being too thorough, overloads his types with too many lessons, or chooses the wrong ones for them, reasonably, to illustrate. For example, on visiting a very good college some time ago, I found the notion manifest that, in presenting Amoeba in General Biology, every possible aspect and viewpoint should be stressed,—occurrence, distribution in time and in geographical range, morphology, taxonomy, habits, behavior, oecology, etc. This would, in our judgment, be a proper method for excluding normal students from the course. Moreover, each of the disciplines referred to above was visited upon all succeeding types, *seriatim.* This is mechanical thoroughness at the expense of both common and artistic sense, and course-making worth the name demands both.

In another highly-esteemed college the biologist incorporates in a similar course the notion that it makes no difference at all what particular specimen the student works upon. To begin with one studies an amoeba, another an infusorian, another an alga or diatom or entomostracan or annelid. "Why worry?" They each and all embody the principles of Biology! Moreover, the lectures seem to have nothing to do with the work done in the laboratory.

Among many such teachers is the idea prevalent that "it is personality that educates." All true, but in this case admirable personality survived in spite of handicaps. As well say "let us away with mere educational disciplines and converse with our students about what-not."

Nor can one justify the hodge-podge of throwing in now a few animal forms, now a few plants to insure variety. The brighter students soon get the idea that Biology is a sort of potpourri, a "footless science," as a physician once expressed it to me. However, a reasonable sense of the spirit and educational philosophy back of good General Biology teaching demands that each type be bulwarked with two sets of defenses, one for its individual justification, the other for its right to its place in the sequence in which it stands. In this inheres what might be called "the dramatic unities," a good course needing to resemble a drama to have human and intellectual appeal. Let us reiterate, also, that there is no such thing in science or literature as a continued climax. The plot must be broken up into divisions which are climactic in their sequence.

With these considerations bearing on the nature and conduct of courses in General Biology it remains to be stated that an elementary course of this character appears to become increasingly justified by each new large development in Biology. The essential agreements in ultimate structure between animals and plants brought out by Schleiden and Schwann, by Max Schultze, by the selection theory and other hypotheses of evolution have been extended by more recent studies on chromosomes and on the mechanism of hereditary transmission. For the justification of the already strategic position of General Biology in the middle-ground between the two great "kingdoms" it is important to realize that none of these great developments, above named, sprang solely from Botany or Zoology as such but always from laws inherent in the nature of both. If we can judge of the future from the past it seems reasonable to predict that the biological generalizations of the twentieth century, like those of the nineteenth, must emerge from similar common sources.

The General Biology Course gives also a peculiar advantage for the presentation of the facts of symbiosis and of interdependence between plants and animals. This aspect has been developed extensively in the textbook by J. G. Needham, and the emphasis is legitimate, for in nature living forms have not evolved alone but as factors of an interdependent symbiogenetic complex of processes. Further, from a broader physico-chemical world view, in the light of Professor Henderson's work on "The Fitness of the Environment," we gain even a fuller confidence, that as an introduction to the principles of the science and as the most rational type of course for the beginner, General Biology is beyond all question superior to distinct courses in Zoology and Botany.

If it be urged that this type of course is too dependent upon the ability and personality of the teacher the answer is that the success of any course is likewise largely thus dependent. No subject will teach itself.

Although biological principles in education are not always to be taken literally, as shown by the misuse of the biogenetic law as applied to primary education, there are here applicable suggestive evolutionary principles which are of interest. The principal lesson of evolution is not that man is an unfolded amoeba but that all life is one. Further, no evolutionary principle is more important than that the great groups of living forms, surcharged with capacity for adaptive

radiation, have sprung from generalized ancestors low down on the main stem of the evolutionary tree. In the organization of scientific courses the analogy seems justified that the more generalized the approach the wider its suggestiveness, the greater the possibilities of future adaptation on a firm substructure into a widely-ranging gamut of specialized possibilities.

It is further our belief that General Biology should be prerequisite to beginning courses in Zoology and Botany as such, as well as for special work in Bacteriology and Physiology in which courses programs of laboratory work and lectures may be organized of much greater strength and thoroughness than would be possible with students having no such general background. A further advantage inheres in the fact that such courses in Botany, Zoology, or other special fields, attract mainly only those who feel some beginnings of a special interest and fitness for work in these specialized directions. An economy of both equipment and effort is thus effected.

THE NORTH CAROLINA COLLEGE FOR WOMEN.
GREENSBORO, N. C.

NOTES ON THE OECOLOGY AND LIFE-HISTORY OF THE TEXAS HORNED LIZARD, *PHRYNOSOMA CORNUTUM*

By J. P. Givler

It was my privilege during two summers spent in a study of *Phrynosoma* in southern Kansas* to observe and record many facts of bionomic interest in relation to this well-known creature. The region named also made available for study directly in the field, in comparison with *Phrynosoma*, representatives of several other genera and four families of Lacertilia. In the laboratory comparative studies were made of general morphology, reproductive organs, eggs and embryos.

The following account is intended to serve as a record of some of these observations and to present in one view a brief account of the bionomics of reproduction of this reptile.

EMERGENCE FROM HIBERNATION

In southern Kansas the Texas Horned Lizard comes forth about May first. When the "toads" first appear in the spring they are thin and emaciated, sluggish, and very dark in color. At first the males greatly preponderate over the females in numbers, being in the ratio of three or four males to one female. Later the females emerge in greater numbers, tending to equalize the sexes.

From the beginning of their life, ex-hiberna, their activity is dependent, principally, upon the sun's light and heat. In the morning they are very sluggish and, when touched, will scarcely move. Later, as they become warmed by the sun, they run about, seek ants and other insects as food and move with a sudden characteristic impetuosity. They are warned at the slightest sound or movement and frequently stop to raise and lower themselves by their front legs, an amusing habit to be appreciated fully only by those who have seen it.

During these early days of spring the Phrynosomas mate freely, the preponderance of males at the outstart, as well as the gradual emergence of the females, insuring the insemination of all of the latter. This is attested to by the fact that, among hundreds of eggs studied, only one was found infertile.

SEXUAL DIMORPHISM

Winton ('14) states for this species observed farther south that, especially in early spring, the yellow cervical crescents are much

* Winfield and vicinity.

brighter in the females than in the males. This we were never able to find true of our Kansas specimens. Also, while Bryant ('11) states for the entire genus *Phrynosoma*, that "the presence of enlarged post-anal scales in the male is a dependable character for determining sex," we have not been able to observe such difference in *P. cornutum* from southern Kansas and northern Oklahoma. In my experience positive separation of the sexes may be made in this species on the following criteria of *body form*.

The torso of the males, between axilla and groin, is short and circular; of the females long and elliptical. The tail in the males is longer and distinctly swollen at the root, both laterally and ventrally, due to the contained hemipenes. The tail in the female is shorter and tapers more rapidly from its base backward. It also lacks the basal swellings. The sex of juveniles may likewise be determined on these criteria while that of advanced embryos is apparent from the presence or absence of hemipenes.

THE OVARIES

In females opened early in May and prior to ovulation the ovaries present an interesting picture. Most conspicuous in each is a collection of about sixteen large eggs, yellow in color, at first about 7 mm. in diameter but later swelling to 8 or 9 mm. at the time of ovulation, surrounded by delicate follicles and globular in form except for flattening due to mutual pressure.

While the number in each group is not constant there tend to be sixteen, making a total for the two ovaries of about thirty-two large eggs ready for ovulation. In some cases there are but ten or twelve eggs in each large group, in others, and but rarely, seventeen or eighteen.

Examined separately, each egg displays a germinal disc clearly visible through the follicle and directed toward the point of attachment in the mesovarium. The disc is white, circular and about 1½ mm. in diameter. The borders, although fairly distinct, shade into the surrounding yolk. At the center of the disc is a small, yet distinct, nucleus, about 0.5 mm. in diameter, and clearly discernible in good light to the unaided eye.

Dorsad of these groups of large eggs ready for laying are to be found, in each ovary, eggs of smaller size, two to three mm. in diameter, and provided, each, with a small amount of yolk. These smaller

eggs are, in each ovary, divided into two groups, one placed laterally, the other mesially in relation to the mesovarium.

Still further dorsad, or lying among, this second group of eggs, are ova of a third order as to size, as yet clear and apparently alecithal.

The condition here observed obtains, doubtless, in many other vertebrates which show a strictly annual periodicity in their egg-laying. So far as we know ovulation in this species takes place rather suddenly, the thirty-two-odd ripe follicles undergoing dehiscence within a few hours, leaving the empty follicles to be resorbed and allowing the next order, or half-grown eggs, to develop to full size during the year following. Meantime the third, or smallest group, from among the remaining oögonia, acquires yolk in its turn. Thus, in *Phrynosoma,* we observe, in correlation with an annual periodicity in egg-group ovulation, an annual initiation of yolk-secretion by the follicles of groups of undeveloped oöcytes against the layings of future years. According to the terms of this hypothesis the secretion of the yolk of any egg requires two years.

THE OVIDUCTS

In birds the ova are treated *seriatim* by the oviduct in the laying down upon them of the albumen, shell-membranes, and shell. The oviduct of the Horned Lizard, on the contrary, is adapted to the simultaneous investment with albumen and shell of sixteen or more eggs carried tandem in its coils. A seriation in this process along the two egg-strings is practically absent, the albumen, which is serous in consistency and very small in amount, as well as the shell, being evidently secreted by the same region of the duct *in situ* rather than by successive regions traversed by the egg in its course.

OVULATION AND EARLY DEVELOPMENT

From a number of observations it is evident that, in *Phrynosoma,* maturation occurs immediately prior to ovulation and that fertilization ensues immediately upon the entrance of the egg into the ostium. In studies of lacertilian embryology the securing of segmentation stages is, however, very difficult. The writer was able to confirm the statement of Peter ('04) that there is no relation between the time of copulation and that of ovulation. Further, the same female may copulate more than once.

Having no way to tell the exact hour of ovulation no method has,

to date, been published whereby the early segmentation stages might be found except by accident. Thus the series of embryos of *Lacerta agilis,* described and figured by Peter in his Normentafel, required six summers to complete.

In my work on *Phrynosoma,* after much practice in external palpation as well as in dissection of apparently gravid females, it became possible, in many cases, by palpation only, to distinguish between ovarian eggs and those which had passed into the ducts. The mass of large ovarian eggs is always smaller in area and more dense, that of the oviducal eggs more diffuse and softer. I found, however, that the two conditions, unfortunately, merge at just the critical time, *i. e.,* with approaching ovulation the ovarian eggs become larger, softer, and less well-defined, which condition merges with that of the early oviducal ova.

After much vexation caused by the sacrificing of females in which ovulation had not yet occurred and others in which the embryos were too far advanced, and after seeking, in vain, aid through use of the flouroscope, I discovered that *exploratory operations* do the creatures practically no harm and hold out much promise for future success in this field of embryology. The animals recover and may be opened and sewed up again several times. If seeking segmentation stages one may thus await ovulation. If the eggs have passed into the ducts one of the latter may be dissected loose, ligatured at base and removed with its eggs, the other being left to develop further.

It is interesting to observe that, whereas we are unable to explain the cause of ovulation the dehiscence of about thirty-two large follicles takes place, so far as we know, almost simultaneously. A change so momentous requires an adequate cause. Up to the time of ovulation the ova are held firmly in their follicles. (There are no visible cicatrices in *Phrynosoma.*) Then, suddenly, the ova are all shelled out and rapidly engulfed by the ostia.

The time-relation between copulation and ovulation has been much studied by vertebrate embryologists with two main results. In some vertebrates, as in the rabbit, a definite interval (nine or ten hours) has been found to exist. In others, as the lizards, there is no known time-relation.

Although we have no evidence to that effect it is our belief that ovulation in *Phrynosoma* must depend upon the liberation of a hor-

mone,—where, and under what circumstances secreted we are now unable to state.

GENERAL FEATURES OF EMBRYONIC DEVELOPMENT

In the correlation of stages in lacertilian embryology we are greatly aided by the Normentafel of Peter ('04), on *Lacerta agilis*, in the Keibel series. But while in general parallel, the ontogenetic development of *Phrynosoma* is more extended and, in the later or foetal stages, much more specialized than that of *Lacerta*. These later differences depend but little on any diversities inherent in the two families represented but rather on the emergence of highly specialized generic characters, such as the shortened and broadened body, horns, and rosettes of scales, the appearance of which overpowers the more fundamental iguanid characters.

We are here, however, concerned with the oecology of this reptile in relation to reproduction. As one species of *Phrynosoma* is viviparous and others oviparous an interesting problem exists in the relation of the period of egg-laying to the stage of development attained at that time. In the common fowl the egg is laid while the embryo is undergoing later segmentation. In lizards the eggs are usually retained much longer, the coelomic cavity of the mother serving as an incubation chamber for the eggs lying within the convoluted oviducts. The precise stage at which laying takes place seems to be a matter of no consequence, lending itself easily to the development of the ovoviviparous habit of *P. douglassi*, in which species the eggs hatch while or immediately after being laid. There is reason, also, for the belief that captivity extends the pre-laying period, in reptiles, by several stages.

In *P. cornutum* I found little constancy in this matter, some laid eggs being as early as Peter's stage 22, others as late as stage 28 or 30. Lizards being poikilothermal much must depend on the temperature of soil and air as well as on the time necessary for the gravid female to find a situation suitable for a nest. Specialized generic and specific characters also here tend to prolong the ontogenetic period within the egg and to extend it beyond the range of Peter's series, his final stage (36) being comparable to *Phrynosoma* embryos several days and stages removed from the laying period.

As above stated the coelomic cavity serves, during the breeding season, as a brood-pouch, the 30 or 35 eggs packing it so full that

gravid females present a "stuffed" appearance. Within their leathery shells the eggs float in a sero-albuminous liquid and so easily that the blastoderms, after the shells are formed, invariably float upward, as in the laid eggs of the fowl, directed toward the back of the mother on which the rays of the sun fall. During the first few hours after the ova are received by the ostia, and before the shells are formed, the germinal discs are directed cephalad, a circumstance which seems to spell suction by the ostium, the discs of the ovarian eggs being invariably directed dorsad and away from the point of dehiscence of the follicles. As the body of the mother is much flattened the eggs lie usually in but one layer and never far from the dorsal surface. The utility of this form of body as an incubator is thus evident.

THE RÔLE OF WANDERING MESENCHYME CELLS

As shown by Jarvis ('08) the germ-cells of *Phrynosoma* arise outside the embryo upon the yolk-sac and migrate along the yolk-stalk to the germinal ridges. Stockard ('15), more recently, has made an elaborate study of the rôle of wandering mesenchyme, showing its importance in the development of *Fundulus*.

It was my privilege, in the examination of embryos of many stages in *Phrynosoma*, under the binocular, both to observe the development of the circulation and its course in the embryonic vessels, and also to witness the importance of extra-embryonic amoeboid cells (wandering mesenchyme?) which appear in large numbers in the yolk beneath the embryo in this lizard.

Very soon after embryonic development begins these amoeboid cells may be found, first in a thin layer and later in a disc-shaped mass, in the thin yolk under the embryo. The mass referred to is of a yellowish-green color. The individual cells are hyaline or faintly granular and show active amoeboid movement. That these cells are important in many ways in histogenesis seems certain. They warrant a thorough study in this or a related reptile in the spirit of Stockard's work on *Fundulus*.

EGG-LAYING AND INCUBATION IN THE NESTS

The nest-building and egg-laying habits of this species have been studied by Strecker ('08) in Texas and my observations are in essential agreement with his. The female digs out a slanting burrow several inches in depth on a sloping hillside and prefers a site just

under a projecting ledge of rock. While it may be unwarranted to state as a general principle, all nests that I have observed faced the east.

The burrow excavated to such depth that the female is about hidden from view, she lays therein the cream-white, leathery-skinned eggs. The eggs are elliptical in form and measure 15 mm. in length by 10 to 11 mm. in diameter. They are dropped into the burrow one at a time. Each egg is covered over with a thin layer of dirt, scraped down by the hind legs of the mother, before the next egg is laid. Finally, the eggs all laid, the female packs the nest with the remaining dirt, smoothes it off and scurries away. After a day or two, the site is indistinguishable.

So far as known to the writer egg-laying may occur, in Kansas, anywhere between the end of May and sometime late in July. I have no facts to offer regarding the duration of the incubation period which Strecker states to be from 35 to 40 days in Texas, except that it must vary with the stage reached at laying and the temperature.

During this entire study no aspect was more interesting than that of the mutual fitness of the developing eggs in their envelopes with that of their earth-nest environment, which serves as a temperature and moisture-controlling brood-pouch. Through some inherited complex of instincts the female selects a site combining the advantage of drainage, roofing, exposure to heating by the sun, and ventilation. Under certain conditions they become turgid and swell, but shrivel like a raisin when allowed to dry. When the latter occurs the eggs are vulnerable to the attacks of ants, the mandibles of the insects cutting through the folds of the shell. When the shell is turgid and smooth the ants can do nothing of the kind.

Daily observing the creatures in their environment the realization is born in upon one that they are literally autochthones, born of the careful regulation of conditions in which they have evolved.

DEVELOPMENT OF CHARACTERISTIC EXTERNAL FEATURES OF THE EMBRYO

In so brief an account but little may be said upon this subject except to state that the early stages, as shown by the figures here demonstrated, are characteristically reptilian. About stage 32, however, phrynosoman characters put in their appearance, the rosettes of large dorsal scales being heralded by single rounded protuberances.

At the same time the Iguanid tail shrivels distally to the more abbreviated condition of *Phrynosoma*. Later, stage 33, the surrounding circlet of scales, appearing in the adult around the large dorsal scales, is laid down as an annular anlage, later to be pinched off into its separate scalar elements.

Pigmentation first appears in the cervical bilateral patches as black markings about stage 35. Rapidly thereafter the pigment appears in the large scalar rosettes caudad. It is interesting to observe that, in the spread of this fundamental scheme of pigmentation, two gradients are to be observed, one spreading caudad, the other laterad.

As might be expected the horns, characteristic of these lizards, are late in appearing, being seen first with stage 36.

The newly-hatched young are pale in color, precocial, and may be found within a very few days, seeking insect food in the manner of their elders.

THE NORTH CAROLINA COLLEGE FOR WOMEN.
GREENSBORO, N. C.

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A MAGNETITE-MARBLE ORE AT LANSING, N. C.*

By W. S. Bayley

Plates 24-27

INTRODUCTION

Near the village of Lansing in Ashe County, N. C., is an iron mine from which is being taken an ore which differs materially from all other iron ores in the State and which resembles in some respects the iron ores obtained from the Franklin limestone in New Jersey. The mine which is the property of the Ashe Mining Co., is on the Virginia-Carolina Railroad alongside Horse Creek, and about half a mile southeast of Lansing Station. (See map, pl. 24.)

Pratt[1] refers to the locality under the name of the Waughbank property as follows:

"About 100 yards from the creek a tunnel was run by the Penna. Steel Co. The tunnel has a direction of N. 40° E., and at a distance of 100 feet a crosscut was made extending 46 feet S. 40° W.

"This crosscut showed ore for its whole distance, making the width of the ore deposit over 30 feet. This ore is composed of coarse granular magnetite in a matrix composed of micaceous material and manganese oxide." The vein was estimated by Pratt to be 70% ore. Analyses of a fair sample of the vein (I) and of a selected sample of the magnetite (II) gave:

	Fe	Mn	P	S	Ti
I	46.25	4.34	.026	.027	tr
II	67.25	1.68			

This is evidently the same deposit as that described by Nitze[2] as "Ballou's Horse Creek ore bank." At the time Nitze wrote the opening was in the "shape of an undercut in the side of the hill into which it extends perhaps 50′ as a slope." The seam, the dip of which "is apparently towards the northeast," is at least six feet wide, the lower two feet being the harder. Nitze's analyses correspond closely with those furnished by Pratt. They are as follows:

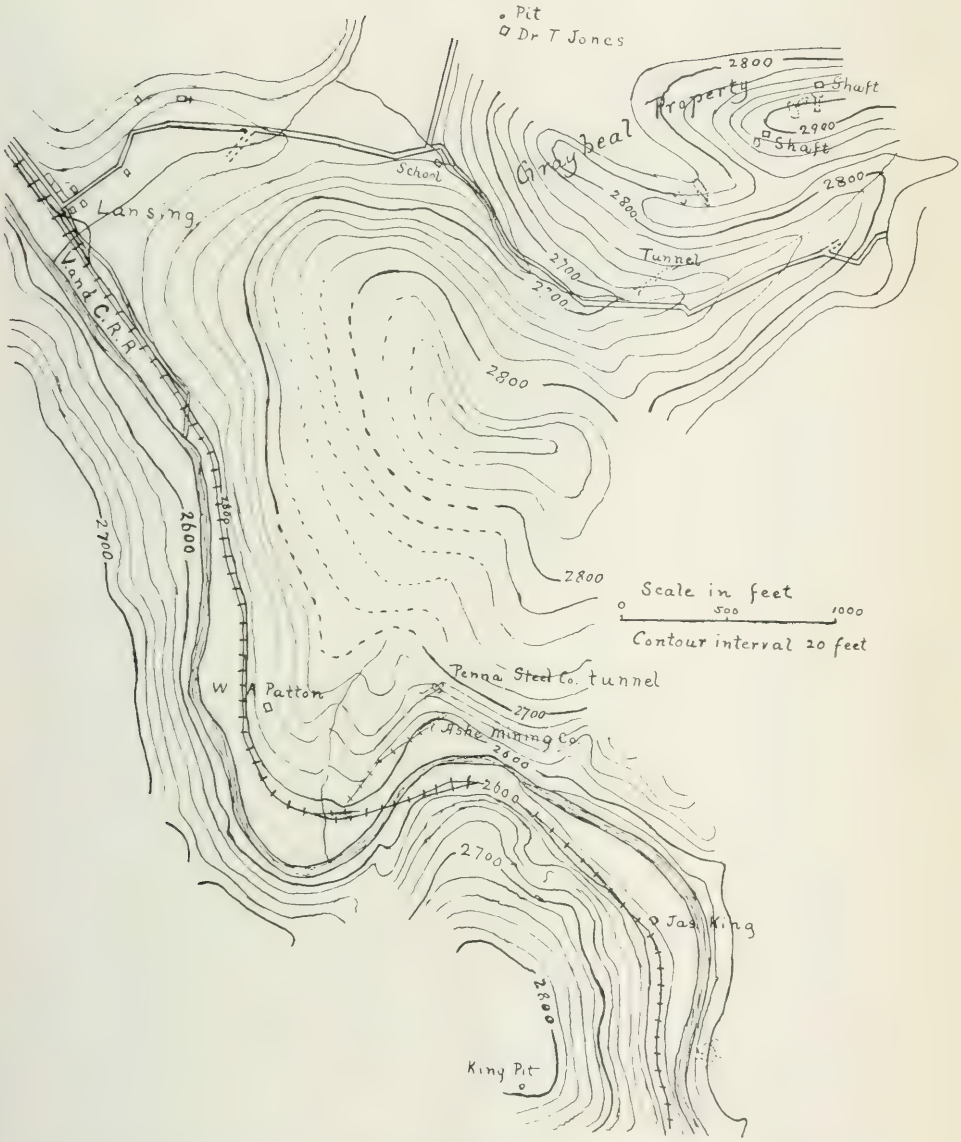
SiO_2	Fe	Mn	S	P	P ratio
1.96	62.48	3.66	.072	.019	.030
4.58	54.02	6.85	.007	.011	.017

* Published with the permission of the Director of the U. S. Geological Survey and the Director of the N. C. Geological and Economic Survey.

[1] Pratt, J. H., The Mining Industry in North Carolina during 1911 and 1912. N. C. Geol. and Econ. Survey, Economic Paper No. 34, p. 68. 1914.

[2] Nitze, H. B. C., Iron Ores of North Carolina. N. C. Geol. Survey, Bull. No. 1, p. 156. 1893.

PLATE 24



Portions of Cranberry, Abingdon, Wytheville, and Wilkesboro quadrangles, showing position of mine at Lansing, N. C.

Capt. Geo. W. Cooke, who is operating the mine for the company, declares that the present mine is on the Waughbank property but that the original opening which dates back as early as 1828 was on top of the hill about 50 feet above the present tunnel and was in an entirely different kind of ore. The tunnel of the Penna. Steel Co. was opened about 15 years ago into the lower portion of the Waughbank deposit. It is parallel to the present tunnel, about 40 feet above it and about 100 feet further west. It is frequently referred to as the upper level. At its end, at the bottom of the Waughbank pit, a little limestone ore was encountered, but most of the ore developed by it was of the siliceous type like that at Cranberry. The relations of the two tunnels to one another and the mutual relationships of the siliceous ore and that now being worked are shown in the sketch, pl. 25.

THE ASHE MINING COMPANY'S MINE

Mineral Composition of the Ore:—The ore of the deposit now being worked is essentially a coarsely granular intermixture of magnesian marble and magnetite (pl. 26). Here and there are particles of quartz but they are rare. The carbonates are in large grains with perfect cleavage constituting a white marble. The magnetite is in irregular though slightly elongated grains scattered through the marble, producing an ill-defined schistosity, which is emphasized by the occasional accumulation of the magnetite grains in lenses with their long axes parallel to the obscure schistosity of the matrix of carbonates and magnetite in which they lie. (See pl. 26.) In a few places the rock is markedly schistose. This is brought about either by the occurrence of many of the magnetite grains in plates, suggesting the plates of hematite in specular ores, or by its occurrence in numerous small lenses elongate in parallel directions. Many of the elongate grains are sheared and drawn out into lines or rows of sharp-edged particles. The carbonate grains associated with the magnetite show no similar elongation, but the schistosity is often accentuated by the presence of calcite veins or layers running in the same direction as the lines of magnetite plates. Evidently the carbonates have been entirely recrystallized since the rock's deformation. Here and there through the mass are embedded small garnets, which in many cases are altered so as to give rise to light brown stains.

A typical lean ore in thin section shows coarse-grained aggregates of two colorless carbonates, of which one is calcite and the other prob-

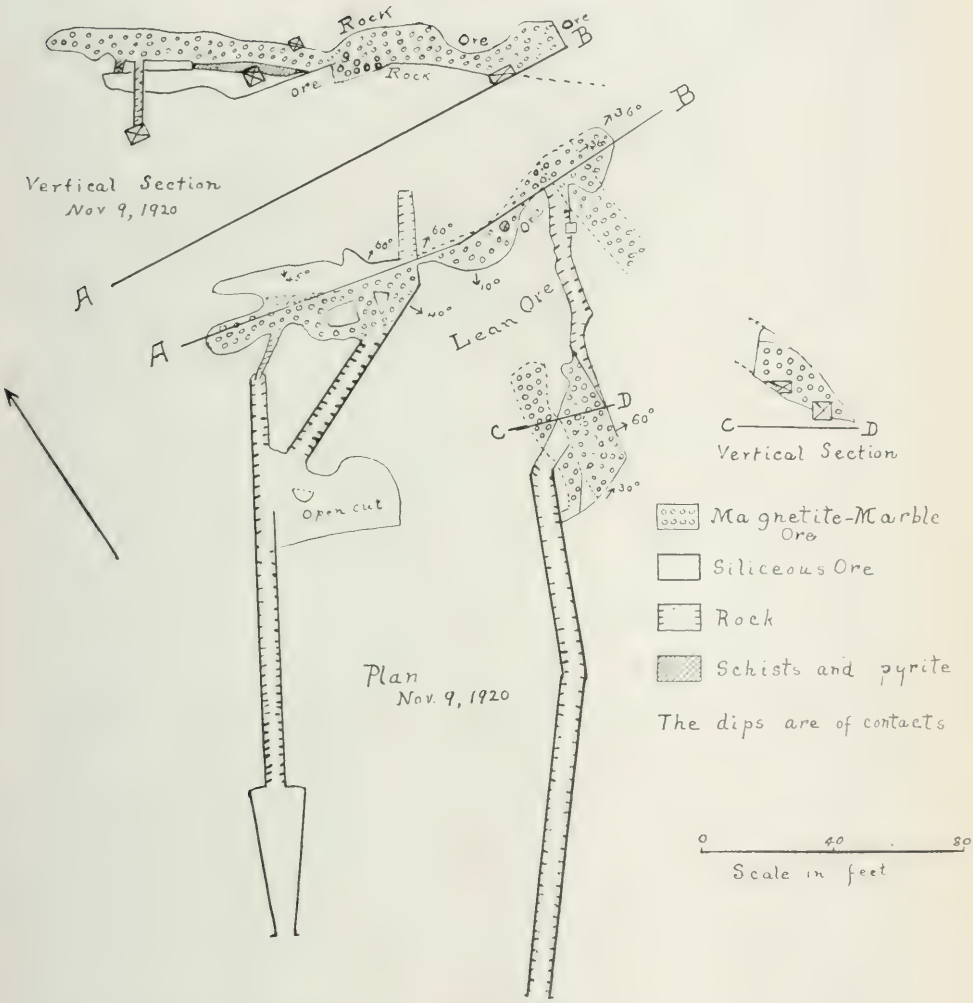
ably dolomite, a few plates of phlogopite and large irregular masses of magnetite. The mica is in streaks of plates extending in nearly straight lines through the section with the individual plates lying between adjoining carbonate grains and more frequently than otherwise near the magnetite. This mineral is often in large areas with very ragged boundaries, the salients of which project considerable distances between the grains of carbonate, or between contiguous twinning lamellae. Occasionally a smaller grain appears to be enclosed in grains of what is regarded as dolomite, and in other instances the larger masses appear to enclose small grains of the carbonate. From the fact that the carbonate inclusions polarize uniformly with the large carbonate grains surrounding the magnetite it is thought that the apparent inclusions are merely portions of projections that extend into the embayments of the magnetite and that their appearance as inclusions surrounded by magnetite is due to the fact that the section was cut through the boundary between magnetite and carbonate.

The richer ore differs from the poorer ore mainly in the larger sizes of the distributed magnetite grains and especially in the much greater sizes of the magnetite lenses. Some of the latter are a foot or more in length and five or six inches in diameter. A photograph showing the contact of one of the lenses with the surrounding marble is reproduced in pl. 26.

The greater portion of the ore, as has been related, is mainly a coarsely crystalline marble containing grains and lenses of magnetite. In many places, however, it contains dike-like masses of a bright green color, which proves to be a fine-grained aggregate, mainly of granular actinolite which, where shearing occurs, is changed to a mass of fibres of bright green actinolite. Often magnetite is present in the granular aggregate, and this is noticeably more abundant near the contact of the green layer with the marble. Indeed it not infrequently happens that there are distinct lenses of magnetite at the contacts of the two rocks even though magnetite may not be present elsewhere in association with the green rock, and occasionally a continuous thin layer of magnetite separates the two for considerable distances. The actinolite layer passes into the carbonate rock by a very gradual transition—the actinolite becoming less and less abundant until it forms a very small portion of the mass.

In this section the actinolite mass is discovered in reality to be complex. It consists of an aggregate of thin layers and flat lenses

PLATE 25



Plan and sections of Ashe Mining Company's mine, Lansing, N. C. (Map furnished by Geo. W. Cooke, Manager.)

made up mainly of equi-dimensional prisms of actinolite that are pleochroic in very light yellowish green and emerald-green tints. These alternate with equally thin layers of carbonates. The maximum extinction of the actinolite is about 20°. Among the actinolite prisms are scattered a few large grains of carbonate, a very few large plates of a colorless mica, perhaps phlogopite, and large irregular masses of magnetite. The actinolite appears as though in crush zones, and its individual prisms have a general parallel elongation in the direction of the layers. In many cases the magnetite masses are crossed by tiny cracks filled with calcite. It is noticeable that the major portion of the magnetite within the layer characterized by the actinolite is usually associated with the carbonates that are always present in it. In some places, however, the magnetite and actinolite are so free from carbonates that the rock is locally a magnetite-actinolite schist.

Around the lenses of magnetite in the marble are often envelopes of actinolite and often there are veins of actinolite cutting through them. In these cases the magnetite is cleaved so that the lenses appear to be granular masses composed of elongate grains of the magnetite. The long dimensions of the magnetite and the long directions of the actinolite fibers in the veins are parallel, but there is no definite relation between the elongation of the fibers and the directions of the veins. The fibrosity may be parallel to the walls of the veins, perpendicular thereto, or inclined to them at any angle. Whatever their direction with respect to the veins, they are all parallel within the mass of a single hand-specimen.

In other specimens veins of actinolite traverse masses of magnetite and marble, and sporadic garnets appear in the mass.

The suggestion furnished by the sections is that a mass of marble and magnetite, with some actinolite, became shattered as the result of movements, and the cracks between the fragments of magnetite were filled with actinolite formed from magnetite and some of the constituents of the marble by metamorphosing processes during the course of this movement. In some cases calcite which was undergoing recrystallization at the time was also forced into the fractures.

There was evidently motion in the rock-mass also after the actinolite was formed and after the magnetite was shattered, since there are present in the rock slickensides coated with acicular actinolite, in many cases to a thickness of one-half an inch or more. In these cases there

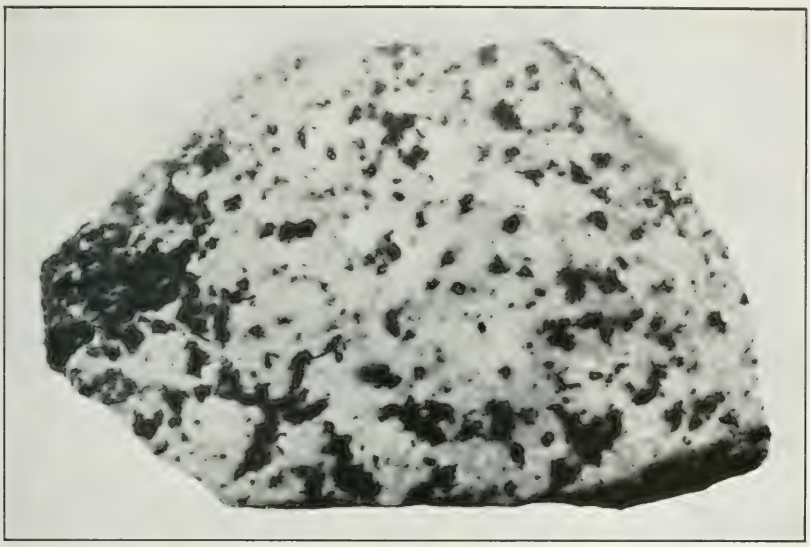
are usually layers of magnetite next to the actinolite, and in the magnetite are frequently small streaks of pyrite. That these various deformations produced little effect upon the structure of the carbonates is due no doubt to the fact that these have recrystallized since the action of the forces producing the deformations ceased.

Here and there through the ore there is also considerable dark hornblende. It occurs in large quantity in some fragments on the mine dump. It apparently is in fairly large dikes in which hornblende, magnetite and frequently garnet are intermingled. Where the hornblende is in dikes a foot or more wide their interiors are coarse black hornblende free of garnet. In the smaller dikes, on the other hand, the hornblende masses often enclosed small lenses of limestone, which have been nearly completely changed to pink garnet. In some instances garnet and hornblende are in equal quantities. The limestone in contact with the hornblende is often banded and it frequently contains lenses of magnetite. In contact with the hornblende-garnet is a narrow layer of fine-grained hornblende, carbonates and pyrite with the latter usually in very thin seams parallel to the boundary. Beyond this are bands of carbonates and magnetite and of carbonates and black mica. The banding is thus the result of consecutive layers of coarse black hornblende, aggregates of black hornblende and red garnet, aggregates of fine-grained dark and light hornblende, thin seams of pyrite and of carbonates, streaks of magnetite and finally layers of carbonate and black mica. There is no common elongation of the carbonate grains in the limestone, but the rock in the neighborhood of the dikes has a distinct schistosity due to the parallel arrangement of the layers.

Often near the borders of the ore deposit and occasionally within its mass are also irregular aggregates of red garnet, black hornblende, magnetite and carbonates in which the garnet is predominant. The hornblende on the whole looks as though it were intrusive and the garnet as though it were a contact product between hornblende and the carbonates. These aggregates are traversed by little veins of white calcite and colorless quartz and contain here and there nests of these minerals, which are unquestionably secondary.

Pyrite is not common anywhere in the ore. It occasionally occurs as thin layers between the layers of granular, light green hornblende and the marble, and in a few places scattered through the magnetite-

PLATE 26



(Above) PHOTOGRAPH OF ORE FROM MINE AT LANSING, N. C. NAT. SIZE.

(Below) PHOTOGRAPH SHOWING CONTACT OF ORE LENS WITH MARBLE IN ORE FROM MINE AT LANSING, N. C.

marble rock in large masses that enclose particles of the other components. Some of the particles are plainly large skeleton cubes, poikilitically developed. In other words, they possess the sieve structure which is characteristic of minerals formed later than the rock in which they are found. In some cases the pyrite apparently replaces calcite and in other cases magnetite. It is believed that it was not a part of the original rock but was subsequently introduced.

Veins in the Ore:—In places fine-grained feldspar-quartz veins cut the hornblende-magnetite masses. In thin section the vein rock is seen to be badly crushed—the quartz areas are aggregates of small quartz grains and the former feldspar grains are now aggregates of small, very light yellow epidote grains. There are, however, no sharp boundaries between the feldspar and the quartz areas. These have been obliterated by the crushing. The quartz areas near their borders are full of epidote grains and the epidote areas contain nests of quartz grains and, further within their interiors, individual grains of quartz. Moreover there are little veins of epidote in the quartz, and vein-like lenses of quartz in the epidote aggregates.

The contacts of the veins and the hornblende masses are also far from sharp. Occasionally there is a streak of small pink garnets separating the two, but for most of the distance the epidote aggregate penetrates the hornblende mass, and hornblende grains are embedded in the epidote. The hornblende mass consists mainly of large crystalloids of hornblende—yellow-green—with large nuclei composed mainly of partly amphibolized light yellowish augite. Often the partially altered pyroxene comprises three-fourths of the area of the grain, and around it is a zone of compact green-yellow hornblende with sharp fibrous projections extending from the more compact portion. Extinctions of 24° against the cleavage in the surrounding zone and of 45° in the nucleus are characteristic. In the spaces between neighboring pieces of hornblende are small nests of quartz and calcite and often in pieces of the amphibole that are not so compact are enclosures of quartz and many more of calcite. Often the areas between the large amphibole grains are filled with quartz and carbonate grains and spicules of green hornblende, but in no case seen do the spicules actually cut through the carbonate and quartz. These minerals apparently simply fill in the spaces between the spicules.

These fine-grained veins are believed to be small veins of pegmatite

that have been completely granulitized, and thus have lost all traces of their granular structure. It is significant that few garnets occur at their contacts with the hornblende through which they pass, but that, on the other hand, garnets are frequently found between the hornblende masses and the marble surrounding them. Where pegmatites cut the country gneiss in the vicinity of the mine large garnets occur in the gneisses near the contact. It may be fair to assume therefore that the hornblende masses are a part of the pegmatite, since upon this assumption the presence of garnets between them and the marble is easily explained as due to contact action. Moreover, the hornblende is an altered augite—and in the Cranberry area in Avery County the pegmatites associated with the ore were originally an augitic variety.

The relations of the pegmatite, hornblende and carbonates, together with the presence of garnets and of streaks of magnetite near the borders of the hornblende are suggestive of contact action. In the old Waughbank Mine the ore was of the same character as that in the Cranberry Mine. If the views of Mr. Cooke are correct the Waughbank ore gradually passed into the limestone ore now characterizing the Ashe Mining Company's Mine. There is very little definite pegmatite in the present mine unless it is represented by the hornblende streaks and the fine-grained veins described above, but there is pegmatite in abundance in the old Waughbank openings. The hornblende streaks in the mine now operating may very well have been very basic phases of augitic pegmatite, which added iron and perhaps silica to the limestone and brought about contact action by which garnets, phlogopite and actinolite were produced.

Chemical Composition of the Ore:—A selected sample of the richest ore freed from adhering limestone was analyzed by J. G. Fairchild of the U. S. Geological Survey, with the result shown below. The analysis[3] of the magnetite separated from the ore of the Ahles Mine in New Jersey is given in II for comparison. The Ahles ore is in limestone.

[3] Bayley, W. S. Iron Mines and Mining in New Jersey. Vol. VII of Final Report Series of State Geologist, Trenton, N. J., 1910, p. 111.

CHEMICAL COMPOSITION OF MAGNETITE FROM THE LANSING MINE, N. C., AND THE AHLES MINE, N. J.

	I	II
SiO_2	2.33	10.60
Al_2O_3	2.38	1.85
Fe_2O_3	60.42	48.44
Cr_2O_3	.00	
FeO	24.80	29.32
MnO	3.01	MnO_2 = 4.19
MgO	3.37	.62
CaO	1.14	.29
Na_2O	.26	.12
K_2O	tr	
TiO_2	tr	tr
CO_2	1.97	
P_2O_5	tr	tr
SO_3	.11	.06
H_2O-	.04	1.36
H_2O+	.83	2.55
S	.00	
V_2O_3	.00	
BaO	.00	.41
SrO	.00	
F	.00	
	100.66	99.81

The analysis of the Lansing ore is that of a very pure magnetic ore. A calculation indicates the presence in it of the following components:

CALCULATED MINERAL COMPOSITION OF LANSING ORE

Magnetite	81.0
Limonite	5.6
Pyrolusite	2.6
Dolomite	4.5
Pyrite	.1
Silicates	6.2
	100.0

The magnetite is remarkably pure. It evidently contains a little manganese, but is free from titanium. In these respects it closely resembles the magnetites in the Franklin limestone in New Jersey.[4]

The percentage of Fe indicated by the analysis is 61.58% and of

[4] Bayley, W. S. Final Report Series of the State Geologist (New Jersey), 7: 111. 1910.

Mn 2.33%, but this analysis is of a selected sample from which material other than magnetite has been removed as thoroughly as possible by careful hand-picking. The ore furnished to the Cranberry Furnace is shipped as taken from the mine, without crushing and careful selection. This, therefore, is much lower in iron, and indeed considerably lower than the minimum limit for ordinary magnetic ore; but because of its extremely low phosphorus and high calcium is acceptable.

Some of the marble-magnetite is too poor in iron to be regarded as an ore, but by rejecting this the balance passes as an ore which though possibly low grade with respect to iron is available to the furnace because practically all the material that is not iron is a mixture of calcite and dolomite which serves as a flux. An analysis of an average specimen of the marble made in the laboratory of the U. S. Geol. Survey by Mr. Fairchild gave: MgO = 9.17%, CaO = 26.32%, and CO_2 = 34.28%, corresponding to a mixture of $MgCO_3$ and $CaCO_3$ in the proportions 1:2, and an excess of 3½% CO_2, a large part of which is in $MnCO_3$.

Analyses of many carload lots of ore made at the Cranberry Furnace at Johnson City prior to the summer of 1919 showed limits of 36.43-52.93 for Fe and .0094-.0114 for P. A series of analyses of 7 cars received during the summer of 1919 gave:[5]

Iron	40.65	42.76	46.46	39.07	40.65	35.11	38.54
Phosphorus	.0062	.0052	.0052	.0052	.0042	.0062	.0057

One analysis[6] of a car of ore very low in iron yielded Fe = 30.52, P = .0052 and CaO = 17.84. This is equivalent to 42.14% magnetite and 31.86% $CaCO_3$, or a total of 76%. There was no record made of the other 24%.

The Ore Body:—The ore body of the mine is reached by a tunnel running 150 feet into the base of the hill just above the level of Horse Creek in a direction N. 40° E. It is in the foot wall, which is a light gray hornblendic gneiss that may belong with Keith's Cranberry granite, which is archean in age. Between this gneiss and the ore-body is a thin layer of gray mica schist, that may readily be a result of shearing of the gneiss along the contact. Immediately above the ore is another thin sheet of a similar schist and above this a light gray fine-grained gneiss that may be a part of the Cranberry granite.

[5] Furnished by Pres. F. P. Howe, Cranberry Furnace Co., Johnson City, Tenn.
[6] Made by Cranberry Furnace Co. Furnished by Mr. Cooke.

The greater part of the country rock is a coarse gray banded gneiss that looks very much like a squeezed porphyritic hornblende granite, perhaps a phase of the Blowing Rock gneiss, also placed by Keith in the archean. This is interlayered with light-colored gneiss which was originally an augitic syenite. It now consists of large anhedrons of a microperthitic feldspar, large light green masses of amphibole, containing here and there nuclei of pyroxene, and surrounded by a border of tiny epidote crystals lying in all azimuths. There are also present a small quantity of brown biotite and a few large grains of quartz. The feldspars are crushed around their edges into a fine-grained mass which now consists of quartz, epidote and pale green amphibole. These gneisses are intersected by veins of pegmatite that is almost devoid of dark components, and on the borders of which are large garnets. In many instances the feldspar of the pegmatites is partially changed to epidote as at Cranberry. In a cut on the railroad layers of hornblende schist are in the gneisses, and along these shearing took place with the production of actinolite-asbestos.

The ore body is sharply marked off from the country rock by the layers of schist below and above. In shape it appears to be irregular. In general it strikes a few degrees E. of North and dips about 36° S. E. In a portion of its course the dip and strike are regular, indicating a width of only four feet and in some places the ore is cut out entirely by what appear to be great fragments of the country rock or by small faults. Near the present end of the tunnel the ore body was apparently chimney-like. It was encountered in an old hole on the surface above the tunnel and was followed downward in a small steeply pitching shoot into the present ore body, where it expands into a sheet with the dip and strike of the surrounding gneisses. At the foot wall is a narrow seam of calcite that appears to be secondary as it sends veinlets into the contiguous ore and gneisses.

In mass the ore appears distinctly schistose. On its borders are selvages of garnet and hornblende, several feet thick. Within these the ore is fairly uniform in character, varying only in the proportions of magnetite and carbonates present. Here and there near its edges are pockets of loose magnetite, especially near the foot wall, where the sparse carbonate cement in lenses of granular magnetite may have been dissolved by percolating water. The pyrite that has already been referred to is confined almost exclusively to the borders of the ore

body and to the vicinity of little veins of hornblende cutting through it. It is apparently most abundant where shearing has taken place. From the main mass of the ore body the mineral is entirely absent, so that it has no bad effect upon the ore. Through the ore are small vein-like masses of coarse black hornblende or of hornblende and magnetite all running parallel to the schistosity of the ore, which is parallel to the general strike of the ore body, thus accentuating the structure. In some cases there are also present in the limestone streaks of magnetite that suggest very strongly little dikes. These are rarely more than 1½ inches wide. Their walls are nowhere sharp, but on the contrary on their margins the magnetite layers pass into the marble by gradations, the carbonate grains becoming more and more abundant toward the marble side of the contact until finally the rock becomes essentially a nearly pure marble. The thin section shows the magnetite streak to be an aggregate of carbonates, actinolite and magnetite, with the last named of course predominating.

The mine has been operating for only a short time. About 500 carloads of ore had been shipped to Aug., 1919. At present the exposed faces of ore suggest the existence of two sheets parallel to the foliation of the country rocks. The explorations are not sufficiently extended to show how far the sheets are continuous, consequently there is no means of estimating the magnitude of the reserve. The lower sheet is believed to pinch out just beneath the floor of the tunnel, as is indicated in the cross section on pl. 25, but its extension in other directions is entirely unknown. The upper sheet has been shown by a raise to extend from the tunnel level to near the surface but there is no evidence to show how far it extends beneath the tunnel or beyond the sides of the raise. Although the vein looks more regular at its present depth than it was nearer the surface, nevertheless there is no certainty that it will not suddenly become broken and irregular.

Origin of the Ore:—If the theory[7] with regard to the origin of the Cranberry ore is correct, and the magnetite in this deposit is due to deposition from ascending hot liquids and gases brought upward by augitic pegmatites, then it seems probable that the marble ores are likewise the result of pegmatitic solutions. Old limestones were metamorphosed by solutions depositing magnetite and producing hornblende and aiding in the development of garnet and actinolite from

[7] Bayley, W. S., The Magnetites of North Carolina—Their Origin. Econ. Geol. v. 16, no. 2, March, 1921, pp. 142-152.

the constituents of the limestone. That the actinolite is in more or less distinct layers may well be due to the presence of argillaceous layers in the original limestone. The production of the actinolite in part at least seems to have been subsequent to the deposition of the magnetite, but that its production was promoted by pegmatite solutions seems to admit of little doubt. The distribution of the components of the ore is such as would occur if they were produced by pneumatothermal contact action, emanating from dikes of pegmatite. No distinct dikes of pegmatite are to be seen cutting the limestone ores, but they are believed to be represented by the small veins of quartz and epidote that traverse it, by the aggregates of epidote and magnetite and those of hornblende and magnetite that appear as streaks in it and by the lenses of dark hornblende that occur here and there. The epidote is believed to represent the feldspar of the pegmatites. All gradations between pegmatites in which the feldspar is only slightly epidotized and those in which all the feldspar has been replaced by epidote are common in the Cranberry area. At Lansing very little of the pegmatite magma reached the position of that portion of the ore body now being worked, but the gases and liquids travelled along the contacts between the limestone and the gneiss, penetrated the limestone near the contacts and caused the deposition of magnetite and the production of garnet which have been described as forming a selvage on the borders of the ore body.

Similar Ores Elsewhere:—The only other point in the state at which similar magnetite-marble ore is known to exist is a few yards north of Dr. Jones's residence, about a third of a mile northeast of the railroad station at Lansing and three-quarters of a mile north of Capt. Cooke's mine. Here a hole was put down at a place where there was much magnetite in the soil. At the depth of 25 feet a big piece of limestone was encountered in the midst of the gneisses, with *manganese* ore on opposite sides. The hole is now filled but on the old dump, which has almost entirely disappeared, a fragment of antinolitic rock was found that is unquestionably a metamorphosed limestone consisting of calcite, actinolite and tremolite.

Since returning from the field the study of the specimens collected suggests that possibly the Red Rock Mine about 1½ miles southeast of Shell Creek in Carter County, Tenn., and one mile from the North Carolina State line is another similar deposit, but information of the

character of its ore is furnished only by the fragments on the dumps.

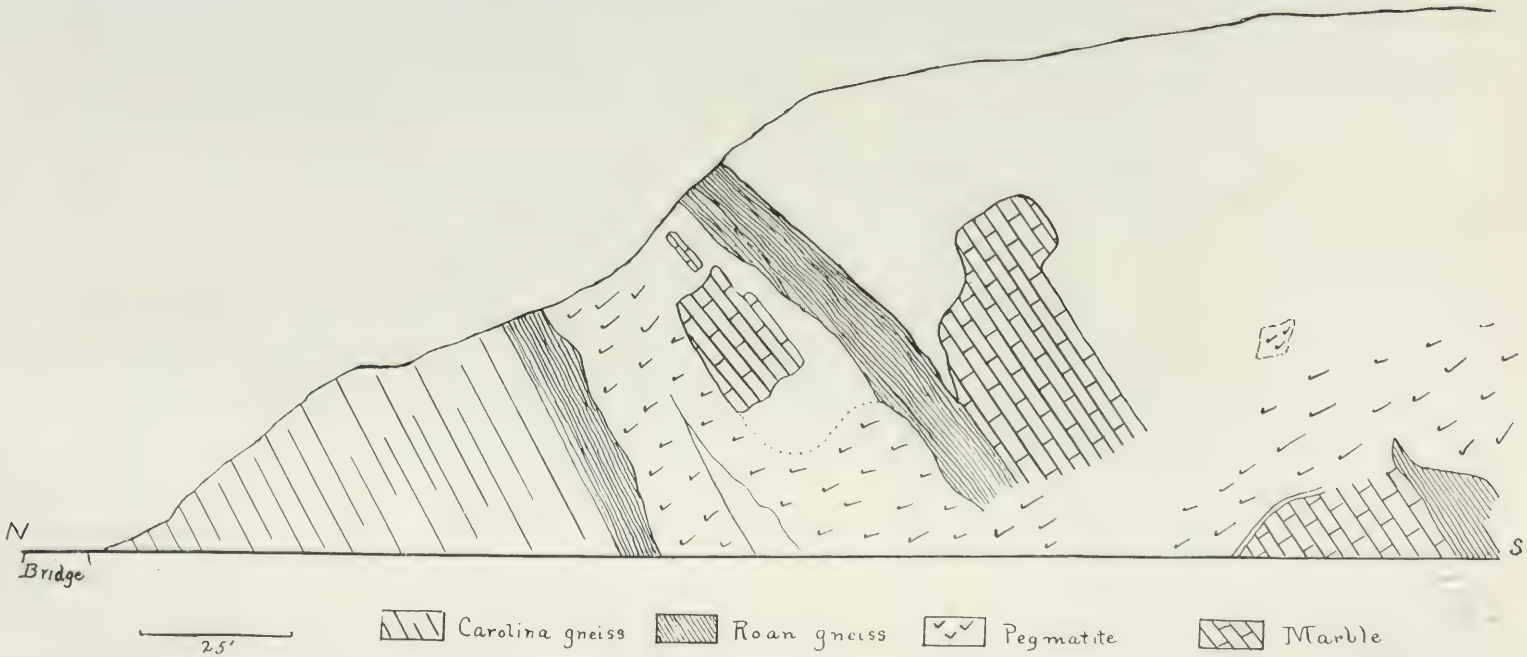
Marble in the pre-Cambrian near Toccane:—The rarity of marble-magnetite ores in western North Carolina may be due to the fact that the limestone beds themselves are rare. Their best known occurrence is in a cut on the C. C. & O. R. R. at Intermont, which is about four miles south of Toccane in Mitchell County. The limestone is a coarse white marble associated with gneisses and pegmatite. It is mapped by Keith as being in the Carolina gneiss—a series of micaceous and garnetiferous schists and micaceous, garnetiferous and cyanitic gneisses, which are believed to be the oldest rocks in the region. Keith[8] describes the marble as occurring in two bands alternating with mica-gneiss and dipping 50° S. E. The rocks are cut by a pegmatite vein, which passes in places across the beds and in other places along them. The upper layer is said to be 70 ft. thick and the lower layer 8 ft. with a 10 ft. thick layer of mica gneiss between them. The marble is white and coarsely crystalline. It consists of 55% $CaCO_3$ and 45% $MgCO_3$. The contacts of the marble with the contiguous gneiss are said to be sharp. Contacts with the pegmatite are equally sharp, but in some places between the marble and pegmatite is a thin contact vein of actinolite which grades into the marble. Inclosed in the lower marble is also a small mass of actinolite and serpentine. The marble is supposed to be a metamorphosed sediment interbedded with silicious sediments now represented by gneisses and schists.

A sketch of the exposure is reproduced in pl. 27. Instead of being in two distinct layers as might be inferred from Keith's description the section now displayed on the railroad shows the marble to be in fragments separated by gneiss and pegmatite. It is possible that the three masses visible in the section may originally have been parts of a single bed or parts of two beds, but it is certain that their present distribution is due to fracturing and intrusion by pegmatite. At the south end of the section near its bottom the limestone is in contact with the pegmatite and with gneiss. For half an inch from the contact with the gneiss the limestone is bordered by a light gray zone in which are many plates of a light mica resembling phlogopite, a few plates of biotite and an occasional garnet. At the immediate contact is a seam of light brown mica.

Under the microscope a section cut across the contact zone reveals the presence in it of many plates of an almost colorless mica with a

[8] Mount Mitchell Folio. Geol. Atlas of the U. S. Folio 124, p. 2-3, 1905.

PLATE 27



Sketch of marble exposures at Intermont, on Clinchfield R. R., at mouth of Sinkhole Creek, Mitchell County, N. C.

slight pleochroism in light yellow tones. These are arranged about parallel to the contact plane. A few crystals of pyrite are the only other components present except, of course, the predominant, comparatively large grains of carbonate, most of which are polysynthetically twinned. The carbonate is free from inclusions except for tiny particles of what appears to be pyrite dust, but between the grains is often a stain of limonite. Immediately at the contact there had been slight movement with the development of a thin layer of light colored mica.

At the contact with the pegmatite the contact zone is about 1½ inches wide, and is composed of two layers, the inner one of which is characterized by the presence of plates of tremolite and more scanty plates of wollastonite scattered through the limestone, but mainly in such a way as to constitute bands running parallel to the contact. The tremolite is generally fresh and colorless but the wollastonite is traversed by many cracks in which have been deposited fibers of a light green micaceous mineral, with a slight pleochroism in greenish and yellowish tones. Occasional tremolite flakes are tinged with green. These are very slightly pleochroic, thus approaching actinolite in character. The outer zone next to the pegmatite consists exclusively of a light-gray platy tremolite arranged with its long directions perpendicular to the contact. The tremolite strongly resembles the mineral at the Lansing Mine that has been called actinolite. Whether the two minerals are actually the same or are different is of little importance. Their presence indicates that the pegmatite added material to the limestone in both cases. The irregular distribution of the limestone, parts being almost completely surrounded by silicate rocks, suggests an explanation of the irregular distribution of the ore at Lansing. The limestone bed was broken into fragments as at the occurrence on the railroad and the limestone ore naturally possesses a similar distribution.

Reserves:—Because of the irregular manner of distribution of the limestone in the schists at the Lansing locality and the small amount of prospecting that has been done in the mine, it is impossible to estimate with any probability of correctness the quantity of ore that may be expected. If the limestone is shattered as it is near Toecane it may terminate within a few feet of the present workings, or it may extend beyond them for a long distance. In either event it is probable that

the limestone ore may be replaced by silicate ore such as was found in the old Waughbank opening above the present mine, in which case it may be valuable or worthless, depending upon the width of the vein. The limestone ore is merchantable even when its iron content is as low as 35%. The silicate ore must carry much more iron before it will be accepted at the furnace, and most of it therefore must be concentrated.

URBANA, ILL., JULY, 1921.

A BOTANICAL BONANZA IN TUSCALOOSA COUNTY, ALABAMA

By Roland M. Harper

Plate 28

Tuscaloosa, on the Warrior River, is one of the typical fall-line cities of the South. Above the city the river and all its tributaries, with a few exceptions, flow their whole length through the Warrior coal field, characterized by essentially horizontal strata of sandstone and shale, which make many picturesque bluffs and cliffs along the river, some of them over 150 feet high, interrupted every half mile or so by wooded ravines, containing small streams which may dry up in summer, and at longer intervals by creek valleys. A few tributaries take their rise in limestone valleys about 100 miles northeastward, but it is not likely that this fact has any perceptible bearing on the richness of the cliff flora to be discussed presently. Below Tuscaloosa the river cuts through Cretaceous and Eocene strata, with no cliffs of hard rock, and conditions are unfavorable for most of the plants herein mentioned.[1]

Above Tuscaloosa the river runs in a general southwesterly direction, so that the left bank is usually shaded, the bluffs on that side facing in various directions between north and west. On this left side a few miles above the city there is a remarkable assemblage of rare and otherwise interesting plants, on exposed cliffs and shaded bluffs and in nearby ravines. For some unknown reason, the greatest concentration of rarities seems to be about eight miles above the city, their numbers diminishing up and down stream from that point. They gradually disappear also away from the river, as one ascends any of the tributary creeks. The writer has had few opportunities to explore the right bank, which is relatively inaccessible, but as most of the bluffs on that side are exposed to the sun in the middle of the day, the shade-loving plants listed below can hardly be expected to thrive there.

At Squaw Shoals, about thirty miles above Tuscaloosa, there were many interesting aquatic plants in the rocky bed of the river until they were drowned out by the completion of a 63-foot dam in 1915[2], but apparently no cliff plants of special interest, except *Heuchera*

[1] For an account of the river-bank vegetation for a distance of about 250 miles below Tuscaloosa see Bull. Torrey Bot. Club **37**:107-126. 1910.

[2] See Torreya **14**:149-155. 1914; Natural History **19**:199-201. 1919.

macrorhiza. And quite recently (May, 1921) the writer has traversed over 100 miles of the river above Tuscaloosa in a canoe, with frequent landings, without materially extending the known distribution of any of the plants mentioned below, not even those which have their southernmost outposts near the fall line.

Before listing the rare plants some additional features of the environment may be mentioned. At the point where they are most numerous and for a few miles farther upstream, the hilltops are capped with sand and pebbles of Cretaceous or later age, belonging to the coastal plain, and characterized by forests of *Pinus palustris* and its common associates, subject to frequent fires, as is usual throughout the range of that tree. In the same neighborhood the lowlands on the inner sides of bends are covered with "second bottom" or terrace deposits, which extend all the way to the coast but are very slightly represented upstream; and *Acer saccharinum* (formerly *A. dasycarpum*), which is perhaps more nearly confined to river-banks than any other tree in the eastern United States, and seems to require twenty feet or more of seasonal fluctuation of water, extends up the river just about to the point under consideration. *Quercus laurifolia,* which is almost confined to the coastal plain, extends a few miles farther upstream.

But all this perhaps has as little to do with the peculiarities of the cliff flora as the fact that some of the river water comes from a limestone valley. It may be a little more significant that there are among these cliffs several "hanging valleys," with mouths high above the river, presumably indicating that the streams which made them are dry most of the time, and therefore have not cut down their channels as fast as the river has. Springs too are scarce along the river, as the canoeist discovers to his discomfort in hot weather. This indicates that there must be little leaching out of the elements of fertility from the rocks.

Some of the plants under consideration are of species commonly supposed to be partial to limestone, although the rock is not noticeably calcareous. A partial analysis of a specimen of the shale made for the writer some years ago showed only 0.42% of lime (CaO), but nearly ten times as much potash (K_2O), namely, 3.95%[3]; and it is quite likely that these and many other supposed calciphiles are really

[3] See Geol. Surv. Ala. Monog. **8**: 54. 1913.

PLATE 28

Rich ravine near Warrior River a little below mouth of Hurricane Creek, with *Aesculus parviflora* in full bloom, and trunk of *Liquidambar* at right. June 28, 1911.

Looking down Hanging Valley on left bank of Warrior River about nine miles above Tuscaloosa and 100 feet above the water. View taken about 50 feet back from mouth of valley. Trees mostly *Pinus Virginiana*. Dec. 2, 1911.

potash-loving species.[4] Some of the species are noteworthy for being confined to Alabama, or more abundant in this state than anywhere else. Others here reach their southern limits or nearly so, and were not recorded from this part of the state by Dr. Charles Mohr in his *magnum opus*, the Plant Life of Alabama (published shortly after his death in 1901).

Comparatively little botanical work of permanent value has been done in the vicinity of Tuscaloosa. Sir Charles Lyell, the eminent English geologist, visited the town in 1846, and published a few botanical observations in his "Second Visit to the United States." A few years later Drs. R. D. Nevius and W. S. Wyman botanized in this vicinity in spare moments, but the only recorded result of their work seems to be the discovery of *Neviusia Alabamensis* and *Sedum Nevii*[5]. Dr. Eugene A. Smith, state geologist from 1873 to the present time, devoted considerable attention to plants in the first few years of his service at the University of Alabama, and collected many specimens, quite a number of which are cited in Mohr's Plant Life of Alabama. Dr. Mohr, although he visited Tuscaloosa occasionally, seems to have done very little field work in this neighborhood, having depended mainly on Dr. Smith for information about the flora of Tuscaloosa County. Messrs. C. L. Pollard and W. R. Maxon of the U. S. National Herbarium visited Tuscaloosa in the summer of 1900, mainly for the purpose of finding *Neviusia*, in which however they were not successful.[6]

The localities described below seem to have been entirely unknown to Dr. Mohr, but with good reason, for they were very inaccessible during his lifetime. The locks which now make navigation possible on the Warrior River for about 75 miles above the fall-line did not exist then, nor did the railroad which now skirts the bluffs on the left side of the river for eight or nine miles; consequently it would have been very difficult to go up the river either by boat or on foot.[7] The main highway from Tuscaloosa to Birmingham indeed passes within a mile or two of some of the most interesting cliffs, but any one not

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[4] See Bull. Torrey Bot. Club **40**:398. 1913.

[5] The writer had the pleasure of meeting both of these gentlemen toward the close of their lives, the former on his last visit to Tuscaloosa in 1913, and the latter a year or two earlier.

[6] See Plant World **3**:136. 1900; **9**:105. 1906.

[7] Since these lines were written Dr. Smith has informed me that about 25 years ago he went with Dr. Mohr and John Muir in a small steamer a few miles up the river, probably to the first shoal above Tuscaloosa, which must have brought them pretty close to some of the cliffs here described; but they did not land there, and thus a wonderful opportunity was missed. (*Pinus Virginiana*, which abounds on top of the bluffs down to within about four miles of the city, is not reported from this or any adjoining county in Mohr's Plant Life of Alabama.)

knowing of the existence of anything unusual along there would not have been likely to walk out from the road to the river through the almost pathless forest, or even if he did so, to walk along the river very far if he happened to strike it at one of the less interesting spots.

My acquaintance with the botanical treasures under consideration began during the first month of my connection with the Geological Survey of Alabama. On Dec. 5, 1905, I walked up the railroad above-mentioned (a branch of the Mobile & Ohio) to a point about ten miles above Tuscaloosa, primarily to study the vegetation of the Paleozoic area where it approaches the fall-line.[8] The results were so interesting that I have since made similar trips at all seasons of the year, and taken several visiting scientists along the same route.

In this brief paper no detailed discussion of the vegetation by habitats or associations is attempted. The plants observed along and near the left bank of the river from the southernmost cliffs to the mouth of Daniels Creek (where the railroad leaves the river) are put in a single list, divided into trees, shrubs, etc., and arranged as nearly as possible in order of abundance in each group. No definite lateral limit can be set for the area treated, but the plants growing in dry woods on the coastal plain material a little back from the top of the bluffs, where fire is frequent, are excluded as far as possible. There are however all gradations between that type of vegetation and the "lithophile" vegetation of the cliffs and the "mesophile" (or more correctly speaking pyrophobic[9]) vegetation of the ravines, affording problems enough to keep ecologists and successionists busy for many years.

In this list the names of evergreens are printed in italics. The letter A after a name indicates that the species is believed to be more abundant in Alabama than anywhere else, S means near its southern limit or farther south than Dr. Mohr reported it, and L indicates species which are commonly supposed to be partial to limestone. The usual habitat of each species in this locality is given in a word or two.

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[8] Some of the interesting finds were described in the Plant World for May, 1906, but the narrative was marred by the insertion of several essentially fictitious common names by the editors without my consent, with the avowed purpose of making the article more "popular."

[9] For an earlier use of this term see Bull. Torrey Bot. Club **45**:33. 1918.

TIMBER TREES

Pinus Virginiana (S)	Tops of bluffs
Fagus grandifolia	Ravines
Juniperus Virginiana (L)[10]	Exposed cliffs
Fraxinus Americana	Ravines
Quercus Muhlenbergii (L, S)	Rocky ravines
Quercus Durandii (A, L)	Ravines and cliffs
Quercus montana (S)	Dry bluffs
Liquidambar Styraciflua	Ravines and river-banks
Celtis occidentalis?	Ravines and river-banks
Liriodendron Tulipifera	Ravines
Ulmus serotina (A, L)	Ravines
Quercus borealis maxima	Ravines
Quercus alba	Ravines
Tilia Americana?	Ravines
Platanus occidentalis	River-banks
Pinus Taeda	Ravines, etc.
Acer Negundo	River-banks
Quercus Michauxii	River banks
Quercus nigra	River-banks
Magnolia acuminata	Ravines

SMALLER TREES

Cercis Canadensis (L)	Ravines and bluffs
Acer leucoderme (S)	Ravines and bluffs
Magnolia macrophylla (A)	Ravines
Cladrastis lutea (L, S)	Bluffs
Ostrya Virginiana	Ravines
Ilex opaca	Ravines
Viburnum rufidulum	Bluffs
Fraxinus quadrangulata (L, S)	Cliffs
Morus rubra	Ravines and banks
Bumelia lycioides (L)	Cliffs
Carpinus Caroliniana	Ravines and banks
Salix nigra	River-banks, etc.

SHRUBS AND VINES

Croton Alabamensis (A, L)	Cliffs
Hydrangea quercifolia (A)	Ravines and bluffs
Aesculus parviflora (A)	Ravines and bluffs
Aesculus Pavia (A)	Ravines and bluffs
Hydrangea arborescens	Ravines and bluffs
Arundinaria macrosperma?	Cliffs
Neviusia Alabamensis (A, S)	Shaded bluffs
Staphylea trifolia	Shaded bluffs
Philadelphus sp.	Cliffs

[10] See Torreya **12**:147. 1912.

Bignonia crucigera ..... Various habitats
Rhus radicans ..... Various habitats
Rhamnus Caroliniana (L) ..... Bluffs
Rhus aromatica (L) ..... Bluffs
Hypericum aureum (L, S) ..... Bluffs
Aralia spinosa ..... Ravines
Adelia ligustrina (L) ..... Cliffs
Parthenocissus quinquefolia ..... Ravines, etc.
Ptelea trifoliata (L) ..... Bluffs
Asimina triloba ..... Ravines
Vaccinium vacillans? ..... Tops of bluffs
Rhus glabra ..... Various habitats
Euonymus Americanus ..... Ravines
Hamamelis Virginiana ..... Ravines and bluffs
Illicium Floridanum (A) ..... Damp ravines
Batodendron arboreum ..... Dry bluffs

HERBS

Cheilanthes lanosa ..... Cliffs
Adiantum pedatum ..... Ravines
Heuchera macrorhiza (S) ..... Cliffs
Dryopteris marginalis (S) ..... Cliffs
Woodsia obtusa ..... Cliffs
Saxifraga Virginiensis ..... Cliffs
Sedum Nevii (A, L) ..... Cliffs
Polystichum acrostichoides ..... Ravines
Eupatorium aromaticum ..... Ravines
Asarum arifolium ..... Ravines
Solidago caesia ..... Ravines and bluffs
Tradescantia hirsuticaulis? ..... Cliffs
Yucca filamentosa ..... Bluffs
Phacelia sp. (A?) ..... Cliffs
Dioscorea sp. ..... Ravines
Oplismenus setarius ..... Ravines
Viola Canadensis (S) ..... Bluffs
Asplenium Trichomanes (S) ..... Cliffs
Alsine pubera ..... Ravines
Croomia pauciflora (A) ..... Ravines
Campanula Americana (L) ..... Cliffs
Isopyrum biternatum (L, S?) ..... Cliffs
Asplenium platyneuron ..... Ravines
Phegopteris hexagonoptera ..... Ravines
Aster Camptosorus ..... Bluffs
Uniola latifolia ..... Bluffs
Arabis Canadensis (L, S) ..... Bluffs
Tiarella cordifolia ..... Ravines
Sedum ternatum ..... Cliffs

Adicea pumila	Damp ravines
Filix fragilis	Cliffs
Eupatorium incarnatum (L)	Bluffs
Syndesmon thalictroides	Ravines
Oxalis violacea	Ravines
Iris cristata (S)	Ravines
Erythronium Americanum (S)	Ravines
Dodecatheon Hugeri (A)	Ravines and bluffs
Washingtonia longistylis (S)	Ravines
Viola rostrata (S)	Ravines
Verbesina Virginica	Bluffs
Solidago amplexicaulis[11]	Ravines
Antennaria plantaginifolia	Dry bluffs
Hepatica triloba	Ravines
Juncoides campestre	Ravines

Taxonomically there is nothing remarkable about this list, unless it is that ferns, oaks, Magnoliaceæ, Saxifragaceæ, Sapindaceæ and other Polypetalous families are rather numerous, and grasses, sedges, and other monocotyledons, Rosaceæ, Leguminosæ, Umbelliferæ, Ericaceæ and Compositæ rather few (using all these family names in their older and broader sense). As in the interior hardwood region of the eastern United States, there are more flowers in spring than at any other season, evergreens are in the minority, especially among the trees, and fleshy fruits are scarce.

For rare plants this locality compares favorably with the more or less celebrated bluffs on the east side of the Apalachicola River in Middle Florida.[12] The two places have several species in common, such as *Fagus, Juniperus, Liriodendron, Liquidambar, Pinus Taeda, Quercus alba, Cercis, Ilex opaca, Ostrya, Aesculus Pavia, Bignonia, Aralia spinosa, Hypericum aureum, Adelia ligustrina, Ptelea,* and even *Croomia* and *Alsine pubera.* And the two endemic trees of the Florida bluffs (representing two genera of Taxaceae) are no more remarkable than the shrubs *Croton Alabamensis* and *Neviusia,* which are not known outside of Alabama. (The former is known from two counties and the latter from three.) It is rather singular that the *Croomia,* unlike nearly all the other species listed, has its northernmost known limit in the area under discussion.

Unfortunately civilization is making inroads on these bluffs and ravines, as on many other beauty spots the world over. The smoke

[11] See Bull. Torrey Bot. Club **31**:26. 1904.
[12] See Torrey **19**:119-122. 1919.

from the trains that pass four or five times a day does not benefit the cliff vegetation any, and whenever a new coal mine is opened or a sawmill located near the river, houses are built nearby, necessitating clearing away some of the forest. The best long-leaf pines on the adjacent hills were cut by lumbermen about seven years ago, and in some places the logs are rolled down the bluffs to the river or some creek, necessitating cutting a swath through the vegetation. A development which may be looked for almost any day is the building of summer homes on the bluffs by some of Tuscaloosa's "idle rich," with a consequent scattering of tin cans and other rubbish in the adjacent ravines. But at any rate, the topography is so broken that little of the area is likely to be molested in the near future by farmers, and there will probably be some interesting vegetation there to study for a generation or two yet.

FISHES IN RELATION TO MOSQUITO CONTROL

By Samuel F. Hildebrand

It has been known for many years that various species of fishes prevented mosquito production when placed in small inclosures, such as cisterns, fountains and pools, but only comparatively recent studies and experiments have led to a fairly definite determination of the species and the conditions most favorable for mosquito control in larger bodies of water. Some of the species which are used for mosquito control in small artificial waters are wholly unreliable in large bodies of water where a greater variety of foods is available, showing that in confinement fish take foods which ordinarily are not eaten. The variegated minnow (*Cyprinodon variegatus*), a strictly herbaceous fish, for example, may be confined in an aquarium and fed on a diet of wiggle tails and minced beef or fish and kept alive for several months. It may also be placed in a pool comparatively free from vegetation, but infested with mosquito larvæ, and it will live indefinitely and provide mosquito control. Experiments and observations relative to *Mollienisia latipinna*, a minnow structurally rather close to *Gambusia affinis* and usually found with the latter in great abundance in potential mosquito breeding areas in the lowland swamps and sluggish ditches of our coastal plains from South Carolina to Mexico, have led to the conclusion, however, that the food of this species consists almost wholly of plants and that it is worthless as an agent for the control of mosquito production.

It, therefore, is necessary, for the purpose of mosquito control in nature, to find fishes that not only choose a habitat suitable for mosquito production but which by preference feed upon live animals. They also must seek "bait" of the proper size and they furthermore must feed at the surface, for that is where the mosquito spends most of its life in the aquatic stages. It likewise is very desirable to use a fish which will reproduce under a wide range of conditions, *i. e.*, in almost any water in which mosquitoes breed, also one which multiplies very rapidly.

Gambusia affinis, a species in which the female reaches a maximum length of about 60 mm. (2⅜ in.), the male being much smaller, very admirably meets all of the requirements mentioned in the preceding paragraph. It is common almost everywhere throughout the mala-

rious sections of the South where it inhabits potential mosquito-breeding areas. It is not limited for food entirely to live animals, but it undoubtedly prefers that kind of a diet, and a wiggle tail certainly is a "bait" of suitable size for this fish and one which appears to "tickle the palate." The habit of surface swimming which is correlated with surface feeding in *Gambusia* is highly developed, the fish having received its common name, "Top Minnow," because of its almost constant appearance at the surface of the water.

Gambusia is viviparous, *i. e.*, the eggs are fertilized and hatched within the body of the parent fish, and the young when born are from 8 to 10 mm. ($\frac{5}{16}$ to $\frac{2}{5}$ in.) long and come into the world well developed, being much better able to take care of themselves than most fishes hatched from eggs in the more usual way. This fish, unlike most others, therefore, requires no special environment for depositing and hatching eggs, the young being born as the female moves about in the water. The species, for this reason, is able to reproduce under a very wide range of conditions. The young come in broods, numbering from a few to one hundred or more, throughout the summer and at intervals of from three to several weeks each. The young when born are so well developed and so thoroughly capable of beginning an independent existence that their chances for survival are excellent. They grow rapidly and the early broods of the season become sexually mature and themselves have young before the end of the summer during which they are born. Multiplication therefore is very rapid.

Gambusia, as already indicated, is common in most of the malarious sections of the South and in many localities it has become distributed to the sluggish ditches and standing bodies of water, as far as natural waterways have from time to time been open. In other localities the fish is not so universally distributed and in nearly every vicinity there are present some waters which the fish is unable to reach because there are no channels connecting them with other bodies of water. It is here where aid in distribution by man is needed.

It is not claimed that *Gambusia,* when present in a body of water, will eliminate all mosquito production under all conditions. Sometimes, when conditions are proper and sufficient top minnows are present, mosquito production is completely eliminated. In many cases it is not eliminated but very greatly reduced.

The value of *Gambusia* as an eradicator of the immature mosquito

may be determined by the inspection and comparison of quiet waters which support top minnows with those in the same locality which do not support top minnows, in order to determine which waters produce the most mosquitoes. Ponds heavily infested with mosquito larvæ and pupæ may be stocked with *Gambusia* and results awaited and observed. One of two similar, neighboring bodies of water both infested with immature mosquito, may be stocked with *Gambusia*. The water which is not stocked with top minnows will serve as a "control" which will furnish a fair comparison. Occasionally it is possible to demonstrate the destruction of mosquito larvæ which *Gambusia* accomplishes by connecting by means of a ditch one pond or pool heavily infested with mosquito larvæ with another supporting top minnows. All of the foregoing experiments and observations have been made within recent years and in every instance either a great reduction in mosquito production resulted or, as in many cases, complete control followed. Wherever mosquito production was not eliminated, if sufficient minnows were used, complete control was prevented by the presence of places of protection for the immature mosquito against fish.

Places of refuge for mosquito larvæ and pupæ in the presence of fish are furnished by such types of plants and floatage which are slightly or partly submerged, causing a mere film of water to stand above them. *Anopheles* larvæ are particularly keen in seeking these places of refuge where they cannot be reached by the minnows. The low aquatic grasses, particularly *Hydrochloa carolinensis,* are a source of much difficulty in securing mosquito control by the use of fish. Mats of floating algæ with a film of water over them also form excellent hiding places for the immature mosquito. Many other plants, some of them strictly aquatic, others of the shore variety, often cause imperfect control when they are partly or slightly submerged. Plants which are wholly submerged do not appear to hinder mosquito control by the use of fish. Certain plants, such as the floating primrose willows and the tall wire grasses, sometimes develop dense masses of roots near the surface of the water which provide a limited amount of protection. The tall plants with straight stalks and with few or no leaves, and without dense roots near the surface, like the cat-tails, the rushes, etc., provide little or no protection for mosquito larvæ and pupæ. The duck weeds not only furnish no refuge but whenever

a pond is largely covered with them they appear to prevent mosquito production. The leaves of these plants are wholly above the surface of the water, they do not have a dense root system, and furthermore it is possible that the more or less constant shifting of the weed masses with the winds or currents may drown the eggs.

Since there are many conditions under which plants furnish protection for the immature mosquito against fish, it is very essential in the conduct of anti-malaria campaigns to make frequent and careful inspections of all waters in the area under control. If it is found that certain plants are preventing mosquito control, then it is time to aid the minnows. The indiscriminate cutting and clearing of vegetation from water deposits certainly is not an economical practice, as such work frequently is not necessary. The biological condition existing in each pond must determine whether or not top minnows will require assistance from man to furnish control of mosquito production. The abundance of top minnows must be carefully considered, and certainly the amount of food available for them in each body of water is of great importance. The writer has shown by experiment that when food is scarce better mosquito control will result than when it is plentiful even though much vegetation of the "protective type" is present, and he knows of no other way to explain why mosquito production in certain ponds is much more nearly eliminated than in others when minnows and plants appear to be identical and present in equal abundance.

It is evident then that top minnows are of much value in controlling mosquito production in permanent standing bodies of water and that they also render excellent service in sluggish ditches. Their value as eradicators of mosquito larvæ has been recognized by health officers, and minnows are used very widely in the South where anti-malaria campaigns are conducted, having in a large measure replaced the use of oil. A definite use for oil in anti-malaria work remains; for places exist in nearly every locality where mosquitoes breed and where fish cannot be used, as, for example, in a film of seepage water, in hoof prints, in temporary pools, etc. It is well known that in order to secure mosquito control by the use of oil a continuous film must cover the entire surface of the water and that during hot weather a new coat of oil must be applied about once a week. It is quite impossible to obtain a continuous film on ponds and lakes, because the oil is

driven to one side or to a corner, leaving the remainder of the water exposed. Furthermore, if oiling is discontinued after it has been applied for some time, the natural enemies of the mosquito have usually either been driven away or killed and thereafter the mosquitoes can reproduce more successfully than before the natural conditions were disturbed. Since fish control is much more permanent in its results and much less expensive, it seems advisable to use fish wherever possible and to apply the oil treatment only where fish cannot be successfully used.

Drainage undoubtedly deserves first place among the measures of mosquito control because of its permanent character, but it is a recognized fact that all water deposits cannot be eliminated and furthermore, it is undesirable to eliminate all of them. The cost of drainage usually is high and therefore often prohibitive. Fish control can usually be substituted in part for drainage, and is especially recommended for rural sections and for other localities where funds for the more expensive measure are not available.

A number of species of fishes besides *Gambusia affinis* have been recommended for mosquito control, but none has been as extensively used as *Gambusia.* Only one other species in the South, *viz., Heterandria formosa,* a viviparous species, belonging to the same family as *Gambusia,* but of much more limited distribution, ranging from North Carolina to Florida, has given results comparable with those obtained with *Gambusia.* Several species of the genus *Fundulus,* also belonging to the top minnow family, probably are of limited value. Some of the sunfishes have been mentioned in connection with mosquito control, but their usefulness in the South is not well established. They certainly are much less efficient than *Gambusia.*

Gambusia affinis, as already noted, is common almost everywhere throughout the malarious sections of the South. What the conditions without these faithful servants would be is difficult to conceive, but it is quite probable that sections which are prosperous would be in a very backward state and that others would be entirely undeveloped. Doctor H. R. Carter, assistant surgeon general, U. S. Public Health Service, who is well qualified to speak as an authority on the subject, positively asserts* that prosperity is not compatible with the prevalence of malaria and he declares that no prosperous community exists

* Public Health Bulletin, U. S. Public Service, No. 105; 40. 1920.

where malaria seriously prevails. If a community cannot prosper when malaria prevails, the importance of combatting such a disease by every known means is evident. The use of top minnows for this purpose, although comparatively new, as already stated, has been adopted by many health officers in nearly all of the southern states wherever practical anti-malaria work is being conducted. Much wider use, however, should be made of this comparatively inexpensive agent. Nature has been kind in the distribution of the top minnow, as already shown, but still natural bodies of water remain in some localities which have not become stocked with *Gambusia*. The artificial waters usually are inaccessable to the minnows and, since they nearly always are near residences, it is especially important to prevent mosquito production in them. Certainly much good can be accomplished by the judicious distribution of the top minnow, and the results will be doubly effective if it is given aid by clearing vegetation from the water wherever necessary.

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NOTES ON THE MORPHOLOGY AND SYSTEMATIC RELATIONSHIP OF *SCLEROTIUM ROLFSII* SACC.*

By B. B. Higgins

Plate 29

In spite of the proved parasitism and general occurrence of *Sclerotium rolfsii* in the warmer portions of the United States, very little is known in regard to the structure of the mycelium and of the sclerotia of the fungus. The few data that have been published on the subject have contained so many errors as to be confusing rather than clarifying. It, therefore, seems desirable to publish, at this time, a few notes that may be helpful to others who come into contact with this fungus.

The reputed appearance and disappearence of the fungus in fields, and its other peculiarities, have led to investigations with the hope that some fruiting stage would be discovered. So far no spores have been found; but certain characteristics of the mycelium have been noted, which are of considerable help in distinguishing the mycelium of this fungus from that of several others that attack plants in a somewhat similar manner. These characters also suggest, in a general way, the spore forms that one should expect to find associated with this mycelium.

On fleshy plants and on fruits, such as cantaloupe, where food and moisture are abundantly available, the growth of *S. rolfsii* is very vigorous and characteristic. The mycelium usually forms broad white sheets and a profusion of sclerotia develops; but on small or more woody stems, such as those of sweet potato slips or of pepper plants, the growth is often very scanty and impossible to distinguish macroscopically from any one of several other fungi that may attack these plants. Even when such plants are placed in a moist chamber, sclerotia often fail to develop.

MYCELIUM

The mycelium is rather coarse, with large cells (2-9 x 150-250μ). The feeding branches which enter the medium or the host tissue and those which enter into the formation of the sclerotia are of the more slender type (about 2μ in diameter). In the broader threads clamp connections occur characteristically, two at each division (figs.

* Paper number 15, Journal Series, Georgia Agricultural Experiment Station.

5-8). Often, however, a branch arises just back of the cross wall in the place of one of the clamp connections (fig. 6). In the larger threads this is the only type of branching that is at all common; but from the more slender threads clamp connections are often wanting and branches may arise from any point, without regard to the cross wall.

The clamp connections often develop abnormally, extending the full length of the cell (fig. 7) or even joining a neighboring hypha or a branch with the main hypha (fig. 8). The peculiar appearance of these clamp connections is evidently what gave Taubenhaus* the impression of budding in the mycelium.

The branches, especially those of the more slender type, often anastomose (fig. 10) and hold the hyphæ together in sheets or occasionally in strands.

The cells of the mycelium are binucleate, at least when young.

SCLEROTIA

The sclerotia first appear as small white tufts of loosely intertwined small branches (fig. 1). Stained sections of such tufts show an actively growing region near the periphery, which is about $\frac{1}{20}$ of a millimeter thick, rich in protoplasm, and showing a much greater affinity for stains than the center of the mass or the looser downy covering which surrounds the growing region. Within a very short time, 24 to 48 hours in rapidly growing material, all the cells of the mass, except those of the downy covering, begin to enlarge (fig. 2) and swell to about three times their former size. At the same time they become vacuolate and, usually, multinucleate. The cell walls of the cells in the growing region seem to gelatinize and coalesce, forming a pseudo-parenchymatous tissue (fig. 2) about $\frac{1}{7}$ millimeter thick. The cells of an outer layer, two or three cells thick, now lose their protoplasm; and the cell walls turn dark, collapse to a certain extent, and form a corky appearing covering over the entire surface of the now mature sclerotium (fig. 3). The outer downy covering has become separated by the formation of this cortical layer and it now sloughs off, leaving the surface dark brown, smooth, and somewhat shiny. The cells of the pseudo-parenchyma are broad, and more or less angled, with thick colorless walls and no air spaces between;

* Taubenhaus, J. J. Recent Studies on Sclerotium rolfsii Sacc. Jour. Agr. Res. **18**: 127. pls. 3-6, fig. 1. 1919.

while those of the center of the sclerotium retain their hyphal character and are separated by large air spaces (fig. 4). The mature sclerotia are dark brown in color, globose to elliptical, and ½ to 1½ millimeters in diameter.

Taubenhaus* suggests the existence of plus and minus strains of the fungus and the necessity of a "sexual act" in the formation of the sclerotia. If proved, this would indeed be an interesting condition, entirely new among fungi, and well worthy of serious study.

The absence of any spore form made the task of separating pure strains for the study unusually difficult. If an ordinary branched filament were used, one could hardly be positive that parts of other filaments were not included as anastomosed branches.

In pursuance of the plan finally hit upon several sclerotia from an old culture, obtained originally from a wilted pepper plant, were planted on agar plates which were then inverted and placed in a culture room until considerable aerial growth had formed under the sclerotium. A few filaments from this growth were picked up on the point of a flamed needle which was then dragged across a sterile agar plate. The plate was then inverted on the stage of the microscope; and, with the low power objective, single unbranched threads were located and their position indicated by ink marks on the bottom of the plate. Blocks of the agar, each containing a single thread, were then cut out with a flamed scalpel and transferred to another plate of sterile agar.

In this way fifty short filaments were isolated and planted. The plates were placed in an incubator and examined under the microscope at least once every twenty-four hours for evidence of growth or of contamination. Most of the number either died or showed contamination within a few days, but five lived and produced new growth. In these five cases the torn ends of the threads died and the new growth developed from two or three cells remaining alive in the center.

After growth was well started all five were transferred to tubes of steamed bean pods where, after a few days, each had produced sclerotia in great abundance. Transfers were then planted on plates of peptone beef extract agar—three colonies to each plate, two of A and one of B, etc., throughout the series; so that colonies of each strain

* Taubenhaus, J. J. l. c., p. 136.

would come into contact with colonies of the same strain and of each of the other four strains.

The production of sclerotia was somewhat irregular in these plates, but no sign of "mixing" was noted. Sometimes they were most abundant where two colonies, either of the same or of different strains, met; but this was not at all constant. Often they began developing abundantly at the center of the colony before it had come in contact with the other colonies on the plate. The most abundant development noted in any case was found where a colony of bacteria was overgrown by the fungus. The variation seemed to be due to irregular food supply and to any irregularity in the surface of the medium which increased the aerial growth of the mycelium.

While this experiment does not prove the non-existence of plus and minus strains, it does show that mixing of such strains is not necessary for the production of sclerotia.

GERMINATION OF THE SCLEROTIA

When mature sclerotia are placed in contact with a suitable medium they send out hyphæ from all over the surface without forming any apparent break or crack in the tissues. Each thread arises and pushes out to the surface separately. In new sclerotia such new growth may, probably, arise from any living cell; but in very old sclerotia the cells of the pseudo-parenchyma appear to be dead, and the new growth arises from the cells of the more loose hyphal weft in the center (fig. 4). The new hyphæ are slender and pass between the old cells and finally push or dissolve an opening between the cells of the compact outer tissues.

The cells of the new hyphæ are binucleate. Whether they arise only from cells that have remained binucleate, or otherwise, has not been determined.

LONGEVITY OF THE SCLEROTIA

If kept dry, the sclerotia remain viable for a long time. Some produced in cultures and kept in the culture tubes grew off readily when they were finally transferred to fresh media, when more than two years old. It is not likely that they last very long in contact with moist soil under field conditions. They seem to be very susceptible to freezing when wet.

SYSTEMATIC RELATIONSHIP

The presence of clamp connections and of the binucleate condition in the mycelium shows the relation of the fungus to the *Basidiomycetes;* but these characters are common to practically all the families of this group. Sclerotia are also produced by members of nearly all families of *Basidiomycetes.* It does not seem possible, therefore, to determine with certainty any closer relationship until spore formation has been observed.

SUMMARY

1. The presence of clamp connections and a peculiar method of branching is a valuable aid in distinguishing the mycelium of *S. rolfsii* from that of other fungi producing similar lesions on plants

2. The affinity of *S. rolfsii* to the class *Basidiomycetes* is indicated by the septate, binucleate mycelium and by the presence of clamp connections at the septa.

3. The mixing of plus and minus strains is not necessary for the production of sclerotia.

EXPERIMENT, GA.

EXPLANATION OF PLATE 29

Fig. 1. Part of a sector from section of a very young sclerotium of *S. rolfsii,* showing interwining of the slender hyphæ; a, the loose hairy covering; b, darker stained growing region; and c, paler hyphæ in the center of the weft. x 367.

Fig. 2. Part of a sector from section of a slightly older sclerotium; a, the loose hyphal covering of the sclerotium; b, the pseudo-parenchyma with its large cells and thick colorless walls; and c, looser growth and large air spaces in the center of the sclerotium. x 367.

Fig. 3. Portion of the outer tissues from a section of a mature sclerotium; a, remains of the loose hyphal coverings, partly dead and sloughing off; b, pseudo-parenchyma, the outer layers of which have formed the brown cortical coverings. x 367.

Fig. 4. Section from near the center of a germinating sclerotium, showing two slender new hyphæ (d) pushing between the partly dead cells of the sclerotial tissue; from a scerotium more than a year old. x 367.

Fig. 5. Septum and double clamp connections in vegetative mycelium of *S. rolfsii.* x 154.

Fig. 6. Portion of a hypha in which a branch has grown out in the place of one of the clamp connections. x 154.

Fig. 7. An abnormality in which the branch taking the place of a clamp connection has grown out and connected with the second cell beyond its place of origin. x 154.

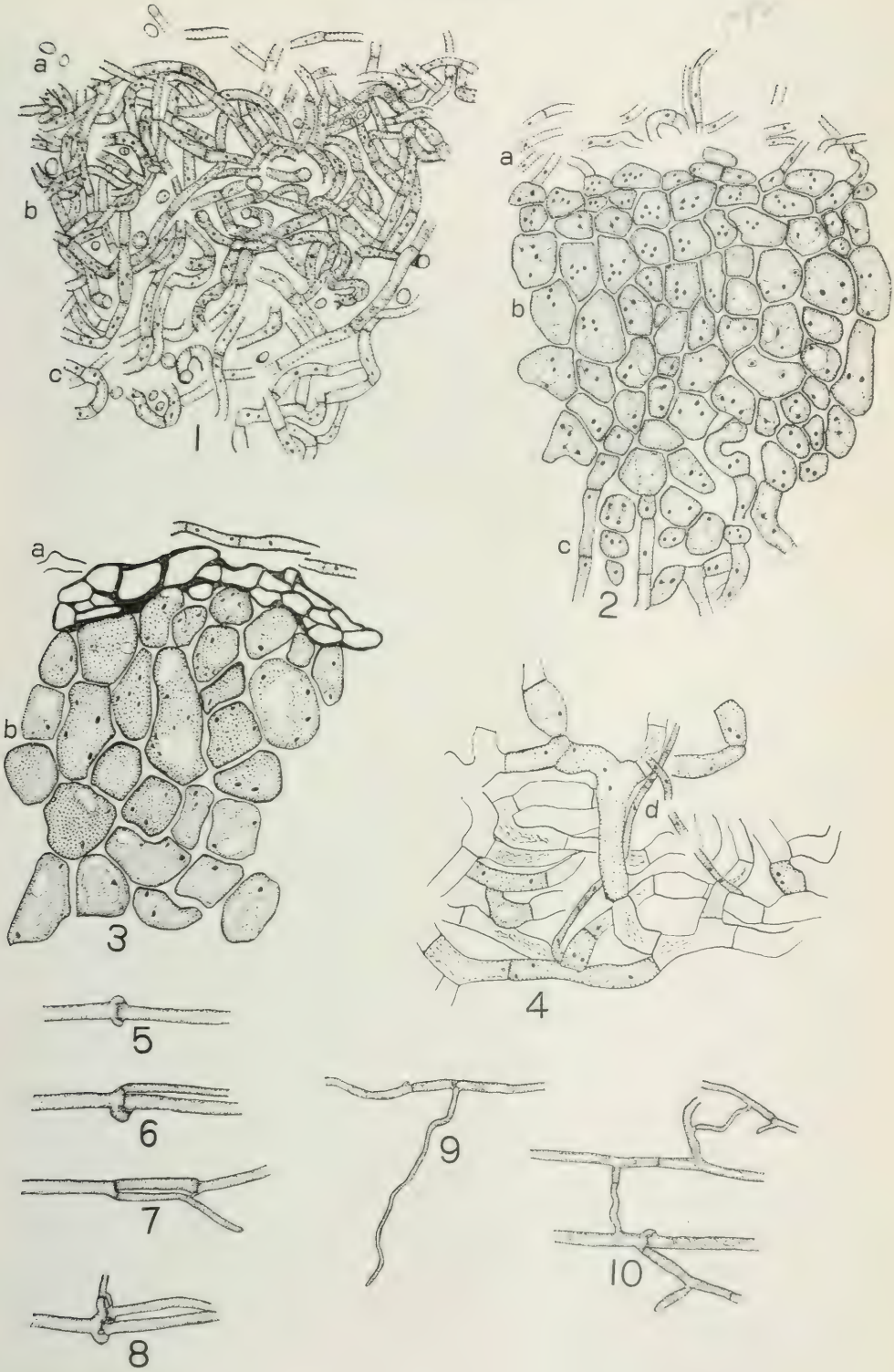
Fig. 8. Another common abnormality in which the clamp connection growing out from a branch connects with the mother hypha. x 154.

Fig. 9. Hypha of the more slender type with a branch arising from near the center of a cell. x 154.

Fig. 10. Anastomosing branches in the vegetative mycelium. x 154.

All drawings made with the aid of a camera lucida.

PLATE 29



AN INTERESTING ANOMALY IN THE PULMONARY VEINS OF MAN

By W. C. George

Plates 30 and 31

Anomalies in the venous system are so common that most of them arouse no very great interest in the anatomist. One of the anomalies (pl. 30, fig. A) found last spring in the anatomical laboratory at Chapel Hill and called to my attention by Dr. C. S. Mangum is so unusual and of such embryological interest as to seem worthy of a brief report. In this case the blood from the upper left lobe of the lung was drained not into the atrium but into the systemic circulation. A fairly large vein, about one-half inch in diameter, emerged from near the middle of the ventral surface of the upper left lobe of the lung and coursed directly cephalad to empty into the left innominate vein about two and one-half inches lateral to the union of the two innominates to form the superior vena cava. The right pulmonary veins and the pulmonary vein from the lower left lobe communicate with the left atrium as usual.

Somewhat similar connections between the veins of the pulmonary and systemic circulations have been recorded previously. With reference to this sort of anomaly Bailey and Miller (1) make the statement that "The upper (more cephalic) [pulmonary] vein on the right side may open into the superior vena cava; or the upper vein on the left side may open into the left innomonate vein. A possible explanation of this is that the pulmonary veins are formed after the heart and other vessels have developed to a considerable degree, and some of them may unite with the other vessels instead of with the atrium." This explanation is apparently based on an erroneous conception of the pulmonary veins being sprouts that grow out from the sinus venosus into the lungs, and does not seem to be a satisfactory explanation in view of the relations existing between the pulmonary and bronchial veins in the adult and their embryonic origin as shown by Alfred Brown (2). Brown has shown that the pulmonary system in the cat arises from an indifferent splanchnic plexus in the region of the lung bud (pl. 31, fig. C). This plexus communicates on the one hand with the sinus venosus and on the other with the neighboring systemic veins (cardinals, segmentals, *et al.*). This plexus around the lung bud differentiates into two systems, the pulmonary and the bronchial.

In the adult the lungs receive their blood supply from two sources,

the pulmonary arteries from the right ventricle and the bronchial arteries from the aorta. Typically the pulmonary veins drain the lungs of the blood brought in by the pulmonary arteries and, through connecting capillaries, a small amount of the blood brought in by the bronchial arteries reaches the pulmonary veins. Most of the blood brought in by the bronchial arteries, however, is carried away from the capillary plexuses around the bronchi by small bronchial veins which empty into the azygos and accessory hemi-azygos veins, representatives of persisting portions of the embryonic cardinals. Conditions similar to that shown in the anomaly that I have cited apparently arise as a result of some interference with the return of the blood through the pulmonary portion of the embryonic splanchnic plexus, thus causing both pulmonary and bronchial blood to enter the bronchial veins and resulting according to the laws of Thoma (3) in the enlargement of the bronchial system and an atrophy and disappearance of that part of the splanchnic plexus which would have formed the left pulmonary vein.

Laws of Thoma (4):

(1) An acceleration of the current leads to an enlargement of the lumen of a vessel, and a slowing of the current leads to its narrowing and final disappearance.
(2) An increase in the blood pressure is the cause for new formation of capillaries.
(3) The growth in thickness of the vessel wall depends on the tension of the wall, which in turn is dependent upon the blood pressure and the diameter of the vessel.

In this particular case then the large vein passing from the upper left lobe of the lung to the left innominate vein would be composed of the left bronchial vein and that portion of the accessory hemi-azygos between the innominate and the junction of the bronchial with the accessory hemi-azygos. On account of the great enlargement of this vein the distal portion of the accessory hemi-azygos appears as a side branch of the "anomalous pulmonary."

CHAPEL HILL, N. C.

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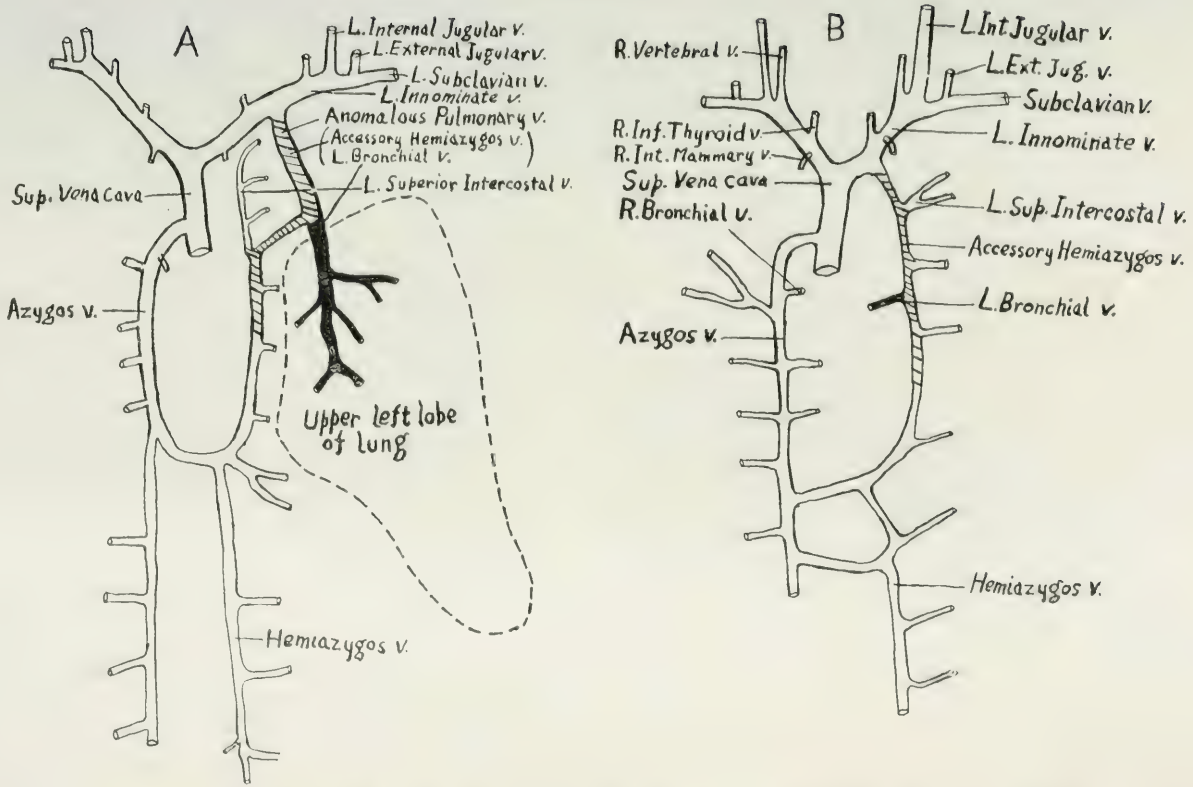
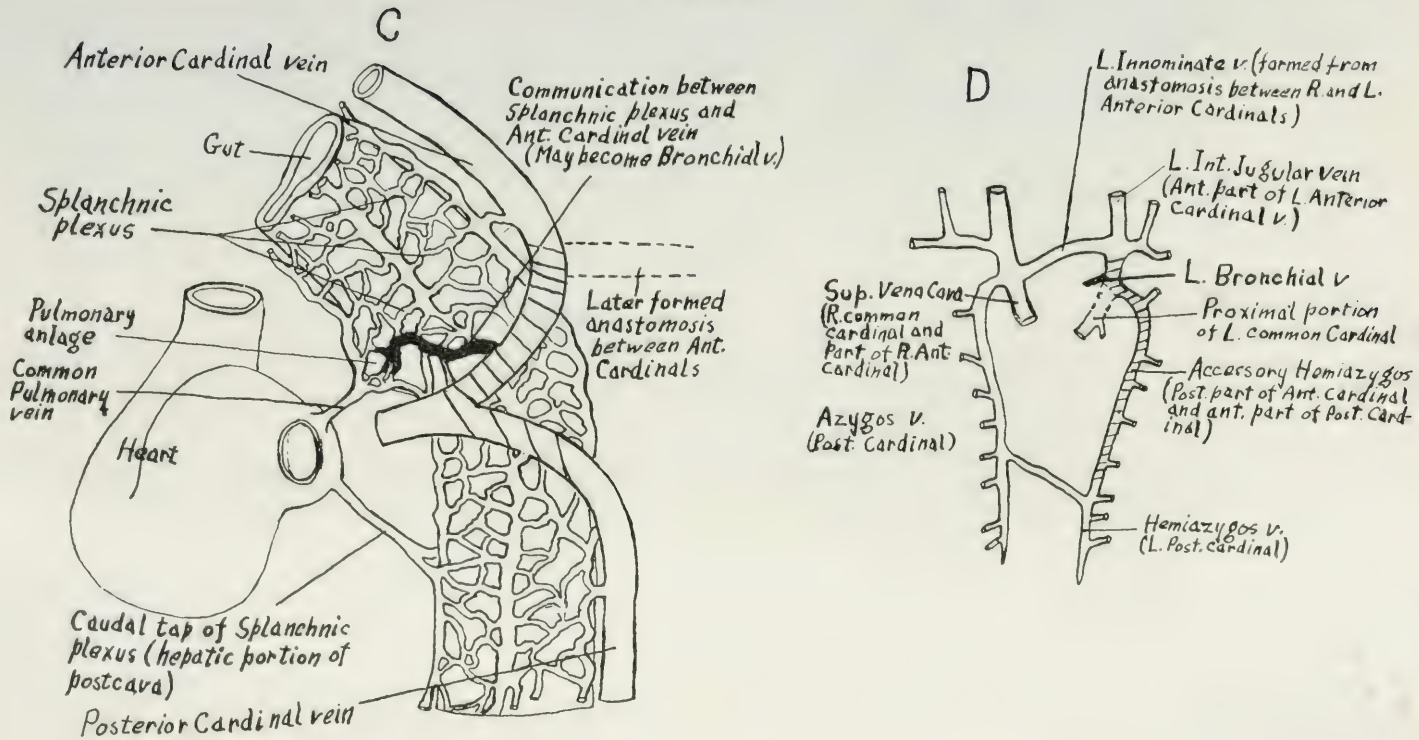
(1) Bailey and Miller: Text-book of Embryology, p. 258, 4th ed., 1921.
(2) Alfred Brown: The Development of the Pulmonary Veins in the Domestic Cat. Anat. Record 7:299. 1913.
(3) R. Thoma: Untersuchungen ueber die Histogenese und Histomechanik des Gefäss-systems. S. 1-91. Stuttgart, 1893.
(4) Quoted from Keibel and Mall's Textbook of Embryology 2:421. 112.

PLATE 30



Two diagrams showing the relations of the thoracic veins and the homologous parts in the anomaly described and in the typical adult body. In A the relations in the anomaly are shown; in B (adapted from Piersol's Anatomy) the typical relations in the adult body. The bronchial veins are drawn in heavy black, and the accessory hemiazygos veins are obliquely cross hatched.



Two diagrams showing the relations of the thoracic veins and the homologous parts in the early and late embryo. C is from a 4.5 mm. cat embryo (adapted from Alfred Brown). The vessels which may give rise to the bronchial and accessory hemiazygos veins are shaded as in the corresponding veins of Pl. 30.

THE EASTERN SHRUBBY SPECIES OF ROBINIA

By W. W. Ashe

The eastern shrubby species of Robinia are separated from *Robinia pseudo-acacia* L. (which has a smooth flat pod and white fragrant flowers) by having pods prickly, hispid, bristly or glandular and pink or purplish flowers.

Key to Eastern Shrubby Species of Robinia

Al. = alleghanian; C. = carolinian. Au. = austroriparian.

Twigs, petioles and pedicels viscid, pod flat, margined (Al. and C.).
  Twigs (often petioles, etc.) covered with viscid secretion....(1) *R. viscosa* Vent.
  Twigs (often petioles, etc.) with short gland-tipped viscid bristles
    (2) *R. viscosa* var. *hardwegii* (Koeh.) Ashe

Twigs never viscid.
  Peduncles, twigs and shoots not hispid, rarely hispidulose.
    Leaves, twigs and peduncles eventually glabrous or nearly so.
      Flowers rose-purple, never fragrant; pods thick.
        Flowers about 15 mm. long, leaflets lance ovate (Al.)
          (3) *R. kelseyi* Cr.
        Flowers more than 17 mm. long, leaflets elliptic (Al.)
          (4) *R. boyntonii* Ashe
      Flowers pale lilac or pinkish, fragrant; pods flat (Au.)
        (5) *R. margaretta* Ashe
    Leaves and inflorescence canescent (Au.).....(6) *R. elliottii* (Chapm.) Ashe
  Peduncles and vigorous shoots usually hispid (in 8 sometimes pubescent), pods thick.
    Flowers more than 20 mm. long, racemes few-flowered (Al.)
      Twigs densely hispid.....(7) *R. hispida* L.
      Twigs sparingly hispid, often merely appressed pubescent.
        (8) *R. grandiflora* Ashe
    Flowers less than 20 mm. long, twigs never densely bristly
      Bristles on twigs short, gland-tipped; 6-18 flowered (C.)
        (9) *R. longiloba* Ashe
      Twigs usually glabrate; racemes 3-6 flowered (Au. & C.)
        (10) *R. nana* (Ell.) Spach.

R. viscosa var. **hardwegii** (Koeh.) n. c.—*R. hardwegii* Koeh.

This plant is frequent around Highlands, North Carolina, associated with the form which has viscid twigs. A few short gland-tipped hairs are to be found on nearly every plant with viscid secretion and as the pubescence becomes more dense there seems to be less of the viscid secretion, so that the form with the viscid secretion gradually passes into the form having viscid pubescence.

Robinia margaretta sp. nov.

A shrub sometimes propagating by root suckers as well as by seed, 1-1.4 m. in height or in cultivation becoming 3 m. high and with a single tree-like stem. Leaves, with linear acuminate herbaceous stipules, rarely with slender thorns, formed of 15 to 19 (to 23 in cultivation), elliptical rather thick firm leaflets, rounded or subcordate at base and rounded or retuse at the mucronate apex, green and sometimes appressed canescent as they unfold, becoming essentially glabrous with age, rachis sparingly hispidulose, petiolule 2-3 mm. long, canescent. Twigs slender glabrous or hispidulose, tan or light chestnut. Racemes spreading 7-13 flowered; flowers faintly fragrant, pale lilac or with the vexellum slightly pinkish, and with a yellowish spot in the center, often with nearly white edges, 16-20 mm. long, the short broad calyx 7-10 mm. long, minutely glandular puberulent, the lobes abruptly acute about two-thirds the length of the tube; pedicels 8-10 mm. long, puberulent and sparingly glandular hispidulose as well as the peduncles. The fruit in spreading clusters of 3-7, is linear 7-10 cm. long and about 1 cm. wide, tipped by the slender curved style, very thin and sparingly hispid with short spreading bristles. Common on sand hills around Augusta, Ga., growing with longleaf pine and *Carya pallida* var. *arenicola* Ashe and near Greenwood, S. C., on red clay uplands with rosemary pine, southern red oak, and white hickory. A specimen from the latter place was cultivated at Washington for five years, fruiting freely, and stock from it distributed. In its small pale fragrant flowers, long racemes, flat pods, and numerous leaflets, this plant is allied to *R. pseudo-acacia*. It is possible that Tab. 19, Abbott's Insects of Georgia, is intended to represent this species.

Robinia grandiflora sp. nov.

R. Hispida var. *rosea* Pursh, Fl. Am. Sept. (1814). Not *R. rosea* Loisel in Duham. Arb. Ed. nov. *t* 17.

A slender shrub 1-3 mm. in height or in cultivation reaching 5 m., propagating extensively by root suckers as well as by seeds. Shoots and twigs mostly soft appressed silky pubescent or also sparingly setulose with weak spreading pale colored bristles; or vigorous shoots densely hispid near the tips. Leaves 15-30 cm. long, the rachis mostly appressed pubescent, at least when young; leaflets 9-13 (to 17 in cultivation), broadly elliptic or broadly ovate 4-6 cm. long, mostly rounded at both ends and tipped with a very short mucro, bronze on

the upper surface and white satiny canescent on the lower surface as they unfold and permanently more or less appressed pubescent. Racemes 6-9 cm. long, 3-7 flowered; flowers large 20-23 mm. long, rose-purple or purple and white with a large pale spot on the vexellum; the calyx 12-15 mm. long, the lobes, gradually acuminate and much longer than the tube, purplish or whitish silky canescent, as well as the pedicels or often with short weak bristles intermixed. The fruit mostly solitary at the ends of the short pubescent and often somewhat hispid peduncles is dark brown, 4.5-6.5 cm. long, tipped by the stout slightly curved style, the slightly margined body about 1 cm., wide and rough bristly where distended by the seeds, but the intervals often much constricted and nearly free from bristles.

This plant was first collected by me on the south slopes of Grandfather Mountain in 1900 and a seed-bearing plant which attained a height of more than 4.5 m. was cultivated for many years. An infertile plant less hispid and more pubescent, the stock of which was collected by me on Grandmother Mountain, in 1915, has been in cultivation since that date and numerous plants from it distributed. This species is evidently closely related to *R. hispida* L., but is readily separated by its larger size, by its pubescence, paler flowers and the fact that it is less hispid. Type, W. W. A., Grandfather Mountain, N. C., July, 1900.

Many plants of this species, of *R. hispida* and of *R. longiloba*, although having perfect flowers do not set fruit. Meehan apparently first called attention to this in the case of *R. hispida* in cultivation. Large patches of *R. longiloba* have been examined, all evidently from the same stock by vegetative propagation without signs of fruit—and it is possible that certain patches may not fruit, just as the plant of *R. grandiflora* which I now have in cultivation has never set fruit —but this I have attributed possibly to the lack of cross fertilization. I have recently obtained fruit of what seems to be typical *hispida* and have a plant from the seed now growing.

FOREST SERVICE,
WASHINGTON, D. C.

A NEW OAK FROM THE GULF STATES

By W. D. Sterrett

There was recently brought to my attention by W. W. Ashe, of the U. S. Forest Service, material of an oak he collected in Louisiana and eastern Texas, and which he seemed to regard as possibly an undescribed species. This material he suggested might represent the same form as a tree which I found in South Carolina in March, 1921, and which I discussed with him: a tree of wet flat woods with leaves somewhat resembling post oak, but locally regarded as a timber tree much superior to the post oak. It was not possible, however, to secure at that season adequate material for study. Information regarding this tree he thought might be of service to me in connection with the preparation of a bulletin on which I worked for the United States Forest Service on the distribution and economic importance of the oaks of eastern United States and on which Mr. Ashe freely gave me assistance and suggestions. The description of this tree based on Mr. Ashe's material and notes is as follows:

Quercus ashei, sp. nov.

The lower leaves, broadly obovate in outline, are 8-12 cm. long, 5-9 cm. broad, deeply 5-lobed, the terminal lobe and upper pair of lateral lobes very broad at the obtuse or even square ends which are usually slightly 3-notched, the lower pair much shorter and more rounded; usually rounded at the very narrow base; thin but firm in texture, dark green and lucid above, and at first more or less stellate pubescent, especially on the midrib; much paler beneath, and clothed at least at first with scattered short stellate pubescence, but often glabrate with age; midrib slender with one pair of prominent lateral veins at or above the middle; petiole short, 3-6 mm. long, slender, more or less permanently stellate pubescent. The upper, sun leaves, resembling those of white oak, thicker, and with thickened margin, pinnated into 3-7 ascending entire lobes, rounded or cuneate base and much longer petiole. Buds small, obtuse, dark chestnut, at first with the outer scales stellate pubescent, at length nearly glabrous. Twigs very slender, 2-3 mm. thick, grooved and covered when young with loose brown or brownish-gray pubescence which is usually more or less persistent until autumn. The fruit often in clusters of 2 or 3 is sessile or sometimes on a stalk as long as the nut, 12-18 mm. long, in-

cluding the cup; the cup from 9-12 mm. wide and not quite as long is almost top-shaped or with slightly rounded sides, the margins thin and closely appressed against the nut, closely gray-canescent and covering about one-third of the ovate nut.

A tree 20-30 m. in height growing on better drained alluvial lands from the Sabine River in Wood County, Texas, eastward to Winn Parish in Louisiana (type, No. 1128W, from near Hinton, Winn Parish, La., in Mr. Ashe's herbarium), with a decidedly tapering usually excurrent trunk 9-12 dm. in diameter, a short bole and rather short spreading branches which form an oblong crown. Bark on trunk steel gray, broken by deep furrows into narrow, flat-topped ridges, rarely exfoliating in thin flakes; that on the angled limbs and on the branchlets gray and smoother.

Common in willow oak flats and also in association with water oak, *Quercus obtusa*, *Q. prinus*, *Q. shumardii*, and white ash. This tree has the general aspect of a post oak of large size, but the crown is prevailingly much narrower and its slender twiggage is very characteristic. From *Q. stellata* it differs in its slender twigs, smaller and thinner foliage, and small dark red-brown and not large tan buds; from *Q. margaretta* in its shorter and more rusty pubescence, which largely persists on the twigs; and from both in the far smaller nut and cup and shorter petiole of the shade leaves. It resembles in several particulars *Q. stellata paludosa* Sarg. (Bot. Gaz. May, 1918, 441) but that is described as having the fruit similar to the fruit of the post oak, whereas according to Ashe's notes, T. J. Gough, of Hinton, La., woods foreman of the Urania Lumber Company, and others, regard the smaller acorns as being one character which separates the two trees; the very slender twigs and white oak-like upper leaves being other distinctive characters. The local name in Texas is water post oak or swamp post oak; at Hinton, La., it is water oak, *Q. nigra* there being called pin oak. Louisiana State Forest Ranger C. N. Bilbray regarded the larger trees in Middle Creek swamp, Natchitoches Parish, La., as white oaks.

WASHINGTON, D. C.

A NEW GENUS OF WATER MOLD RELATED TO BLASTOCLADIA

By W. C. Coker and F. A. Grant

Plate 32

Septocladia n. genus.

Plant small, slender, the short or long stalk not conspicuously differentiated; branches usually dichotomous, often verticellate in groups of 3-5, separated from the nodes by distinct and complete septa, not constricted at intervals; in vigorous cultures repeating the branching in the same way to form a complex plant. Sporangia oval, terminal, sympodially arranged, not rarely in chains of several, often clustered by the shortening of the branches, which continue the stem by one or more lateral buds beneath. Spores biciliate at times, but the two cilia so closely approximated or fused as usually to appear as one. Resting bodies (unfertilized eggs), borne in the same way as the sporangia and of the same size and shape, at maturity enclosed in a thin, hyaline sheath out of which they finally fall through an apical slit; the wall brown and conspicuously pitted as in *Blastocladia*: the whole probably representing a thin-walled oögonium completely filled with a thick-walled parthenogenetic egg.

A saprophytic aquatic of anomalous structure and differing from all other Phycomycetes in the regular and normal septation of the plant body. To be placed in the Family *Blastocladiaceae.*

Septocladia dichotoma n. sp.

Characters of the genus. Threads extending about 3 mm. from the substratum on a termite ant, about 10-73μ thick, growing gradually more slender distally at each joint, basal joints 35-130μ long, those of central region up to about 675μ long; tips blunt, hyaline. Sporangia oval, 28-46 x 55-76μ; spores escaping singly through one or two usually apical holes or short papillae, biciliate (or uniciliate by fusion of the two cilia?) oval when swimming with the cilia apical, monoplanetic, amoeboid before encysting 10μ thick when at rest; sprouting by a slender thread. Resting bodies appearing later than the sporangia but of the same shape, 25-39.2 x 36.3-49.2μ, the conspicuous pits apparently sunken from the outside in regular fashion as in *Blastocladia Pringsheimii,* at maturity slipping from the thin, clasping sheath; their sprouting not observed.

Found only once, October 20, 1921, on a knuckle bone of beef partly covered with water, in Sparrow's pasture, Chapel Hill, N. C. (F. A. Grant col.).

There is no doubt of the close relationship of this plant to *Blastocladia* of which four species are now known, and which was made the type of a new family, *Blastocladiaceae,* by Minden (Crypt. Flora, Mark Brand. 5: 506. 1912). The four known species of *Blastocladia* are as follows:

Blastocladia Pringsheimii Reinsch (Jahrb. f. Wiss. Bot. 11:291. 1876). Sporangia much elongated, resting bodies with thick and pitted wall, not slipping from a sheath at maturity; sterile, slender filaments often present among the reproductive bodies.

Blastocladia rostrata Minden (l. c., p. 604). Much like *B. Pringsheimii,* but resting bodies slipping from sheath at maturity.

Blastocladia ramosa Thaxter (Bot. Gaz. 21:50. 1896). Sporangia shorter; resting bodies with thin and scarcely pitted wall; sterile filaments absent.

Blastocladia prolifera Minden (l. c. p. 606). Much like *B. ramosa,* but sporangia proliferating internally, as in Saprolegnia: the only species with this habit. Resting bodies slipping from a sheath at maturity.

In the form of the sporangia and resting cells and in the absence of sterile filaments among them our plant resembles most closely *B. ramosa* and *B. prolifera.* The remarkable resting bodies with their thick brown, strongly pitted walls and peculiar habit of slipping at maturity from the closely fitting sheath are so strikingly similar in structure and habit to those of *B. rostrata* and *B. prolifera* and in structure to those of *B. Pringsheimii* that one is immediately convinced of their close relationship. The diagnosis of the family will have to be extended to include septate as well as non-septate forms.

On an agar plate the plant does not do well. A few root-like threads grow out, branched and with cross-walls in the older portions, and in these older portions are found resting bodies or sporangia, sometimes fifteen or twenty of the latter may be in a row. The reproductive bodies are sometimes found in clusters or single on short lateral stalks.

On boiled corn grain the growth is good. The threads are about the same size as on an ant but average longer, as much as 5 mm. The protoplasm in threads is not as dense as when grown on ant.

Threads at substratum as large as 102μ in diameter. Sporangia are produced better than on ants, and resting bodies are so abundant that with the unaided eye they give a brick dust color to the entire

culture. The resting bodies are at first dark and have numerous large oil droplets. As they get older the walls assume a yellowish-brown color and the contents become homogeneous. They appear singly along the branches in sympodial arrangement.

In a discharging sporangium a few spores that failed to get out were observed to crawl about actively in an amoeboid fashion for a good while. After an hour they had encysted and one had sprouted.

The spores are of a peculiar internal structure, resembling closely those of *B. Pringsheimii* as shown by Thaxter (l. c. pl. 3, fig. 11). Most of the protoplasm is at the end opposite the cilia, the center is almost clear and the cilia seem to extend down through the clear tip to a protoplasmic mass below, as shown in our fig. 5.

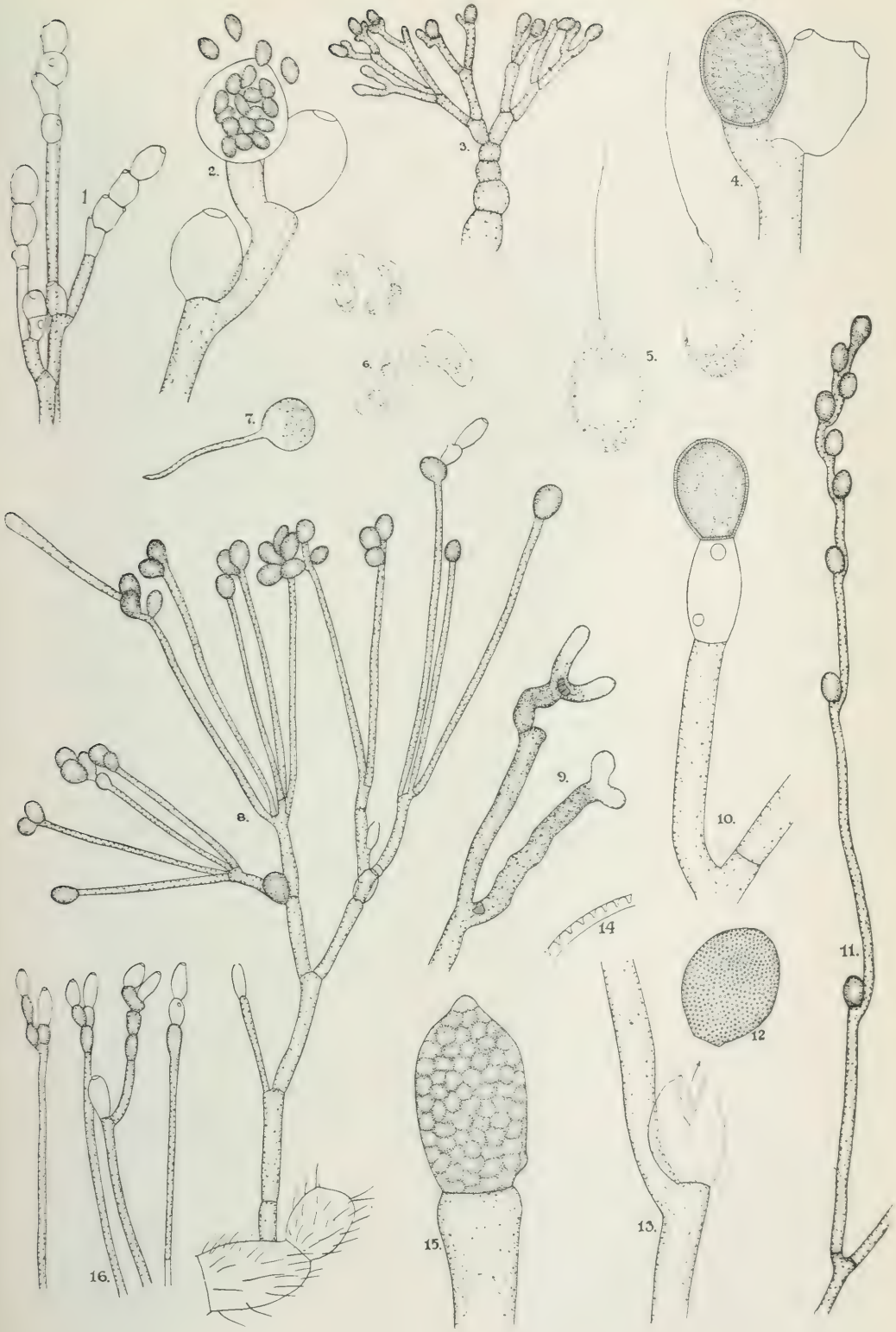
CHAPEL HILL, N. C.

EXPLANATION OF PLATE 32

Septocladia dichotoma

Fig. 1. Empty sporangia in chains. x 154.
Fig. 2. Three sporangia, one discharging spores, two empty. x 420.
Fig. 3. Vegetative branch, showing short joints and young resting bodies. x 59.
Fig. 4. Optical section of resting body and empty sporangium with two apertures. x 420.
Fig. 5. Two spores showing cilia. x 1296.
Fig. 6. Spores showing amoeboid movement before encysting. x 810.
Fig. 7. Sprouting spores. x 1008.
Fig. 8. Habit sketch, showing empty sporangia and resting bodies. x 96.
Fig. 9. Vegetative tips, showing refractive bodies and clear blunt tips. x 150.
Fig. 10. Optical section of mature resting body with empty sporangium below. x 420.
Fig. 11. Long, slender thread on corn grain, showing sympodial arrangement of resting bodies. x 96.
Fig. 12. Surface view of resting body, showing pits. x 420.
Fig. 13. Part of branch, showing thin sheath out of which the resting body (Fig. 12) has slipped. x 420.
Fig. 14. Section of thick wall of the resting body, showing the pits and the sheath outside. x 1296.
Fig. 15. Mature sporangium just before discharge of spores. x 420.
Fig. 16. Group showing some sporangia before maturity and some after emptying. x 96.

PLATE 32



FOREST TYPES OF THE APPALACHIANS AND WHITE MOUNTAINS

By W. W. Ashe

I. DEFINITIONS AND ENUMERATIONS OF TYPES*

Within the White Mountains of New England and in the Appalachians† from Pennsylvania southward more than 50 distinct forests types or tree societies occur. Of these, more than 30 are within the Alleghanian area (*Castanea* and *Betula lutea-Pinus strobus* phases) of the Transition life zone; about 10 are in the Canadian life zone, and about the same number in the Carolinian area of the upper Austral zone, which extends well up into the mountains towards their southern end (Appendix 1).

DEFINITION OF FOREST TYPE

The forest type is that arborescent species or admixture of species with the accompanying subordinate vegetation (which taken together constitute the *vert*) which nature has developed as best adapted to a given site. For this reason an understanding of the distribution of the forest types, their composition, and the determining environmental factors are a necessary basis for the best silvicultural practice. Unfortunately, site and type have been confused: The site is the sum of the ecological (*i. e.*, edaphic, topographic, and meteorological) factors; the forest type with its accompanying life is the biotic corollary as it exists.

TYPE CHANGES

The type does not necessarily, even in the absence of stress, replace itself in all its elements without change. There are (1) changes in composition due to replacement (oscillations); and (2) changes due to modification of the accompanying flora, especially the

* The detailed composition of the forest types, their relationship and local distribution, especially their altitudinal distribution will be presented in subsequent papers, as well as the grouping of the White Mountain forest types.

† There was submitted at the meeting of the Society of American Foresters held at Toronto, Canada, December 28, 1921, a paper with the title "Reserved Areas of Forest Types as a Guide in Developing an American Silviculture." That paper records the most accessible location of areas in an unmodified or little modified condition of each of the upland Appalachian types noted in the tabulation herewith presented. The suggestion was made in that paper that the Society of American Foresters consider the subject of recommending that these areas or similar areas of forst types be withdrawn from exploitation and be held primarily for demonstration purposes. That paper, however, was read by title only but will appear in the February, 1922, issue of the Journal of Forestry.

micro-organisms which promote nitrification. Type replacement may be effected

(1) By direct self-replacement under cover, as spruce beneath spruce, or hemlock beneath hemlock.

(2) By direct self-replacement without cover, as southern jack pine or mountain pine in openings caused by the death of old trees of the same species.

(3) By alternation: Yellow poplar, for example, replacing chestnut when it windfalls or dies; and chestnut establishing itself beneath the cover of the poplar; rosemary pine appearing in oak windfalls; and oak appearing beneath the cover of the pine.

(4) By succession (often following fire or resulting from windfalls, etc.), as a nurse stand (temporary type) of aspen, birch, and popple followed by a stand (permanent type) of spruce.

PERMANENCE OF TYPE

While the type is essentially permanent, oscillation in its composition from time to time or intermission in the continuity of its permanent form may occur. In addition to such oscillations within the type, the site may be subject at least to slight or temporary modification by the type (edaphic changes). For example, there is evidence for believing that the accumulation of humus beneath the oak-yellow poplar mixture on certain situations due to retarded nitrification may result in accumulation of raw humus and the development of a subpeaty site and thus favor a change to a chestnut site and chestnut type; or a chestnut type quality 1 may with increase in peaty accumulations and greater acidity become highly favorable for invasion by laurel, and the site decline to chestnut quality 2 with laurel. On swampy sites there may eventually be better drainage as a result of accumulation of humus, resulting in a drying of the site (Appendix 2). For instance, an alder and red maple site may become suitable for red maple and white oak. The type also is subject to change by natural stresses within itself (Appendix 3). The killing of chestnut by *Endothia parasitica* on large areas is resulting in profound changes in the forest types on what originally were chestnut sites; and undoubtedly this must be regarded as constituting an organic change in the forest types in the region which is affected, until or unless a resistant strain is developed from individual trees. Such resistant individuals are often noted.

SEPARATION OF TYPES

In deciding what shall be regarded as constituting a permanent forest type or tree society in such a complex as obtains at the southern end of the Appalachians, only such societies have been considered as are most sharply defined and well marked either by composition or, in the case of pure stands (at least 66% pure), by marked differences in the height of the dominant trees and in the volume of wood (quality of stand). The intergrading or transitional stages have been neglected, as well as temporary types. In such societies the quality of the stand, which is an expression of the possibility of yield of the tree society, is considered as important a concept as is varying proportion of species: for example, practically pure stands of chestnut occur and are widely distributed from Connecticut to northeastern Alabama, but the chestnut in the pure stands of this species on different sites may vary greatly in height from not to exceed 40 feet along dry and wind-swept upper slopes and crests of ridges, to exceeding 110 feet on sites most favorable for its growth. The same condition is observed in other species, and for this reason to obtain an adequate expression of the forest site the height of the trees in the mixture should be considered as a feature as well as the intermixture of species. With this variation in the height of the overwood there is a concomitant change in the character of the undershrubs and herbaceous associates.

In the division of pure stands into types, the height of the dominant trees (Appendix 4) in the mature forest has been regarded as the criterion, with an interval of 25 feet (Appendix 5) between the different types. It has been suggested (Appendix 6) that this interval be standardized on the basis of 20 feet at 100 years for Appalachian species, which for stands of old timber practically conforms to the interval of 25 feet which is being employed. This interval in height results in a difference exceeding 2,000 cubic feet of wood per acre in stands of average height (100 feet), and indicates a great difference in the average amount of available soil moisture in the root zone on soils having the same mechanical condition and depth (Appendix 7), *i. e.*, a difference in the number of critical (dryest) periods and a corresponding difference in the maximum depth of the water table; or a marked difference in transpiration and evaporation of soil moisture.

The passage from one forest type to another is seldom abrupt, but usually there is a gradual transition, as that which accompanies (1) difference in altitude; (2) variation in drainage, as when the mountain slopes are ascended; or (3) change in the physical texture of the soils, where the soils are residual and have been more or less transported and difference in available moisture results. The most abrupt transition from type to type within a short distance is usually that which is due to difference in insolation, between north and south slopes (Appendix 8), especially when the slopes are steep, or that which results from marked differences in soil composition, especially that between residual soils from the weathering *in situ* of calcareous rocks (and still containing enough lime to render them alkaline or neutral) (Appendix 9), and contiguous soils derived from a country rock deficient in lime or potash.

In the eastern prevailingly gneissic, metamorphosed and foliated division of the Appalachians, there is no definite stratification of the country rock, and the forest types occur characteristically in patches. In the Alleghanies, on the other hand, where there is not only definite stratification but great difference in the character of the country rock—soft limestone, cherty limestone, clay shale, sandy shale, sandstone and quartzite alternating and the extremes often being in juxtaposition—the types are prevailingly in horizontal zones along the slopes of the long ridges trending northeast and southwest which characterize the Alleghanian structure, the zonation of the types due to stratification of soils being interrupted by surface configuration, where minor valleys and hollows indent the slopes.

The facies of the mixed type (society) can often be separated into two groups of species: That portion of it which is formed of species each of which constitutes more than 20 per cent of the stand, *controlling species,* and the *minor species* each of which forms less than 20 per cent though more than 5 per cent of the mixture. *Locals* are species of limited distribution and while within a limited area they may be abundant in a type, they do not form a general feature in it throughout its entire distribution (*Cladrastis tinctoria, Robinia viscosa, Magnolia macrophylla, Tsuga caroliniana*). Locals may be species in the formative stage or they may be relics of species possibly once of wide distribution which have become nearly extinct. *Vagrants* are species of wide distribution entering possibly many

forest types but seldom sufficiently abundant in any locality to form a distinctive feature in a type (*Sassafras, Magnolia acuminata*). A certain species or several species within the facies of the accompanying vegetation may be so indicative of the type as to be *index species*. These may be of particular importance in the under shrubs and herbaceous concomitants and have significant value in indicating the character of the superior association after it has been destroyed (Appendix 10). A knowledge of the shrubby and herbaceous index species, especially such as are not affected by the removal of the superior stand (sun species), is economically of paramount importance as a guide in the determination of the quality site in cases where the superior stand has been cut, especially in the case of pure stands. The vert in the Appalachian forests usually may be separated into (1) the *superior stand* overwood or sun stand of designated species, a portion of the trees in which may be dominant, a portion intermediate and codominant, and a portion suppressed (Appendix 11); (2) beneath the superior stand there may be an inferior stand or underwood of trees or shrubs tolerant of shade (such as dogwood, witchhazel, sourwood, laurel, or Kalmia), and below this a ground cover or mat of small shrubs (*Vaccinium Leucothoë, Xolisma*) as well as an herbaceous flora, each a more or less distinctive and varying concomitant of the forest type.

Some of the important features of the forest associations of the Appalachians have been considered in connection with its general phytogeography. Kearney, in an excellent article, discusses some of the forest types as developed at the extreme southern end of the region. Harshberger considered the central portion of the region in two articles published in 1903 (Appendix 12), and later, 1911 (Appendix 13), covered the subject in a broader manner; while Schimper (Appendix 14) also discussed the forests of this region in their local distribution. The forest types in which chestnut occurs have been briefly considered in "Chestnut in Tennessee," and there are a number of other references in forest literature of the Appalachians to the forest types of the region.

TABULATIONS OF FOREST TYPES

In the tabulations below the following common names are employed (see Journal of Forestry 14: 233. 1916):

Mountain pine for *Pinus pungens;* Black pine for *P. rigida;* Rosemary pine for *P. echinata;* Small shagbark hickory for *Hicoria carolinae septentrionalis;* Sand hickory for *H. pallida;* Spanish oak for *Quercus coccinea;* Spotted oak for *Q. shumardii* Buck. (See Bull. Charleston Museum 14: 2, 9, 1918); Southern red oak for *Q. rubra* L. (*Q. falcata* Mx.); Mountain lin for *Tilia heterophylla* of Authors.

APPALACHIAN FOREST FORMATION

Associations	*Societies or Forest Types*
Spruce	Spruce, qualities 2, 3, 4, 5, sub 5.
	Spruce with southern balsam.
Hemlock	Hemlock and spruce.
	Hemlock—birch, qualities 1, 2, 3.
Beech—birch—sugar maple	Beech—birch—sugar maple, quality 3.
	Beech pure, qualities 4, 5.
	Yellow buckeye—sugar maple—yellow birch, qualities 2, 3.
	Mountain lin—black birch—yellow buckeye—white ash, quality 2.
	Black cherry—sugar maple—birch—mountain lin, quality 2.
Chestnut	Qualities 2, 3, 4, 5.
Yellow poplar	With red oak—chestnut—hemlock, qualities 1, 2.
	With white oak—sugar maple, quality 1.
	With white oak—black oak—white hickory, qualities 3, 4.
	With black gum—red maple—white oak, quality 3.
Red oak	Qualities 4, 5, sub 5.
Chestnut oak	Qualities 3, 4. 5.
White oak	White oak, qualities 2, 3.
	Mixed oaks (southern red oak and sand hickory).
Spanish oak	Quality 3.
Scrub oak	Scrub oak barrens, quality sub 5.
Pin oak	With red maple—black gum—alder, quality, 3.
Pine types	White pine, qualities super 1, 1, 2.
	White pine, white oak, and chestnut.
	Black pine and Spanish oak.
	Rosemary pine and black oak.
	Rosemary pine and post oak.
	Rosemary pine and blackjack oak.
	Spruce pine.
	Mountain pine.

PHYSIOGRAPHIC AREAS AND CHIEF ASSOCIATED FOREST TYPES IN APPALACHIANS

Canadian Life Zone

Highest crests (over 6,000 feet, in North Carolina and Tennessee).
- Red spruce (subalpine).
- *Alnus viridis.*
- *Rhododendron catawbiense.*

High crests and thin-soiled upper slopes (5,500 to 6,000 feet, in North Carolina and Tennessee; over 3,500 feet in northern West Virginia.
- Red spruce, qualities 4 and 5.
- Southern balsam, qualities 4 and 5.

Medium slopes.
- Red spruce, qualities 3 and 4.

Lower slopes and valleys (within the Canadian zone) (4,000 to 5,500 feet, in North Carolina and Tennessee; over 3,000 feet in northern West Virginia).
- Red spruce, quality 2.
- (Spruce and yellow birch, intergrading).
- (Spruce and hemlock, intergrading).

Swamps.
- Black spruce and southern balsam.

Alleghanian Area of Transition Life Zone

Very high crests (over 5,000 feet, in North Carolina and Tennessee; over 2,500 feet in northern West Virginia).
- Beech pure, quality 4.
- Red oak pure, quality sub 5.
- Chestnut pure, quality 5.

High crests.
- Chestnut pure, quality 5.
- Chestnut oak pure, quality 5.
- Scrub oak, quality sub 5.
- Red oak pure, qualities 4 and 5.

Lower crests.
- Spruce pine—chestnut oak, quality 4.
- Mountain pine—black oak, quality 4.
- Chestnut oak pure, qualities 4 and 5.
- Scrub oak, quality sub 5.
- Yellow poplar—black oak—white hickory, quality 4.

High slopes, north and west aspects.
- Yellow buckeye—sugar maple—yellow birch, qualities 2 and 3.
- Beech—yellow birch—sugar maple, quality 3.
- Hemlock—birch, qualities 2 and 3.

High benches.

Black cherry—sugar maple—mountain lin—black birch, quality 2.

Red oak pure, qualities 4 and 5.

Beech pure, qualities 4 and 5.

High slopes, south aspects.

Chestnut pure, qualities 4 and 5.

Slopes (middle altitudes), northern and western aspects.

Chestnut pure, qualities 3 and 4.
White oak pure, quality 3.
Hemlock—birch, qualities 1 and 2.
Black pine—chestnut oak—Spanish oak, quality 4.

Slopes (middle altitudes), southern aspects.

Chestnut pure, qualities 3 and 4.
Chestnut oak pure, qualities 3 and 4.
White oak pure, quality 3.

Slopes (lower) northern aspects.

Chestnut pure, qualities 2 and 3.
White oak pure, qualities 2 and 3.
Spanish oak pure, quality 3.
Yellow poplar—white oak—black oak—white hickory, qualities 3 and 4.

Slopes (lower) southern aspects.

Chestnut pure, qualities 2 and 3.
Chestnut oak pure, quality 3.
White oak pure, qualities 2 and 3.

Hollows, ravines, coves.

Chestnut pure, quality 2.
Mountain lin—buckeye—ash, quality 2.
Yellow poplar—chestnut—red oak—hemlock, qualities 1 and 2.
Yellow poplar—white oak—sugar maple, quality 1.

Alluvials (drained) and valleys.

Yellow poplar—white oak—black gum—red maple, quality 3.
Beech pure, quality 4.
White pine, qualities super 1, 1 and 2.
Hemlock, qualities 1 and 2.

Swamps.

Red maple—pin oak—alder—green ash—black gum.

Carolinian Area of Upper Austral Life Zone

Crests and dry flats (under 2,500 feet, in North Carolina; under 1,500 feet in Augusta County, Virginia).

Rosemary pine and post oak, quality 3.
Rosemary pine and blackjack oak, quality 4.

Slopes and flats.

Rosemary pine—black oak—white hickory, quality 2.

Black oak—southern red oak—white oak—sand hickory, quality 2.
Spotted oak—black oak—northern red oak—chinquapin oak—southern sugar maple—Biltmore ash, quality 3.
Chinquapin oak—small shagbark hickory—northern red oak—post oak—red cedar, quality 4.

Alluvials and riparian.

Sweet gum—swamp southern red oak—spotted oak—black gum—*Acer tridens*—green ash—*Celtis laevigata*, quality 2.
Sweet gum—white oak—black gum—shagbark hickory—sycamore, quality 2.
River birch—sycamore—red maple—black willow, quality 3.

MOST IMPORTANT VEGETATION TYPES (APPALACHIANS)

Mesophytic associations

Deep soils.

White oak societies.
Yellow poplar societies.
Chestnut societies.
Black oak—southern red oak society.

Medium soils.

Black cherry—birch, quality 2.
Spanish oak, quality 3.
Yellow buckeye—white ash—mountain lin societies.

Shallow soils.

Red oak societies, qualities 4, 5 and sub 5.
Beech, qualities 4 and 5.

Xerophytic associations

Mountain pine.
Spruce pine.
Black pine.
Yellow pine.
White pine.
Scrub oak, quality sub 5.

Lithophytic associations.

Chestnut oak societies.
Red spruce societies.
Hemlock—yellow birch, quality 3.

Psychrophytic associations.

Red oak, quality sub 5.
Alnus viridis.
Rhododendron catawbiense.
Hemlock—yellow birch (to southward).
Yellow buckeye—sugar maple—birch (to southward).
Beech, quality 5.

Oxylophytic associations.

Chestnut with laurel, qualities 4 and 5.
Rhododendron catawbiense.

Helophytic associations.

Red maple—black gum—green ash—alder.

For most of the forest types listed the quality sites are given, the quality of the site being indicated by the dominant trees in the superior stand having the general range of heights as follows:

Quality super 1	140 feet and over
Quality 1	125-139 feet
Quality 2	100-124 feet
Quality 3	75-99 feet (average)
Quality 4	50-74 feet
Quality 5	25-49 feet
Quality sub 5	Under 25 feet

FOREST TYPES OF CANADIAN LIFE ZONE WITHIN THE APPALACHIANS

In the Canadian Life Zone the following forest types are represented in the Appalachians:

1-5. Red spruce, qualities 2, 3, 4, 5, sub 5 (subalpine).
6. Southern balsam, quality 4
7. *Alnus viridis* (local).
8. *Rhododendron catawbiense* (local).
9. Black spruce—balsam (local).

FOREST TYPES OF ALLEGHANIAN AREA, TRANSITION ZONE

In the Alleghanian area of the Transition Zone there are two distinct forest divisions: the chestnut phase and the white pine and sugar maple—birch phases. The chestnut phase is the more southern, while the forest types of the white pine and sugar maple—birch phases are more representative of the Alleghanian area to the northward. In the following notes the paragraphs are numbered according to the numbers of the types.

1-4. Chestnut pure types, qualities 2, 3, 4 and 5. These types with their transitions to other types occupy not less than 10 million acres from Connecticut to northern Alabama. They are located especially on the acid and subacid (often semi-peaty top soil, Porter black loam of the Bureau of Soils series) soils from gneiss, metamorphosed sandstone and sandstone deficient in lime and potash (Appendix 15).

5-7. Chestnut oak pure types, qualities 3, 4 and 5. These types occupy not

less than 2 million acres from Pennsylvania southward. They are located especially on soils derived from sandstone and shale.

8-9. White oak pure types, qualities 2 and 3. These types occupy not less than one million acres. They are especially developed on the dryer soils derived from shales and located to the west of the Blue Ridge, though they likewise occur along and to the east of the Blue Ridge in northern Virginia and to the northward.

10. Spanish oak type, quality 3. This type occupies not less than 500,000 acres. It is especially developed on the dryer phases of subacid soils derived from gneiss between 2000 and 4000 feet altitude in the mountains of western North Carolina. In south central Pennsylvania, Maryland and northern Virginia it occurs at altitudes between 1,000 and 2,000 feet.

11. Scrub oak type, quality sub 5. This type occurs usually in small areas, the aggregate being not in excess of 50,000 acres, largely in Virginia, West Virginia and to the northward. In the mountains of Virginia, West Virginia and Maryland it is characteristically developed on shallow soils derived from sandstones and shale. It fringes many of the shrubby barrens along the crests of the Shenandoah Mountains.

12-13. Yellow buckeye—sugar maple—yellow birch types, qualities 2 and 3. This society extends southward from Roan Mountain (Appendix 16) to the Great Smoky Mountains, being typically developed on north slopes between altitudes of 4500 and 6000 feet. They occupy thousands of acres in the Smoky Mountains, where they are at their optimum. To the northward by dilution they merge into the beech—birch—maple society.

14. Black cherry—sugar maple—mountain lin—black birch type, quality 2. This type is probably at its optimum in West Virginia and Pennsylvania on elevated portions (3000 to 3500 feet) of the Alleghany plateau. In North Carolina it occurs only in patches usually between 4500 and 5500 feet. In West Virginia, however, the lin ceases to be a component.

15. Mountain lin—yellow buckeye—white ash type, quality 2. Most characteristically developed along the eastern Appalachians in Tennessee and North Carolina between 3000 and 5000 feet altitudes, prevailingly in coves and hollows. It does not extend north of West Virginia.

16-17. Yellow poplar—chestnut—red oak—hemlock types, qualities 1 and 2. These are characteristic cove types of the southern Appalachians and are at their optimum between southeastern Kentucky and the mountains of northern Georgia. Quality 1 produces heavier yields of hardwood lumber than any other association within the Alleghanian area. It is best developed between 2500 and 3800 feet in North Carolina and Tennessee. In middle Pennsylvania, where its identity is lost, it occurs below 2000 feet altitude.

18. Yellow poplar—white oak—black gum—red maple type, quality 3. This forest type indicates the wettest site on which yellow poplar naturally grows. It is well developed on gravelly flats on the head of Davidson River, Transylvania County, N. C., but is not uncommon on similar sites throughout the region.

19. Yellow poplar—white oak—sugar maple type, quality 1. This society is characteristically developed in middle Kentucky, middle Tennessee, and extends

southward through the Sand Mountain of northern Alabama. It occupies not less than a million acres, much of it on limestone soil, being some of the most productive land in these states.

20-21. Yellow poplar—white oak—black oak—white hickory (big leaf cucumber) types, qualities 3 and 4. These types are typically developed on sandy soils, often calcarious, on the Cumberland Mountains in Tennessee and the Sand Mountain in Alabama. Quality 4 represents the dryest site on which the yellow poplar occurs.

22-23-24. Red oak pure types, qualities 4, 5 and sub 5. These types occur in comparatively small bodies along crests of ridges and north slopes with shallow soil from Pennsylvania southward to northern Georgia. In northern Georgia and the adjacent territory they occur between 3000 and 5000 feet altitudes. They probably occupy in excess of 100,000 acres. In the White Mountains these types occupy south slope or valleys (as on Oliverian Brook, Bethlehem, Grafton County, N. H.).

25-26. Beech pure types, qualities 4 and 5. These stands occupy comparatively small areas along the crests of the ridges, mountain summits, and benches on upper slopes between (in North Carolina) 4500 and 6000 feet. It is doubtful if the aggregate area exceeds 10,000 acres. (Appendix 17.)

27. Beech—yellow birch—sugar maple type, quality 3. This forest type occupies several million acres. To the northward it is characteristically developed at medium altitudes on loamy and clay soils, often rocky. To the southward it becomes limited to north slopes and correspondingly higher altitudes, phases of it frequently occupying extensive areas of stony soil, especially on the Cumberland plateau and the north slopes of sandstone ridges.

28. Red maple—pin oak—green ash—black gum—alder type. This is characteristically a type of the wet clay flats and wetter alluvials and enters the Appalachians only in Virginia, West Virginia and Pennsylvania. It is one of the less important types occupying comparatively small areas. South of West Virginia pin oak is absent.

29-31. Hemlock—birch types, qualities 1, 2 and 3. These occasionally are almost pure hemlock. While the birch is prevailingly yellow birch, there is, especially toward the South, a considerable admixture of black birch. These types once occupied not less than 10 million acres in the Eastern States. The present area of the unlumbered types probably is less than a million acres, mostly in small bodies. Quality 3 is characteristically developed on soils which are either wet, on account of lack of drainage due to the stony substratum, as developed around Highlands, N. C., or there is better drainage and the type is located on north slopes with poor insolation, as occurs throughout the Shenandoah Mountains. (Appendix 18.)

32. Spruce pine—chestnut oak—chestnut type, quality 4. This type is most characteristically developed on the points of shale and sandstone ridges in Kentucky and Tennessee. It occurs, however, to the northward on similar sites through extreme northeastern West Virginia and northern Virginia to Maryland and is likewise well developed in places on spurs of the Blue Ridge in

western North Carolina and even occasionally as far south as Jasper County, Alabama.

33. Mountain pine—chestnut oak—black oak type, quality 4. In North Carolina, South Carolina and northern Georgia this type is developed on heavy clay soils on crests of spurs of the Blue Ridge Mountains between altitudes of 1500 and 3000 feet. This type occurs occasionally in the mountains of Tennessee and Kentucky and probably extends northward to Pennsylvania.

34-37. White pine pure, qualities super 1, 1 and 2. These types formerly occupied many million acres, especially to the northward. In the Appalachians they become localized and restricted in area, being best developed between altitudes of 500 to 2000 feet in Pennsylvania and 3000 to 4000 feet in Tennessee and North Carolina. They are the exponent of sandy or gravelly soil phases. In many places in the Appalachians they intergrade with hemlock qualities 1 and 2, as is the case in the Shady Valley, Tennessee, and other nearby valleys, or (No. 37) into chestnut—white oak as in the upper valley of the Linville River in North Carolina and Horse Creek Valley in Blount County, Tennessee, quality 1.

38. Black pine—chestnut oak—Spanish oak type, quality 4. Characteristically a type of sandy or gravelly soils; in the extreme south on northwest slopes at higher altitudes but to the northward seeking other exposures and level sites.

FOREST TYPES OF CAROLINIAN AREA WITHIN THE APPALACHIANS

In the Carolinian area of the Upper Austral Life Zone the following forest types are represented:

1. Rosemary pine—black oak—white hickory type, quality 2. A widely distributed type throughout the Piedmont, occupying not less than 5 million acres, and the source of much yellow pine timber. In the Valley of Virginia it ascends to an altitude of 1100 feet; and in the Asheville Basin to 2600 feet. Its identity is lost in western Maryland and southern Pennsylvania.

2. Rosemary pine—post oak type, quality 3. A widely distributed type in the Piedmont. In the mountains it is largely restricted to low ridges in North Carolina, Tennessee and southward and does not ascend above 2500 feet in North Carolina.

3. Rosemary pine—blackjack oak type, quality 4. Widely distributed in the Piedmont. In the Appalachians it is largely limited to low ridges, seldom ascending above 2000 feet in North Carolina, Tennessee and southward; or 1100 feet in Augusta County, Virginia.

4. Black oak—southern red oak—white oak—sand hickory type, quality 2. Best developed at the lower altitudes and on dryer sites on the Cumberland Plateau of Tennessee and to be southward in Alabama, specially on calcarious sandy soils.

5. Spotted oak—black oak—northern red oak—chinquapin oak—southern sugar maple—Biltmore ash type, quality 3. At the southern end of the Alleghany ranges this is a common society on slopes and in hollows on soil derived from limestone. It is doubtful if it extends northward beyond Kentucky.

6. Chinquapin oak—small shagbark hickory—post oak—red cedar type, quality 4. This covers a large portion of the limestone barrens of Tennessee and Alabama. It passes especially at lower altitudes and outside of the mountains into pure red cedar (cedar barren).

7. Sweet gum—swamp southern red oak (*Quercus pagoda*)—spotted oak—black gum—*Acer tridens*—green ash—*Celtis laevigata* type, quality 2. This occurs along alluvials of larger streams at the southern end of Appalachians at altitudes of 2,000 feet or less. (Appendix 18.)

8. Sweet gum—white oak—black gum—shagbark hickory—sycamore type, quality 2. This occurs on alluvials, chiefly of smaller streams at altitudes below 3000 feet in northern Georgia and below 1000 feet in the mountains of Virginia.

9. River birch—sycamore—red maple—black willow type, quality 3. This is a riparian type and occurs on alluvials of smaller streams at altitudes below 2500 feet at the southern end of Appalachians, and in Maryland below 800 feet.

APPENDIX

(1) In Augusta County, Virginia, the Carolinian zone ascends to 1,100 feet; in the French Broad basin, and southward to approximately 2,600 feet on sunny slopes. See also Kearney, Science 12:831. 1900.

(2) See also Warming, Ecology, 359.

(3) Among the most important of these natural causes may be mentioned insects. White pine and black pine have been practically exterminated over wide areas from Pennsylvania southward since 1870 by the southern pine beetle, *Dendroctonus frontalis* (see Hopkins' reports). Chestnut has ceased to exist in great portions of Alabama, Georgia and the Carolinas, largely as a result of the two-line chestnut borer and the root fungus. (See "Chestnut in Tennessee," page 11.) Within the past decade the composition of stands in which the hickories form a significant element has been seriously modified, especially in northern Illinois and the adjacent region, by an insect (*Scolytus quadrispinosus*). Two decades ago there was a similar modification in the composition of oak, hickory, and rosemary pine stands in Piedmont Carolina, through the dying out of the southern red oak and black oak, there being in many places a displacement of the natural equilibrium which cannot be restored for many years. How large a part drought, an extended period of which terminated about this time, and insects relatively contributed to this condition is a subject of conjecture.

(4) Dominant is employed in the sense of exceeding all other in height, its significance in an extensive forest literature (see Standard Dictionary). Controlling species is used to designate such as are numerically preponderant.

(5) The basis for division is approximately the same as that which has been used in the work of appraising hardwood timber lands for purchase for eastern National Forests; *i. e.*, an interval of 16 feet in the length of the merchantable stem (a standard saw-log length) or 25 feet as the difference in the height of the crown of the dominant trees, since approximately one-third of the total height of a tree with a deliquescent form is in the crown and two-thirds in the stem.

(6) Frothingham, Journal of Forestry 19:1. 1921.

(7) Mechanical condition is the basis for the classification of soil types employed by the Bureau of Soils of the Department of Agriculture; while the moisture content, and the number of times that the critical moisture period is reached (Briggs and Schantz, the wilting coefficient) are determined by (1) humus content and granulation, (2) depth of water table, (3) transpiration factors of wind and insolation, the precipitation being the same; and these are controlling factors in determining site.

(8) Kearney, Science 12:841. 1900. Noted particularly also by Shreve, Vegetation of a Desert Mountain, 97. 1915. The result of differences in insolation is noticeable to a marked degree in the southern portion of Walker County and in Jasper County, Alabama, along the southern edge of the Alabama National Forest. Here on the uplands are typical forests of longleaf pine while in the deep gorges of the streams penetrated by direct sunlight only during a few hours each day may be found fragments of hemlock—black birch type; and the yellow poplar—cucumber—beech—black birch—northern red oak mixture. To a less extent this is also noticeable in the deep hollows which indent the bluff formation along the Mississippi River in its most dissected phases.

(9) Contrary to general opinion, many of the surface soils derived from limestones, in cases where the unaltered limestone is at a great depth, are not only not neutral but even acid. This is due to the fact that the so-called limestone soils, produced from the weathering of impure limestone, are residuals, consisting of the less soluble, chiefly silicious materials. The more rapid is erosion the thinner, as a rule, is the residual blanket permitting the roots of more plants to come in contact with the calcareous elements in the unleached limestone. Many of the residual soils in the Appalachians from the Silurian and Cambrian limestones, consequently, are acid and support stands of plants associated with acid soils.

(10) North Carolina Pine, Bull. 24, N. C. Geo. Survey, p. 57. 1915.

(11) In the superior stand or sun stand certain species (like yellow poplar) may be largely intolerant of shade throughout their entire life period. Such species produce relatively few suppressed trees in the mature stands. Other species, like beech and white oak, are tolerant for a long period and consequently produce many suppressed specimens; while tolerance of some others, like balsam, progressively declines with age. The leaves of dominant and suppressed trees of the same species, or the sun and shade leaves on dominant trees may be quite different. In the southern red oak and its races the sun leaves are smaller, more divided, and more densely pubescent beneath. In *Tilia heterophylla* of Authors the shade leaves are larger, thinner, and often glabrous, having been mistaken for *T. glabra,* whereas the sun leaves are silvery-white pubescent beneath. The records of the occurrence of *T. glabra* in the eastern Appalachians are largely based on collections of such shade leaves.

(12) Botanical Gazette 34:241, 369. 1903. Unfortunately the value of these articles is marred by a number of errors in the determination of very com-

mon trees, as, for example, *Quercus phellos* is credited to the valley of the Swannanoa River, when the species should be *Q. imbricaria.*

(13) Phytogeography of North America, 1911.

(14) Plant Geography.

(15) Coville, Formation of Leaf Mould, An. Rept. Smiths. Inst., 338-340. 1913.

(16) Harshberger, Bot. Gaz. 36:375. 1903.

(17) Kearney (l. c., 831) regards beech as being characteristically a transitional or northern tree. He apparently overlooked the fact that beech reaches its best development along the bluff formation in Louisiana and Mississippi, and that there are magnificent forests which contain a large proportion of this tree throughout other portions of the Gulf States and Tennessee. It occurs to the very coast in North Carolina (var. *caroliniana*) and forms nearly pure stands on the beech flats around the southern edge of the Dismal Swamp. Stone (Plants So. N. J., p. 84, 1911) records beech as forming pure stands in New Jersey. It is probable that the New Jersey tree is the same as the North Carolina coastal form.

(18) The tendency is for southern types especially those of the low-lands to extend up the valleys of the streams beyond the general limits of the life zone of which they are representative as finger-like projections into the more northern types when deficiency in insolation is not a controlling factor. This is particularly noticeable when the soils of the lowlands are sandy and consequently "warm," while those of the surrounding uplands are clayey and "cold." Such projecting tentacles of southern types are noticeable in Tishomingo County, Mississippi, on the sandy alluvials of Bear Creek where typical lower austral societies, such as tupelo, cypress, button bush, white bay, southern red maple and alder occur contiguous to the yellow poplar, white oak, black oak, white hickory, big leaf cucumber society on the adjacent slopes of the Pearson hills which are the southwestern outlyers of the Appalachians. Similarly the intrusion of fingers of the Carolinian alluvial flora into the transitional are noticeable in eastern Tennessee and western North Carolina. On the other hand, when deficient insolation is a controlling factor tentacles of northern types penetrate areas in which southern types prevail. Such cases are the colonies of hemlock and birch which occupy the deep gorges of the Sipsey and other rivers in Jasper County, Alabama (see also Appendix No. 8), or the groups of these trees on steep north slopes along the south bank of the Potomac River below Great Falls, Virginia.

FOREST SERVICE,
WASHINGTON, D. C.

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OF THE

Elisha Mitchell Scientific Society

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ERRATA

In vol. 35, pl. 49, the words "right" and "left" should be reversed.

In vol. 38, p. 23, line 24, the word "deposition" should be "disposition."

PLATE 1

Laccaria laccata. Hartsville, S. C. (No. 72), fig. 1.
Laccaria amethystea. No. 5178, fig. 2.
Laccaria tortilis. No. 3612, fig. 3.
Clitocybe cyathiformis. No. 4934, figs. 4 and 5.
Clitocybe infundibuliformis. No. 3248, fig. 6; No. 3260, fig. 7.
Clititocybe subnigricans (young plant). No. 3357, fig. 8.

BY RESOLUTION OF

THE ELISHA MITCHELL SCIENTIFIC SOCIETY

AND

THE NORTH CAROLINA ACADEMY OF SCIENCE

THIS NUMBER IS DEDICATED

TO THE MEMORY OF

CHARLES BASKERVILLE

BORN 1870

DIED 1922

JOURNAL

OF THE

Elisha Mitchell Scientific Society

Volume XXXVIII SEPTEMBER Nos. 1 and 2

PROCEEDINGS OF THE TWENTY-FIRST ANNUAL MEETING OF THE NORTH CAROLINA ACADEMY OF SCIENCE

HELD AT CHAPEL HILL, N. C., MAY 5 AND 6, 1922

The Executive Committee met Thursday night at the Faculty Club of Trinity College with the following members present: J. L. Lake, president, Bert Cunningham, secretary, F. A. Wolf, R. N. Wilson, and H. R. Totten.

The following recommendations were adopted for presentation to the Academy:

1. That the business meeting of the Academy shall be held on Friday afternoon at 4:30.

2. That a special committee consisting of the president, the editor of the ELISHA MITCHELL JOURNAL and the secretary be appointed to revise and publish the constitution and membership list and consider the advisability of adding to this a brief history of the Academy, getting the whole out in booklet form for distribution to prospective members.

3. That the fiscal years be changed from January to January to October to October so that it may coincide with the A. A. A. S. year, and the Elisha Mitchell year.

4. That the secretary be authorized to discontinue the practice of placing papers on the program in the order of their arrival, and to arrange the program as deemed best in his judgment.

5. That a loose-leaf system of records and accounts be adopted.

6. That the old secretary's book be rebound.

7. That the secretary be authorized to have reprints of the proceedings made for distribution to interested parties.

8. That the Academy pay to the ELISHA MITCHELL JOURNAL the sum of $125.00 for the Journals to the membership rather than the $75.00 now paid. The latter price was based upon a membership of 100. There are now 163 members.

The following were then elected to membership: J. F. Dashiell, J. F. Daugherty, L. M. Dixon, J. E. Eckert, C. O. Eddy, N. B. Foster, E. H. Frothingham, F. A. Grant, F. Haasis, M. L. Hamlin, C. H. Higgins, A. L. Hook, C. F. Korstian, W. E. Jordan, E. C. Linderman, Mary Lyon, I. H. Manning, A. C. Martin, Bessie Noyes, K. B. Patterson, W. L. Porter, R. S. Pritchard, Mrs. J. C. Root, P. O. Schallert, F. W. Sherwood, H. G. Smith, S. C. Smith, J. H. Taylor, M. F. Trice, G. W. Vaughn, F. C. Vilbrandt, Ruth Walker, N. F. Wilkerson, C. F. Williams, W. T. Wright, L. E. Yocum.

The following were reported as resigning: J. S. Downing, H. Spencer, M. R. Smith, C. B. Williams. All resignations due to removal from the state.

The secretary-treasurer then made a financial report which is printed elsewhere.

The secretary reported the adoption of a policy of notifying members when their titles for papers were received.

The committee extended the time for Dr. A. Henderson's paper on Einstein to 45 minutes, and then adjourned to meet Friday at 2:30. There was no new business presented at the Friday meeting of the committee.

The Academy was called to order Friday morning by President Lake and the presentation of papers was begun. After the appointment of the following committees the Academy adjourned at 1:20 for lunch:

Nominating—C. S. Brimley, H. V. Wilson, C. W. Edwards.

Auditing—W. C. Coker, R. N. Wilson, J. P. Givler.

Resolutions—W. A. Withers, H. N. Gould, Miss Mary Seymour.

After lunch many visited the flower show at Davie Hall which served as a demonstration for Mr. Totten's paper, as shown on the program. At 3:00 o'clock the Academy re-convened and the reading of papers was continued until 5:45 when the Academy adjourned until 8:00 p. m.

The evening meeting was called to order by the secretary who introduced President Chase of the University who welcomed the Academy and spoke a few well-chosen words as to the relation of science to daily life. President Lake of the Academy responded and then delivered the Presidential Address on "The Search for the Ultimate Atom." This was a timely review of the various discoveries which have led to our modern ideas of matter. The Academy then called for the paper by Mr. C. S. Brimley—"Twenty Years of the North Carolina Academy of Science." This paper was highly appreciated as it was given by one who has been with the organization since its birth. An informal "get-to-gether" was enjoyed after adjournment.

At nine o'clock Saturday morning the Academy opened with a business meeting. Reports of Committees were first called for.

The Committee on Natural Resource Conservation reported, and the Committee was continued.

The Representative of the Academy on the Council of the American Association made a report.

The Auditing Committee reported the books of the Treasurer as satisfactory.

The Publicity Committee reported some progress, but was somewhat uncertain as to what was expected of it. After further instruction the committee was continued.

The Committee on High School Science reported, and the committee on the order of the Academy was reorganized as follows: Chairman—Bert Cunningham; J. N. Couch, R. N. Wilson, and A. F. Roller.

The Legislative Finance reported no progress.

The Executive Committee reported and all the recommendations shown above were adopted.

The Treasurer gave a summarized report as follows:

RECEIPTS

Saving Account former Treasurer	$196.98
Dues	438.79
	$635.77

EXPENDITURES

Current Expenses	$141.85
A. A. A. of S.	158.00
	$299.85
Balance Saving Account	200.00
Balance Check Account	135.92
	$635.77

The Academy ordered the Secretary to send the following telegram to Dr. E. W. Gudger—"N. C. A. S. in session at the University sends you hearty greetings and is glad to report that the treasurer's balance is now $370.00."

The Resolutions Committee reported as follows:

The Committee on Resolutions very respectfully recommends the adoption of the following:

1. That the Academy place upon record its appreciation of the services of its officers who have arranged such an attractive program and secured such a large attendance.

2. That the thanks of the Academy are due to our gracious hosts who have so charmingly entertained its members during the present meeting.

3. That the Academy dedicate the volume of the Journal of the Elisha Mitchell Society containing the report of the Proceedings of this meeting to the memory of the late Dr. Charles Baskerville, one of its earlier members, one of its very active workers, and at one time its President.

W. A. WITHERS,
MARY SEYMOUR,
H. N. GOULD.

The Nominating Committee presented the following for office and they were elected by the Academy:

President—Dr. A. Henderson, University of North Carolina.

Vice-President—Dr. H. B. Arbuckle, Davidson College.

Secretary-Treasurer—Dr. Bert Cunningham, Trinity College.

Executive Committee—Dr. H. N. Gould, Wake Forest, Professor J. P. Givler, N. C. College for Women, Dr. B. W. Wells, State College.

The time for the Annual Meeting was discussed, and was finally left in the hands of the Executive Committee as in the past.

The invitation to hold the next meeting in Greensboro at the N. C. College for Women was announced and accepted.

At 11:00 papers were presented to the joint meeting, and at 11:30 the Chemists and Physicists adjourned to other quarters to hold their separate meetings. Their papers are shown on the following programs. The last paper was read just before lunch time and the Academy adjourned.

Following is the present membership of the Academy. Those marked with an asterisk were present at the meeting.

Andrews, W. J., Civil Engineer.....Raleigh
*Arbuckle, H. B., Professor of Chemistry, Davidson College.....Davidson
Babb, J. S., University of North Carolina.....Chapel Hill
Bahnson, F. F., 28 Salisbury Road.....Winston-Salem
*Baker, Miss Lucretia, Meredith College.....Raleigh
Balderston, Mark, Guilford College.....Guilford College
Barnes, J. T.....Roanoke Rapids
Barret, H. P., 211 Vail Ave.....Charlotte
Barrow, Miss Elva E., Chemistry Dept., N. C. College for Women....Greensboro
*Bell, J. M., Dept. of Chemistry, University of North Carolina.....Chapel Hill
Binford, Raymond, President Guilford College.....Guilford College
Bonney, Miss E. C., 1421 Fourteenth Ave.....Hickory
Bottum, Miss F. R., St. Mary's School.....Raleigh
*Blomquist, H. L., Dept. of Biology, Trinity College.....Durham
*Brimley, C. S., Division of Entomology, N. C. Dept. of Agriculture.....Raleigh
Brimley, H. H., Curator State Museum.....Raleigh
Browne, Wm. Hande, Dept. of Electrical Engineering, State College.....Raleigh
Bruner, S. C., Estacion Agronomica.....Santiago de las Vegas, Cuba
*Bullitt, J. B., Professor of Pathology, Univ. of North Carolina.....Chapel Hill
Burch, Wayne, Trinity College.....Durham
Cain, William, Kenan Prof. Emeritus of Math., Univ. of N. C.....Chapel Hill
Campbell, Miss Eva G., Dept. Biology, N. C. College for Women.....Greensboro
Clapp, S. C., Superintendent State Test Farm.....Swannanoa
*Cobb, Collier, Professor of Geology, Univ. of N. C.....Chapel Hill
Cobb, William B., Louisiana State University.....Baton Rouge, La.
*Coker, W. C., Kenan Professor of Botany, Univ. of N. C.....Chapel Hill
Collett, R. W.....White Hall, S. C.
*Couch, J. N., Dept. of Botany, University of North Carolina.....Chapel Hill
*Cunningham, Bert, Professor of Biology, Trinity College.....Durham
Dashiell, J. F., Prof. of Psychology, Univ. of North Carolina.....Chapel Hill
Daugherty, J. F., Dept. Physics, Univ. of North Carolina.....Chapel Hill
Davis, Harry T., Assistant Curator State Museum.....Raleigh
Denson, Lee A., U. S. Weather Bureau.....Raleigh
*Derieux, J. B., State College.....Raleigh
Dixon, A. A., State College.....Raleigh

*Eckert, J. E., Dept. Zoology, State College.....Raleigh
*Eddy, C. O., Dept. Zoology, State College.....Raleigh
*Edwards, C. W., Professor of Physics, Trinity College.....Durham
Farmer, C. M., 115 Orange Street.....Troy, Ala.
*Farrington, R. K., Med. Student, Univ. of North Carolina.....Chapel Hill
*Foster, N. B., Dept. of Physics, State College.....Raleigh
*Frothingham, E. H., U. S. Silviculturist.....Asheville
*George, W. C., Asso. Prof. Histology and Embryology, Univ. N. C...Chapel Hill
*Givler, J. P., Professor of Biology, N. C. College for Women.....Greensboro
*Gould, H. N., Dept. of Biology, Wake Forest College.....Wake Forest
*Grant, F. A., Asst. in Botany, University of North Carolina.....Chapel Hill
*Gross, P. M., Dept. of Chemistry, Trinity College.....Durham
Groves Miss Pattie J., 802 Watts Street.....Durham
Gudger, E. W., American Museum of Natural History.....New York City
*Halverson, J. O., Dept. of Agriculture.....Raleigh
Haber, V. R., Division of Entomology, N. C. Dept. of Agriculture.....Raleigh
Hatley, C. C., Columbia University.....New York City
*Heck, C. M., Dept. of Physics, State College.....Raleigh
*Henderson, Archibald, Prof. of Mathematics, Univ. of N. C.....Chapel Hill
*Hickerson, T. F., Prof. Civil Engineering, Univ. of N. C.....Chapel Hill
Hobbs, A. W., Asso. Prof. Mathematics, Univ. of N. C.....Chapel Hill
Hoffman, S. W.,.....Statesville
*Holland, Miss Alma, Dept. of Botany, Univ. of N. C.....Chapel Hill
*Holmes, J. S., State Forester.....Chapel Hill
Haasis, F., Forest Examiner.....Asheville
*Hamlin, M. L., Indust. Chemist, Trinity College.....Durham
*Higgins, C. H., Dept. of Science, Salem College.....Winston-Salem
Hook, A. L., Dept. of Physics, Elon College.....Elon College
Ives, J. D., Stetson University.....Deland, Fla.
Ivey, J. E., State College.....Raleigh
*Jordan, W. E., State College.....Raleigh
*Jones. E. P., Indust. Chemist, Trinity College.....Durham
Kilgore, B. W., Director of Experiment Station.....Raleigh
Korstian, C. F., Forest Examiner.....Asheville
Krausz, H. B.....Raleigh
*Lake, J. L., Professor of Physics, Wake Forest College.....Wake Forest
*Lasley, J. W., Jr., Asso. Prof. Math., Univ. of N. C.....Chapel Hill
Lehman, S. G., State College.....Raleigh
Leiby, R. W., Division of Entomology, N. C. Dept. of Agriculture.....Raleigh
Lewis, R. W., Citizens Bank Building.....Raleigh
Lugn, A. L., Dept. of Chemistry and Physics, Lenoir College.....Hickory
Linderman, E. C., Dept. of Sociology, Greensboro College.....Greensboro
Lyon, Mary, Dept. of Biology, Greensboro College.....Greensboro
*Mabee, W. Bruce, Division of Entomology, N. C. Dept. Agriculture.....Raleigh
*MacNider, W. DeB., Kenan Prof. of Pharmacology, Univ. of N. C....Chapel Hill
Marion, S. J., Dept. of Chemistry, State College.....Raleigh
Markham, Blackwell.....Durham

Mendenhall, Miss Gertrude, 1023 Spring Garden Street.....Greensboro
*Metcalf, Z. P., Prof. of Zoology and Entomology, State College.....Raleigh
*Mitchell, T. B., Division of Entomology, N. C. Dept. Agriculture.....Raleigh
*Manning, I. H., Dean Med. School, Univ. of N. C.....Chapel Hill
*Martin, A. C., Dept. of Botany, State College.....Raleigh
*Nixon, L. M., Chemist, Dept. of Agriculture.....Raleigh
Nowell, J. W., Wake Forest College.....Wake Forest
*Noyes, Bessie, Dept. H. Biology, N. C. College for Women.....Greensboro
*Patterson, A. H., Prof. of Physics, Univ. of North Carolina.....Chapel Hill
*Paull, N. M., Assistant Prof. of Drawing, Univ. of N. C.....Chapel Hill
Pegram, W. H., Dept. of Chemistry, Trinity College.....Durham
Petty, Miss Mary, N. C. College for Women.....Greensboro
*Phillips, Charles, Dept. of Pathology, Wake Forest College.....Wake Forest
Pillsbury, J. P., State College Station.....Raleigh
Plummer, J. K., 499 Courtland Street.....Atlanta, Ga.
Poteat, W. L., President Wake Forest College.....Wake Forest
*Powell, T. E., Jr., Professor of Biology, Elon College.....Elon College
Pratt, J. H., State Geologist, Univ. of North Carolina.....Chapel Hill
*Prouty, W. F., Prof. of Stratigraphic Geology, Univ. of N. C.....Chapel Hill
*Patterson, K. B., Assistant Prof. of Math., Trinity College.....Durham
*Porter, W. L., Prof. of Biology, Davidson College.....Davidson
*Pritchard, R. S., Chemistry Dept., Wake Forest College.....Wake Forest
*Randolph, E. E., Chemistry Dept., State College.....Raleigh
Randolph, E. O.....College Station, Texas
Randolph, Mrs. E. O.....College Station, Texas
Rankin, W. S., State Board of Health.....Raleigh
*Rhodes, L. B., Division of Chemistry, N. C. Dept. Agriculture.....Raleigh
Robinson, Miss Mary.....Wadesboro
*Roller, A. F., High School.....Raleigh
Ruffner, R. H., State College.....Raleigh
Root, J. C., Mrs., High School.....Raleigh
*Satterfield, G. H., Trinity College.....Durham
*Saville, Thorndike, Asso. Prof. Engineering, Univ. N. C.....Chapel Hill
*Seymour, Miss Mary F., N. C. College for Women.....Greensboro
Shaffer, Miss Blanche E., N. C. College for Women.....Greensboro
Sherrill, Miss Mary L., Mt. Holyoke College.....S. Hadley, Mass.
Sherrill, Miss Mildred, High School.....Henderson
Sherwin, M. E., State College.....Raleigh
Sherman, Franklin, Entomologist, N. C. Dept. Agriculture.....Raleigh
Shore, C. A., State Laboratory of Hygiene.....Raleigh
*Shunk, I. V., 222 West Morgan Street.....Raleigh
Smith, J. E., Iowa State College.....Ames, Iowa
*Smith, S. C., Dept. of Chemistry, Univ. of N. C.....Chapel Hill
*Speas, William E., Dept. of Physics, Wake Forest College.....Wake Forest
Stiles, C. W., Hygienic Laboratory.....Washington, D. C.
*Stuhlman, Otto, Jr., Dept. Physics, Univ. of N. C.....Chapel Hill
*Sullivan, R. W., Chemical Dept., Wake Forest College.....Wake Forest

*Schallert, P. O. ..... Winston-Salem
*Sherwood, F. W., Chemist, Dept. of Agriculture ..... Raleigh
*Smith, H. G., State College ..... Raleigh
*Taylor, J. H., Grad. Student, Trinity College ..... Durham
Taylor, C. C., State College ..... Raleigh
*Taylor, Haywood, M., Dept. of Chemistry, Univ. of N. C. ..... Chapel Hill
*Taylor, W. F., Wake Forest College ..... Wake Forest
Thies, O. J., Jr., Dept. of Chemistry, Davidson College ..... Davidson
*Totten, H. R., Dept. of Botany, Univ. of N. C. ..... Chapel Hill
*Trice, M. F., State College ..... Raleigh
*Vann, H. M., Dept. of Anatomy, Wake Forest College ..... Wake Forest
*Venable, F. P., Kenan Prof. Chemistry, Univ. of N. C. ..... Chapel Hill
*Wells, B. W., Dept of Botany, State College ..... Raleigh
*Wells, Mrs. B. W., State College Station ..... Raleigh
*Vaughn, G. W., Asst. Prof. Engineering, Trinity College ..... Durham
*Vilbrandt, F. C., Prof. Indust. Chemistry, Univ. of N. C. ..... Chapel Hill
*Walker, Ruth, Dept. Biology, N. C. College for Women ..... Greensboro
*Wheeler, A. S., Dept. of Chemistry, Univ. of N. C. ..... Chapel Hill
Wilkerson, N. F., Grad. Asst. Biology, Trinity College ..... Durham
*Williams, C. F., Dept Horticulture, State College ..... Raleigh
*Wright, W. T., Dept. Physics, N. C. College for Women ..... Greensboro
Williams, C. B., State College Station ..... Raleigh
Williams, J. H., High School ..... Raleigh
*Williams, L. F., State College ..... Raleigh
Wilson, Donald B., State College ..... Raleigh
*Wilson, Henry V., Dept. of Zoology, Univ. of N. C. ..... Chapel Hill
*Wilson, R. B., Dept. of Biology, Wake Forest College ..... Wake Forest
*Wilson, R. N., Dept. of Chemistry, Trinity College ..... Durham
*Winston, Lula G., Meredith College ..... Raleigh
Winters, R. Y., State College ..... Raleigh
*Withers, W. A., Dept. of Chemistry, State College ..... Raleigh
*Wolf, F. A., Plant Pathology, State College ..... Raleigh
Wright, Miss Eva K., Dept. of Chemistry, N. C. College for Women .. Greensboro
*Yocum, L. E., Dept. of Biology, N. C. College for Women ..... Greensboro

The following papers were presented:

The Search for the Ultimate Atom. J. L. Lake. (Presidential Address.) Historical review of the discoveries leading up to the modern ideas of matter. Appears in full in this issue.

Twenty Years of the North Carolina Academy of Science. C. S. Brimley. Appears in full in this issue.

Coördinate Systems in Mathematics. J. W. LASLEY, JR.

Descartes in the seventeenth century furnished mathematicians

with the means of attacking geometric situations by means of analysis. It is now one of the problems of the mathematician to adapt to a problem that particular system of coördinates best suited to it. In trying to do this many kinds of coördinate systems have arisen. One of these, namely homogeneous coördinates, besides possessing marked power in itself, includes many of the more frequently used systems as particular cases. A detailed and connected account of this system is a need keenly felt by students of mathematics. This paper points out this need, and suggests lines along which this account may be developed.

A Note on the Pulmonary Circulation in Vertebrates. W. C. GEORGE.

Some anomalies in the pulmonary veins of man were described. Attention was called to the correspondence between the atypical condition in these anomalies and the typical relations of the vascular drainage of the air-bladders of some fishes.

Notes on Protozoa. BERT CUNNINGHAM.

The report consisted of two parts. The first was a systematic study of the forms occurring near Durham. The following classes and orders were observed:

Class Rhizopoda		29
Order Gymnamoebida	5	
Testacea	24	
Class Actinopoda		2
Order Aphrothoracida	2	
Class Zoomasiigophora		18
Order Monadida	1	
Phytomastigida	2	
Euglenida	11	
Diniferida	4	
Class Ciliata		44
Order Holotricha	19	
Heterotricha	12	
Hypotricha	8	
Periotricha	5	
Class Phytomastigophora		3
Order Chrysoflagellata	1	
Chloroflagellida	2	
	96	96

No attempt was made to study the Sporozoa.

The second part was the presentation of a number of rare forms which had not yet been identified by the writer. Among these rare forms was a species of *Tintinnus* observed in the Plankton Collections* of Chesapeake Bay (fig. 1). It bears the characters of the genus, with the following specific characters:

Length 0.275 mm. Diameter 0.05 mm.

Cylindrical with corrugated constriction near the interior end; nucleus single.

It was observed but once in some four hundred collections averaging about 2,000 individuals per collection. Found in a bottom collection (23.79 meters) taken just off Cape Henry, July 9, 1920.

FIG. I

New Dyes Derived from 5-Chloro-2-amino-p-cymene. A. S. WHEELER and I. V. GILES.

A new series of dyes was obtained by coupling the diazo salt of 5-chloro-2-amino-p-cymene with the following compounds: 1, Beta-naphthol (dyes wool scarlet); 2, Alpha-naphthol- (dyes wool claret brown); 3, Phenol (dyes wool capucine yellow); 4, Salicylic acid (dyes wool Mars orange); 5, Resorcinol (dyes wool Brazil red); 6, Alpha-naphthol-2-sulfonic acid (dyes wool burnt Sienna); 7, Beta-naphthol-7-sulfonic acid (dyes wool scarlet); 8, Alpha-naphthol-4-sulfonic acid (dyes wool scarlet). Silk dyeings show different shades from those indicated for wool.

A "Nature-Experiment" on the Development of Frogs and One on the Physiology of Sponges. H. V. WILSON.

In an artificially inseminated batch of eggs of *Hyla pickeringii,* a large number exhibited an abnormality which may with justice be reasoned from as if it were the result of a planned experiment. In these embryos the tail begins to grow out as a pair of buds at a time when the exposed yolk area is so large that in side view it forms one-third to one-fourth the total circumference. Except in the mid-dorsal region where the archenteron has an actual aperture there is

* Collections taken by the U. S. Fisheries for a Biological and Hydrographical Survey which is as yet incomplete.

only a virtual blastopore lip, that is, laterally and ventrally the ectoderm and yolk cells are not set off from one another by a groove. This virtual blastopore lip which on the concrescence hypothesis contains the material destined to form the axial organs of the embryo, *gradually closes along the ventral surface of the tail and at the posterior end of the body.* This fact forms additional evidence for the view that concrescence, although it may occur in teratological embryos, is not a constant or basic process in the embryogeny of a vertebrate body.

The recorded observations on the Phloeodictyine sponges leave in doubt the question whether the tubes (fistulae) which project from the body carry the currents of water outwards, inwards, or perhaps in both directions. A specimen of *Phloeodictyon putridosum* taken by U. S. Bureau of Fisheries Steamer Albatross, in the Philippines, seems to answer this question, which no one has yet had the opportunity of studying on the living sponge. The specimen referred to is spheroidal, 115 mm. in diameter, and bears about forty fistulae on its upper and lateral surfaces. Just beneath the natural surface of the body a calcareous alga, one of the *Corallinaceae*, of branching, filamentous habit, has formed a practically solid calcareous layer 5 mm. thick. This layer, interrupted only by the fistulae, extends all over the sponge body. The interior of the sponge is thus left in connection with the surrounding water only through the fistulae, which, it is therefore obvious, must conduct currents both inwards and outwards.

The Stems of Grape Hybrids. C. F. WILLIAMS.

A study of transverse and longitudinal sections of mature one-year wood of *Vitis vinifera*, *V. rotundifolia* and their F_1 hybrids shows the pattern of the phloem tissue and the character of the cork cambium to be specific. In *V. vinifera* the pattern is square in outline with alternate tangential layers of hard and soft bast, prominent cork cambium and a large sclerenchyma bundle externally. The rays extend intervascularly without expansion, the open ends acting as lenticels. In *V. rotundifolia* the pattern is triangular, the hard bast outlining the soft radially, with a small sclerenchyma bundle inside the cork cambium. The rays expand in the vascular region by tangential division. Typical lenticels are present and the cork cambium inconspicuous. The F_1 hybrids of this cross show inter-

mediate characters of great variation, especially in regard to cork cambium, demonstrating that anatomical characters are inherited as well as the ones of color, size, weight, etc., usually studied.

Wild Ferns and Flowers of Chapel Hill. H. R. TOTTEN.

The Department of Botany, with the assistance of the classes in Botany 1 and 2, brought in wild plants found in flower during the first week in May. These were put on display for two days, so that the botany students and others interested in our native plants could familiarize themselves with them. One hundred and seventy-one plants were displayed in flower. This number includes thirty-four naturalized weeds and fourteen escapes. The Virginia Spiderwort *(Tradescantia virginiana)* and the White Bladder Campion *(Silene alba)* have not been previously reported from Chapel Hill. Not included in the number given above were several plants not in complete flower, also twelve ferns and one of the fern allies.

The Calcium Content of Mixed Feeds in Relation to the Feeding Requirement of Animals. J. O. HALVERSON and L. M. NIXON.

Dr. Forbes and associates of the Ohio Agricultural Experiment Station showed that in heavy milking cows there is an actual shortage or loss of calcium from the body. Perhaps a higher calcium content of mixed feeds for animals under domestication is necessary. Concentrated dairy feeds require a somewhat higher, more carefully regulated calcium content. The addition to mixed feeds relatively low in calcium of such high calcium-containing substances as alfalfa leaf meal, meat, and ground bone to poultry and hog feeds, and beet pulp, alfalfa meal, or calcium carbonate to dairy feeds, is a commendable and beneficial practice. Actual intensive feeding practice strengthens this belief. Recent work on the importance of the mineral elements in nutrition has shown that they are fundamentally necessary in the growth of farm animals as well as in the animals of the laboratory; that they are as necessary in the ration as is a protein of both adequate quality and quantity.

Studies on Fermentation of Rare Sugars by Plant Pathogenic Bacteria. F. A. WOLF.

Organisms from the same host may be indistinguishable on the basis of their ability to ferment the carbohydrates of the Descriptive Chart. The fermentation of rare sugars has, therefore, been used as

a means of identification of these closely related organisms. In the case of two leafspot diseases of tobacco commonly designated as wildfire and angular leafspot caused by *Bacterium tabaccum* and *B. angulatum* respectively, both are able to form acid from dextrose and saccharose but not from glycerine and lactose, but the farmer attacks in addition mannitol and galactose whereas the latter is without action on them. A similar specialization obtains in the case of two leafspot organisms, *Bacterium glycineum* and *B. sojae* from soybean. This study emphasizes the necessity of employing in phytopathological studies the rare sugars for diagnostic purposes.

Pod and Stem Blight of the Soybean. S. G. LEHMAN. (Read by F. A. WOLF).

This disease is capable of causing serious damage to the soybean, particularly in wet seasons. It attacks pods, stems, and less frequently, leaves, but greatest apparent loss results from attacks on pods. Very young pods drop off when attacked, but older ones remain firmly attached. The causal fungus penetrates the pod wall and invades the developing seed. The ovule may abort at an early stage, or, if attacked later in its development, the seed becomes shriveled to various degrees depending on the time and severity of infection. Seeds in diseased pods are often completely invested with a conspicuous white fungus covering. Diseased areas on stems, pods, and leaves become specked with minute black fruiting bodies, pycnidia, which begin exuding small, hyaline, single celled spores within a few days after their appearance.

The causal fungus is placed in the form genus *Phomopsis,* and in reference to its host, it is assigned the binomial "*Phomopsis sojae.*" It has been isolated from stems, pods, and seed, and has been observed to cause the death of seedling soybean plants by growing from the seed coat onto the hypocotyl and causing its decay. It overwinters in diseased stems and seed. The practice of such sanitary measures as plowing under diseased plants after harvest, use of disease-free seed, and crop rotation are recommended as control measures.

Variation of Protein Content of Corn. H. B. ARBUCKLE and O. J. THIES.

Appears in full in this issue.

Some Phases of Structure and Development of Garden Pea and White Sweet Clover Seeds as Related to Hardness. L. E. YOCUM.

Appears in full in this issue.

Notes on the Reproduction of Hydra in the Chapel Hill Region. H. S. EVERETT.

Appears in full in this issue.

Dormancy in Seeds of Persimmon (Diospyros virginiana). H. L. BLOMQUIST.

A preliminary report on an investigation in germinating seeds of persimmon, showing that there is a marked period of dormancy under both natural and artificial germinating conditions. The length of this period has not been definitely determined but seems to extend over two to several years, depending upon the physical, chemical, and biological conditions of the soil and upon the location of the seed and the variation in its structure. The main cause of the delay in germination has been found to be due to a layer of the seed covering which caps the radicle and exerts a certain amount of resistance to the expansion of the embryo and a decrease in water absorption. By removing this cap one hundred per cent germination was secured with seeds collected in the autumn from mature fruit.

Some Investigations into the Bacteriology of Common Colds and an Autogenous Vaccine Therapy for Six Months at Wake Forest College. W. L. TAYLOR and CHARLES PHILLIPS.

In the fall of 1921 bacteriological cultures were made from the noses or throats of 25 persons having fresh colds. Growth was made in dextrose blood broth and on dextrose blood agar plates, reaction Ph 7.2, the broth tubes incubated anaerobically and the plate aerobically. Incidental saprophytic bacteria were largely ruled out by this method. The organisms identified and obtained in pure culture were: *Staphylococcus albus* and *aureus*, *B. Mucosus capsulatus* (Friedlander), *Streptococcus hemolyticus* and *viridans* type, *Micrococcus tetragenus* and *catarrhalis*, *Pneumococcus* types 2 and 4, *B influenza*, and two strains of *Diphtheroids*. Several strains of most of these were obtained. A polyvalent vaccine of these was made and standardized to contain 1000 million per cc. This was given by the usual technique hypodermically every 4-5 days in these doses, .25cc,

.50cc, .75cc, 1cc repeated twice, six doses for the whole treatment. Of 35 people reporting for doses, only 20 reported with regularity allowing tabulation, which was carefully done in detail to check claims against actual results. A column of figures in percentages shows actual findings. The summary gives several interesting points of discussion. Here is a group of common colds, 25 in number, occurring in an average college community, and from which were isolated 10 different organisms of varying pathogenicity. A polyvalent autogenous vaccine made up from these was found to be relatively nontoxic in the dosage used in spite of the nature of some of them. In treating these cases there was found to be no constant relationship between the number of doses taken and freedom from colds during the trial period of October to April, 2% getting absolute protection, while 70% had one or more colds after the last dose, all living under comparable conditions. This is true also for those cultured or not cultured, suggesting little if any specificity for the vaccine. Over half of those treated claim some benefit from its use, in reduced severity of colds contracted and number expected, judging from previous experience during these months. Not enough people took the full six doses, making this group too small to draw conclusions from. The attitude of the members of this group towards this vaccine trial is partially shown by 65% of them stating their probable willingness to try something similar next winter.

Some Intestinal Cestode and Nematode Parasites of Cats of Wake Forest, N. C. R. B. WILSON. (Body of the paper accepted as a thesis for the M. A. degree, 1922.)

The writer made at Wake Forest College an examination of the intestines of 25 cats for Cestode and Nematode parasites. The report gives an account of the material used and the method of study followed. The result of the study can best be given in the form of a table showing the relative number of each kind of parasite, as follows:

Number of Cats	Taenia crassicollis	Dipylidium caninum	Ascaris mystax	Anchylostomum trigonocephalum	Unidentified Nematode of Large Int.
25	60	150	106	13	Many

The unidentified nematode of the large intestine was very small, measuring 320 to 432 microns in length by 10 to 19 microns in thickness. These worms had the general appearance of larvae, but

no intermediate developmental stages were found, and no adult worm was found in the alimentary canal from which it could come. The investigation of this organism is continuing.

The Age of the Ocoee and Associated Rocks of Clay County, Alabama. W. F. PROUTY.

The geological age of many of the rocks occurring in the semi-crystalline area in the southern Appalachians has long been in doubt. Dr. Safford of Tennessee, in 1856, assigned the Ocoee to the Potsdam Group (Cambrian). Arthur Keith of the U. S. Geological Survey, working in portions of Tennessee and North Carolina in more recent times, demonstrated the conformity of the Ocoee with the fossiliferous Cambrian. In 1903 Dr. Eugene A. Smith of the Alabama Geological Survey discovered Carboniferous fossils in a small area of the Talladega Phyllites (the unquestioned equivalent of at least a part of the Ocoee of Tennessee).

It fell to the lot of the author to work out the relationship of this small fossiliferous area to the associated rocks. This work was carried on in the geological mapping of Clay County, Alabama.

The area in which the Carboniferous fossils occur is considerably faulted, but the fault block in which these fossils occur is connected with and proves to be conformable to a series of dark slates and conglomerates underlying it with a thickness of several thousand feet. From a careful study of the sequence of sediments in this area with those in the Coosa and Cahaba Coal Fields, a little to the west, one is brought inevitably to the conclusion that the conglomerate of Talladega Mountain just to the west of and geologically older than the fossil beds is the Millstone Grit of the Pennsylvanian, and that the underlying formations for some distance to the west, in the area of the Ocoee (Talladega), are of Mississippian age.

The Hillabee Schist, a metamorphic basic igneous rock, both cuts across the strike of the Carboniferous Ocoee and intrudes it, thus demonstrating its Post Carboniferous age. A little farther to the east in Clay County areas of altered Talladega (Ocoee) of probable Carboniferous age are intruded by the Pinkneyville granite, thus suggesting if not proving their Post Carboniferous age.

It is thus evident that the Ocoee is a group and that it includes rocks varying in age from Cambrian to Pennsylvanian. It is also evident that some of the larger areas of green schist in contact with

these Ocoee slates are Post Carboniferous, and that some of the larger granitic masses to the east of the Ocoee proper are probably also of Post Carboniferous age.

The Variation of the Photoelectric Current With Thickness of Metal. OTTO STUHLMAN, JR.

Silver and platinum deposited in the form of transparent and semi-transparent wedges were examined for variation of the photoelectric current as thickness of the metal was increased. The metal was deposited on quartz by the evaporation method and examined when monochromatic light fell on the metal side of the plate.

The results are found to be consistent with the view that the probability of an electron going a given distance without losing its ability to escape falls off exponentially with the distance, when this distance is less than about 40 mm. Up to this thickness there is a parallelism between optical absorption and photoelectric emission. For large wave-lengths this parallelism is more pronounced than for short wave-lengths. For greater wave-lengths optical absorption may increase but photoelectric emission decreases terminating at the threshold value of photoelectric sensitivity.

The results seem to support the view that photoelectric emission is probably not caused by the absorption of energy out of the incident light beam, the light only acting as the agent which sets the electron free from its parent atom.

Geology of the Muscle Shoals Area, Alabama. W. F. PROUTY.

Appears in full in this issue.

Chemistry in Its Relation to the State Water Supplies. G. F. CATLETT.

Appears in full in this issue.

The following papers were presented but no abstracts have been received:

The Dipterous Galls of the Hickories. B. W. WELLS. (Lantern).

Instincts in Social Life. (By title). C. C. TAYLOR.

The Effect on Tops of the Wilting of Succulent Vegetables. L. B. RHODES.

The Polymorphic Genus Clavaria. W. C. COKER.

A Review of the Fulgoridae of Eastern North America. Z. P. METCALF.

Striations in Inorganic Solutions. C. M. HECK.

A Parasite of the Mediterranean Flour Moth. J. E. ECKERT. (Lantern).

Spore Discharge in Some Genera of Water Molds. J. N. COUCH.

To appear in full in an early issue of this Journal.

Laboratory Work in Elementary Genetics. C. O. EDDY.

The Echigo Oil Fields, Japan. COLLIER COBB.

Acoustics of Auditoriums. A. H. PATTERSON.

A Review of High School Science Teaching. J. N. COUCH. (Lantern).

Sand Dunes of Niigata. COLLIER COBB.

A New Species of Isoachlya. F. A. GRANT.

To appear in *The Saprolegniaceae*, a volume by W. C. Coker, to be published soon by The University of North Carolina Press.

DEMONSTRATIONS

Wild Flower Show. H. R. TOTTEN and the class in Botany 2.

Abnormal Frog Embryo *(Hyla pickeringii)* with Developed Tail and Exposed Yolk. H. V. WILSON.

A Sponge *(Phloeodictyon putridosum)* with a Shell made up of a Parasitic Calcareous Alga. H. V. WILSON.

Striations in Inorganic Solutions. C. M. HECK.

Laboratory Work in Elementary Genetics. C. O. EDDY.

The following papers were presented to the Physics Section:

How Einstein's Theory of Relativity Was Verified. ARCHIBALD HENDERSON.

In this paper, for which forty-five minutes were allowed, the attempt was made to put into simple terms a *précis* of the general ideas

underlying Einstein's theory of universal gravitation. It was indicated that the differences in results given by the theories of Newton and Einstein are surprisingly small, despite the fact that the theories have few points of resemblance, and proceed from totally different assumptions. The difficulties of finding natural phenomena which will verify Einstein's theory are very great, but finally three were arrived at. These are: the deviation of a ray of light from a rectilinear path, or deflected for example by the attraction of the sun; the advance in the perihelion of Mercury over a period of a century; and the shift of solar light lines to the red end of the spectrum.

Dr. Henderson sketched in outline the fundamental principles of Generalized Relativity, and derived the equation of the curve taken by a ray of light. A figure which was exhibited, as well as the calculations, showed that the deviation according to Einstein's theory, amounted to 1.74″. This figure, which was exactly twice the amount given by the Newtonian theory, was verified (within thirteen per cent) by two astronomical expeditions sent out by Great Britain during the World War, one to Principe, the other to Sobral. Since the time of Leverrier, it has been known that there was a discrepancy of approximately 43″ in a century between the actual advance of the perihelion of Mercury and the computed value according to the Newtonian theory, even allowing for all the known influences. From the equation of the orbit, as computed by the Einstein theory, and the known values of the constants, it was shown that the advance for the perihelion of Mercury came out to be about 43″—a most remarkably accurate determination. Last of all, it was shown by a simple computation that a ray of light from the sun, being of greater wave-length and higher frequency (i. e., redder) than a ray from a terrestrial source, would cause a shift of the spectral lines an appreciable amount toward the red end of the spectrum. Only quite recently, by isolating the solar ray in a vacuum, the French physicist Pérot has shown that the actual shift, for cyanogen, affords entirely satisfactory agreement with the value in Angström units computed according to the Einstein theory.

Effect of an Electric Field Upon Colloids in Non-conducting Liquids. N. B. FOSTER.

X-Ray Spectra from Crystals. J. B. DERIEUX.

Analysis of Crystal Structure from X-Ray Spectra. A. A. DIXON.

The Color of Metals by Transmission. OTTO STUHLMAN, JR. (Lantern).

Use of an Audion Tube as Negative Resistance. D. A. WELLS.

Problems of Research in North Carolina. (By title.) C. W. EDWARDS.

Some Suggestions for the Teaching of Physics. A. H. PATTERSON.

The following papers were presented to the Chemists:

Zirconium Ferrocyanide. F. P. VENABLE and R. A. LINEBERRY.

Zirconium Citrate. F. P. VENABLE and E. C. MOEHLMANN.

Modification of the Official Sodium Method. J. O. HALVERSON, L. E. MORGAN and J. H. SCHULTZ.

The Determination of Potassium in the Official Sodium Method. J. O. HALVERSON and J. A. SCHULTZ.

A Modified Thermoregulator. M. L. HAMLIN.

A Convenient Form of Condenser. M. L. HAMLIN.

Phenolsulphonphthalein and Some of its Derivatives. W. N. ORNDORFF and F. W. SHERWOOD.

Binary Systems of Metanitrotoluene and Another Mononitrotoluene. J. M. BELL and J. L. MCEWEN.

The Nitration of Certain Nitrotoluenes. J. M. BELL and W. B. SMOOT.

The Nitration of Orthonitrotoluene. J. M. BELL and H. G. PICKETT.

The Chlorination of 2-Amino-p-cymene. A. S. WHEELER and I. V. GILES.

New Derivatives of 2-Bromo-5-hydroxy-1,4-Naphthoquinone. A. S. WHEELER and B. NAIMAN.

BERT CUNNINGHAM, *Secretary.*

PROCEEDINGS OF THE ELISHA MITCHELL SCIENTIFIC SOCIETY, OCTOBER 11, 1921, TO JUNE 2, 1922

250th Meeting—October 11, 1921

Collier Cobb—*Physiographic Processes in Relation to Harbor Development and Harbor Maintenance.*

The observations on which these studies are based have been extended over practically the entire northern hemisphere, and the processes considered are here presented merely in outline. The object of these studies has been to examine into the physical conditions and the physiographic processes that have to do with the formation, preservation, and destruction of harbors. The pursuit of this object is facilitated by a tentative classification of these sheltered waters, based upon the circumstances of their origin; and this leads to an attempted grouping of those various forms of energy, operating upon and within the earth, which tend to improve or to destroy harbors; and, lastly, it is purposed to consider to what extent these natural processes may be affected by the coöperation of man, or by the hindrance that he may offer to Nature's operations.

The forces at work upon our shorelines include all of those agencies for the application of solar energy which are generally described as *gradational,* resulting in the disintegration of rock-masses, and the transportation and deposition of detritus. These atmospheric and aqueous agents effecting gradation may be considered in the following groups: 1. The work of the atmosphere; 2. Rain and rivers; 3. Snow and ice; 4. Wind and waves; 5. Tides and currents; 6. Plants and animals. A comparison of harbors of sub-arctic regions with those of sub-tropical and tropical regions, in essentially similar rocks and rock-structures, will at once reveal the interesting fact that harbors owe their chief characteristics to the processes by which they have been formed, rather than to the geological formations out of which they have been carved.

Besides the forces of gradation just enumerated, which have to do with the application of solar energy, there is another group of agents deriving its energy from the earth itself. This comes from the slow cooling of the earth's mass, its warping, and the creeping

of its crust, producing the movements of subsidence, elevation, and sudden jarring, which take place along the border-line between land and sea. Indeed, there is an everlasting see-saw between the land and sea taking place along the shoreline, and this profoundly affects all harbors. This is especially noticeable on both sides of the North-Pacific, and the changes on our Pacific coast—especially in Alaska—and in Japan, in a single generation, have been so marked as to force us to believe that the uniformitarians have overaccentuated the slow movement, through all time, of the forces now in operation. The modern geologist is forced to recognize that there have been changes—sometimes gradual and sometimes sudden—in the intensity and mode of action of existing forces. And these changes seem more and more marked as wider areas of the earth's crust have come under the scrutiny of the geologist, during the century that has not yet elapsed since Sir Charles Lyell made his epoch-marking generalization; but that does not mean that the geologist of today is in any sense swinging to the conclusions of the catastrophist. These forces bringing about elevation and subsidence are covered by the term *diastrophism.*

Vulcanism is another of the igneous agencies for the application of terrestrial energy, whose work as a harbor-maker, of little importance in the past, is destined to play an important part in the immediate future. Since our own nation has learned that the way to national power is over the waves, and our hope is that the conquests of the future will be of a commercial sort, harbors of refuge and naval harbors are now seen in a new light, as aids to commerce without which the commercial harbor can never grow into a great port. Harborage of such a sort is afforded in numerous instances where the rim of a volcanic crater has broken down in one or more places, and the whole submerged to such an extent that the central cavity forms excellent harborage, often of great strategic importance. Harbors of this kind are known in nearly all seas; but they have hitherto been dismissed with the statement that they have no other than a scientific interest, if indeed they are mentioned at all in any discussion of the subject. Fortunately, our own country owns several such harbors in different parts of the Pacific. These and coral-reef harbors, which are to be considered in some detail, afford excellent naval harbors and coaling stations, not only in the Pacific and

the Caribbean, but in other parts of the world as well, and the ownership of such harbors is a matter of immediate and strategic importance.

The classification adopted, tentatively, gives us:

I. Estuarine harbors, lagoon harbors, delta harbors, formed in the main by gradational processes, but in most cases profoundly influenced by diastrophic action.

II. Fjord harbors, moraine-enclosed harbors, indented kame-plains, all the product of glacier action.

III. Crater harbors, coral-reef harbors, and a combination of these two, in which the reef, fringing close upon the volcanic rock, has profoundly influenced the form and the commercial or strategic value of the harbor.

While the effect of organic life on harbors is generally very great, the influence of animal life is not always beneficial; and the influence of plants is almost wholly detrimental, leading to the accumulation of sediment and the consequent shoaling of water.

In determining the value of each harbor considered, the geological and other physical features of the shore; the strength, direction, range, and scour of the tides; the depth of water in the protected area; the influence of prevailing and seasonal winds; the angle at which the heaviest waves impinge on the coastline and their pounding on the headlands; the slope of the foreshore; the transportation of detritus to the basin and its deposition by the currents; and the width and shape of the entrance, have all been taken into account. Lastly, the industrial and commercial possibilities of the hinterland have often been examined into in an effort to determine whether a promising harbor might some day be developed into an important port.

Election of Members:

The following members of the faculty were elected to Active Membership in the Society: Dr. H. B. Anderson, Dr. H. W. Crane, Dr. F. C. Vilbrandt, Prof. G. M. Braune, Prof. H. F. Janda, Prof. E. L. Mackie, Mr. C. D. Beers, Mr. J. H. Bradley, Mr. J. F. Daugherty, Mr. M. A. Hill, Mr. H. F. Latshaw, Mr. G. W. Smith.

The following students were elected to Associate Membership: From the Department of *Botany*—J. N. Couch, F. A. Grant, Mrs.

W. J. Matherly; *Chemistry*—J. A. Bender, C. K. Brooks, F. C. Cochran, E. W. Constable, H. D. Crockford, E. D. Jennings, J. L. McEwen, E. O. Moehlmann, J. L. Mourane, L. V. Phillips, H. G. Pickett, W. B. Smoot; *Civil Engineering*—J. P. Clawson, L. W. Fischel, N. P. Hayes, E. M. Knox, O. E. Martin, L. J. Phipps, J. W. Taylor, J. S. Wearn; *Electrical Engineering*—G. T. Finger, J. L. Pressley, R. A. Tillmann, R. M. Wearn, D. A. Wells; *Geology*—E. J. Alexander, H. H. Bullock, R. E. L. Carson, C. W. Fowler, H. C. Harris, T. G. Murdock; *Mathematics*—J. N. Brand, W. V. Parker; *Medicine*—Howard A. Patterson; *Pharmacy*—E. B. Bristow, J. E. Campbell, W. A. Prout; *Physics*—Wade Gardner, C. G. Mauney; *Psychology*—W. D. Glenn, John H. McFadden; *Zoology*—W. L. Smith.

251st MEETING—NOVEMBER 8, 1921

F. P. VENABLE—*Isotopes.*

The growth of the idea that the atoms of the elements might be dissimilar as to their relative weight was traced through the work of Crookes and others and the revelations of radio-activity; the necessity for assigning a number of elements to the same position in the Periodic Table was pointed—hence the need of a new designation, namely, isotopes. The physical demonstration of the existence of isotopes, the determination of their atomic weight and the relative proportions in which they occurred were described, and the close agreement with accepted atomic weights noted. The paper appeared in full in this Journal, Vol. 37, p. 115.

W. C. COKER—*A Visit to Lapland and to Some Old Herbaria.*

The past summer was spent in Europe in the study of fungi in several of the most important herbaria. About a month was spent (two weeks at first and two weeks later) at Kew Gardens, England, in the use of the fine library, and in looking over plants sent by our Dr. M. A. Curtis to Rev. M. J. Berkeley. Another month, with the exception of a short trip to Lapland, was spent in Stockholm, Sweden, with daily trips by tram to the massive new Riks Museum, where are to be found several fine collections of fungi, notable among them being those of the Sydows and that of Bresadola, the latter recently bought by the well-known mycologist Lars Romell, a patent lawyer by profession and a devoted scientist by instinct, who has deposited

it at the museum and made it available for study. The Lapland trip was to Abisco, arriving on July 18, about a week too late to see the full midnight sun, but there was no darkness and the sun was visible for twenty-three hours of the day. The Laps were all living in the same primitive fashion, but some of them were well-to-do from the profits of their reindeer herds. After a few days in Copenhagen and Berlin about a week was spent at the Riks Herbarium at Leiden, Holland, where may be found the herbarium of Persoon, one of the greatest pioneers in the study of fungi. After several days study at the Herbarium of the University of Paris, at the Jardin des Plantes, where one is constantly reminded of the great Lamarck, Kew was again visited for two weeks, and the trip ended.

252nd MEETING—DECEMBER 13, 1921

A. S. WHEELER—*Research in Progress in Organic Chemistry at the University of North Carolina.*

A study is being made with Mr. I. V. Giles of the action of chlorine upon 2-amino-p-cymene. The constitution of the monochloro-derivative has been determined and a series of new dyes has been prepared by coupling it up with hydroxy compounds in the benzene and naphthalene groups. These dyes are browns and yellows, especially adapted to wool. The problem given to Mr. S. C. Smith is the constitution of the N,N′, β, β. β-Dichloro-hydroxyethylidene-bis-nitranilines, discovered some years ago by Dr. Wheeler. Mr. H. M. Taylor is engaged in determining the constitution of bromo-2-amino-p-cymene and will seek to prepare new dyes with it. Mr. F. P. Brooks is studying the complex reaction between phenylsemicarbazine and acetonylacetone, a diketone. The solution of the constitution of Oxyjuglone is in the care of Mr. A. P. Sledd. This substance was discovered 35 years ago. Mr. B. Naiman is studying the behavior of monobromo-5-hydroxy-1,4-naphthoquinone. Mr. T. P. Dawson's work concerned the addition and condensation products of chloral with 3-nitro-4-toluidine. To Mr. C. K. Brooks was given the problem of the constitution of monobromoamino-p-xylene. Dr. Wheeler is working in his own laboratory upon the reaction between phenylsemicarbazine and acetylacetone, having a grant from the Graduate School to pay the cost of the raw materials.

A. H. PATTERSON—*The Ether vs. What?*

The older theories of the ether were given, and the various theories of light described, with the reasons for and against each. The difficulties attendant upon the results of experiments of Airy, Lodge, Michelson and Morley, etc., were described, and the newer attempts to frame theories to account for all observed facts were presented: the wave theory, the ether-storing theory, the Cone-Ray theory and the Quantum theory.

Each of these was examined as to its ability or inability to explain Ionization and Photo-electric effects, Interference effects and Quantum relations. In the course of the discussion of the paper Einstein's latest views on the subject were brought out.

253rd MEETING—JANUARY 10, 1922

G. M. BRAUNE—*Experimental Determination of Lateral Earth Pressures.*

The question of finding the correct or approximately correct lateral pressures existing in masses of granular material such as earth pressures against retaining walls or grain in elevators has been studied by physicists and engineers for a great many years.

The problem as occurring most often in engineering structures is the active pressure against retaining walls. The correct determination of this force affects the design of construction work, involving the expenditure of millions of dollars yearly, and therefore a proper knowledge as to its correct magnitude is of great economic value.

C. A. Coulomb, the French physicist and engineer, was probably the first one to present a working theory for the determination of earth pressures. Rankin, the great English engineer, developed the theory on the assumption that the filling material behind the wall consisted of an incompressible homogenous granular mass of unlimited extent, without cohesion, the particles being held together by friction on each other. These assumptions lead to the ellipse of stress and make the resultant earth pressure on a vertical surface parallel to the top surface. The German engineers have also given much study to this problem and some valuable experiments have been made by Mueller-Breslau at the Charlottenberg Laboratories. In America Major William Cain has contributed more than anyone else in this country, and is considered an authority on the subject.

When the writer became connected with the University of Cincinnati some nine years ago, he decided to construct an earth pressure machine of such a size that it would reduce the effect of cohesive stresses to a minimum.

The method adopted of obtaining the magnitude of the earth pressure was to measure the horizontal and vertical components of the action of the filling material upon a "free body." In order to carry out this method a wooden wall or gate five feet wide and six feet high was constructed which fitted into the open front of a concrete bin five feet wide and nine feet long, six feet high at the front, and twelve feet high at the rear. The wall is supported by two vertical rods or contact points which rest directly upon Fairbanks' platform scales of two thousand pound capacity. Thus, any vertical force acting on the wall is directly transmitted to the scales and is registered. The horizontal thrust of the earth against the wall is measured by three horizontal struts, one at the top in the center of the width and one at each of the lower corners. These struts by rocker-arm arrangements transmit the pressure directly to platform scales of one thousand pound capacity. From the individual scale readings, the amount, direction and point of application of the resultant pressure can be computed.

Method of Operation. Before any filling material is placed in the bin the riders are run out on the scale beams so that the beams will always be down. The reading on the scales will at all times be in excess of the contemplated active earth pressures; the gate is prevented from moving into the bin by bearing angles. Then after the filling material has been placed in the bin, by moving the riders and by allowing the beam to float, we will get active and not passive pressures.

Description of Experiments. The results of the experiments made on this machine and tabulated below were made, under the direction and supervision of the writer, by Mr. Jacob Feld, a fellow in the Civil Engineering Department of the University of Cincinnati. The filling material consisted of sand weighing one hundred pounds per cubic foot. The angle of natural repose was found to be forty degrees and the angle of internal friction thirty-four degrees. The angle of friction between the sand and the dry wood of the wall was twenty-six degrees. When the wood was wet this angle increased to thirty-

one degrees. Readings were taken for every three inches of fill, the material being shovelled in horizontal layers.

The tabulated quantities of these experiments are defined as follows:

h = height of fill, feet;
P' = $\sqrt{H^2 + V^2}$, total pressure per foot width;
H = horizontal component per foot width, pounds;
V = vertical component per foot width, pounds;
Φ^1 = angle of inclination of the resultant from the normal to the back of wall; $\tan \Phi^1 = V/H$;
x = height of point of application above the base of the wall $= \frac{\text{H top x 6 ft.}}{\text{H total}}$
x/h = ratio of height of the point of application of the resultant to total height of fill;
H^1 = theoretical horizontal component from formula $H = \frac{1}{2} wh^2 \tan^2 (45° - \frac{1}{2} \Phi)$;
w = weight per cu. ft. of filling material;
Φ_1 = angle of natural slope (40 deg., as determined for this material);
H_2 = same as H_1 where
Φ_2 = angle of internal friction (34 deg., as determined for this material).

h	P'	H	V	Φ^1	$\frac{x}{h}$	H_1	H_2
2 ft.	62 lbs.	54 lbs.	32 lbs.	30° 50′	.425	44 lbs.	56 lbs.
4	242	205	131	32° 50′	.358	174	226
6	545	464	285	31° 30′	.365	393	507

Conclusions—For this case, horizontal fill and vertical wall, the formula $H = \frac{1}{2} wh^2 \tan^2 (45 - \frac{1}{2} \Phi)$ may safely be used, if Φ is taken as the angle of internal friction. For this special case, Coulomb's and Rankin's theories give the same formula.

OTTO STUHLMAN, JR.—*Theory of the Audion and its Application to the Wireless Telephone.*

Through the courtesy of the American Telegraph and Telephone Company three reels of moving pictures were shown, the first two of which illustrated the theory of the audion and the third its application to the wireless telephone.

Preliminary experiments were shown to illustrate a stream of electrons and how this same stream of electrons functioned in the case of the audion. The subsequent discussion went into details of the origin of the discovery and development of the thermionic effect and the contributions made by Richardson, his students, and the results of recent experiments on the audion as developed by the research laboratories of the great electrical manufactories of the country.

254th MEETING—FEBRUARY 14, 1922

T. F. HICKERSON—*Transition Spirals for Roads: A New Method.*

No abstract furnished.

FRANK C. VILBRANDT—*The Manufacture of Beet Sugar.*

Beet sugar, indistinguishable from cane sugar, is obtained from a variety of white beet containing from 12-19% sugar. At best, however, beet sugar factories obtain but 240 pounds of refined sugar per ton of beets sliced.

Preparations are begun nine months previous to the sugar campaign to make the ten weeks campaign successful and efficient. The agricultural staff oversee the best cultivation to insure good beets and eliminate mongrel stock. The engineering staff overhaul the entire plant and make the proper repairs and changes.

In fall the topped, matured beets are transported to the nearby factories and stored in bins or sheds in the yards. Each bin is provided with a flume which transports the dirty beets through stone, sand and trash catchers to the beet-washer. The washed beets, after elevation to a picking table to remove decayed beets, are weighed and sliced. The v-shaped slices provide for minimum settling of the cossettes, minimum rupture of the cells and maximum exposure of cell walls through which the diffusion takes place.

The cossettes are extracted in three and one-half ton batches in fourteen diffusion battery cells, three of which at any time are being filled, the others in operation. The fresh water meets the most exhausted cossettes, leaving the battery as concentrated juice in the part holding fresh cossettes. Calorizors between each battery maintain the optimum temperature for extraction.

The exhausted pulp is dumped and pumped to the pulp house where a reduction of 12% moisture is effected by means of a wet drag, pulp presses, and a furnace.

The raw juice is limed, carbonated and filtered at least two times to reduce the pulp and non-sugars by precipitation, coagulation and filtration. The juice also receives a sulfur dioxide treatment to reduce the lime content and color. Calorizors between each set of equipment maintain the optimum temperature.

This treated and purified juice is evaporated down in quintuple effect evaporators from 10% to 60% solids, treated with sulfur dioxide,

filtered and evaporated under vacuum down to grain in the "A" or "White" pan. The "strike" is then made and the mix centrifuged. The resulting "first swing" sugars are washed with steam, dried and granulated, the product being the refined white granulated beet sugar.

The first swing of molasses is evaporated to grain in the "B" or "Brown" pan and dropped into crystallizers, where for 60 to 80 hours crystal growth is permitted with agitation and slow cooling. These crystals are centrifuged from the waste molasses, redissolved and introduced into the system of refining to be evaporated down with the raw juice and recovered as white sugar.

Coöperation among the various stations is eminently important to reduce loss of sugar in wash and waste water, extraction of undesirable non-sugars and reduction of coal consumption. A loss of each 0.03% sugar in any operation in a 100,000 ton beet campaign registers a loss of 600 bags of sugar and each 3% additional quantity of water to be evaporated increases the daily consumption of coal 10 tons.

The hope is expressed that sugar beet culture and beet sugar plants may become more extensive to increase our home supply of this staple.

255th MEETING—FEBRUARY 25, 1922

DR. J. E. MILLS, Director of Chemical Research at Edgewood Arsenal.—*Chemical Warfare—Methods of Attack and Defense.* (By invitation).

A review of the development of chemical warfare was given and special mention made of the following methods:

Cylinders are used for cloud gas attacks, the cylinders being filled principally with chlorine or with mixtures of chlorine and phosgene. They are generally installed in the front line and released under suitable wind conditions. 20 tons of gas or even more will be used per 1000 yards of front for such an attack. The advantages and disadvantages of this form of attack were discussed.

Livens projectors are used and installed in special trenches, later carefully camouflaged, generally somewhat back of the front line. They fire a drum containing 30 pounds of gas and have a range of nearly a mile. Thus exceedingly high concentrations of gas can be

placed directly upon the target. It is probably the most deadly form of gas attack known. The principal gases used in Livens drums are phosgene and chlorpicrin.

The 4″ Stokes mortar is used for gas, each shell carrying about 7 pounds. The rate of fire is very high, 10 rounds per minute being maintained even at night. The range is approximately 1000 yards.

All of the above weapons are used by gas troops and have the advantage over the Artillery of being able to place very high concentrations of gas upon the objective. As compared with the Artillery they have a disadvantage as regards the range of the weapon and also as to the accuracy of the weapon.

The number of gas shell used towards the end of the War was very large, amounting in some cases to 50% and even more of the total shell used. If the entire War is considered probably not much more than 5% of the total shell used were gas shell. Altogether the French filled about seventeen million gas shell. Mustard gas was by far the most effective gas used by the Artillery.

Methods of gas defense deal with personal protection, such as that afforded by the mask or by protective clothing, and with group protection, such as that afforded by gas alarms and protective dugouts. Gas protection is also sought by keeping troops fairly well apart or by abandoning gassed areas.

It is probable that the use of gas combined with aviation will greatly change methods of coast defense and naval offense.

256th MEETING—MARCH 14, 1922

H. B. ANDERSON—*Spirocheticidal Action of Arsphenamin (Salvarsan, "606").*

Spirochetes are a class of microscopical organisms which are, although placed with the Bacteria, very closely related to the Protozoa. After the discovery of *Spirocheta pallida* by Schaudinn, who at first classed it with the Protozoa, there were many experiments made to determine the spirocheticidal action of various arsenical compounds such as had been efficient in the treatment of protozoan diseases. Ehrlich discovered a synthetic organic arsenical compound which had very pronounced spirocheticidal action. This he called salvarsan. Soon after this discovery he placed neo-salvarsan on the market too. When the war broke out the allied nations took up the manu-

facture of salvarsan and in the United States is was called arsphenamin and neo-arsphenamin.

The author reports a dark field study of six cases with primary lesions and one case with secondary lesions after the administration of arsphenamin and neo-arsphenamin. Six of these cases showed an absence of live spirochetes in the lesions 48 hours after the administration of the drug. One seemed more refractory to arsphenamin and did not show complete sterility of the lesion for 8 days after the administration of the drug.

J. F. DASHIELL—*Measurement of Intelligence in Different Social Classes.*

After preliminary discussion of intelligence and its measurement, and of the correlation of economic class differences with certain physical and mental traits, a brief experimental study was reported. In continuation of a study made four years earlier by Chase and Carpenter, Dashiell and Glenn made Binet intelligence examinations of Chapel Hill children belonging to different social-economic groups. The same results were found: a correlation between economic class and intelligence level; the country, town, and faculty children showing respectively low, medium, and high levels. To make sure that previous conditions of literacy in the children's life played no part, a series of motor performance tests was given the same subjects. Results for the faculty group were still distinctly high, but the country children now excelled the town children slightly. Thus, the Chapel Hill school population appears divisible into two groups on the basis of hereditary family stock, with a subdivision of one of these on the basis of environmental opportunity.

257th MEETING—APRIL 11, 1922

ARCHIBALD HENDERSON—*Generalized Relativity and the Three Tests.*

The Newton and Einstein cosmologies were compared in detail, using the device of parallel columns. The author then outlined the trend of Einstein's thought in reaching his epochal generalization, and showed how the transition was made from the Restricted to the Generalized Relativity. In especial, he described the practical mode by which Einstein's theory was tested, and indicated the procedure employed in making these tests. In particular he announced that news he had just received from Paris that the third test,—the shift

toward the red end of the spectrum of rays of light emanating from the sun,—had been conclusively established to a very close degree of approximation by the eminent French physicist Pérot.

W. F. PROUTY—*The Rejuvenated Ocoee.*

J. M. Safford of Tennessee, described the Ocoee in 1856. He then classed it as "Metamorphic" and considered it of Pre-Cambrian age, but in his report of 1869 he placed this group in the Potsdam (Cambrian). Arthur Keith after careful study of the western portion of the Ocoee of Tennessee and North Carolina, confirmed Safford's correlation for the western portion and, like Safford, placed the entire group in the Cambrian.

In 1903 Dr. E. A. Smith of Alabama discovered fossils in the eastern portion of the Ocoee of that State. These were determined by David White to be of Carboniferous age. The working out of the relationship of this fossiliferous area to the rest of the Ocoee recently fell to the author in the study of Clay County, Alabama. A careful study of the structure of the area brings out the fact that a considerable portion at least of the Ocoee is of Carboniferous age, both Mississippian and Pennsylvanian being represented.

At the present time therefore it is known that the Ocoee Group consists of at least three systems of rocks.

258th MEETING—MAY 9, 1922

WM. DEB. MACNIDER—*The Changes Induced in the Kidney by the Continued Use of Alcohol.*

Dogs were employed in the experiments. The animals were given 10cc. of 20 per cent alcohol once a day to the point of establishing a moderate grade of intoxication. Such a state was shown by muscular incoördination and drowsiness.

Following such a usage of alcohol the animals develop in from seven to eighteen days a well-marked albuminuria. The number of tube casts in the urine are few as compared with the quantitative output of albumin. There is but a slight reduction in the elimination of phenolsulphonephthalein. Kidneys from such animals show but slight injury to the tubular epithelium. The glomerular capillaries show an early and very marked accumulation of stainable lipoid in the endothelium.

H. V. WILSON—*Metschnikoff, Zoologist and Pathologist.*

Elie Metschnikoff (1845-1916) is doubly distinguished in that he brought to light a great idea in abstract science and himself carried it over and further developed it in a field that is directly concerned with the physical welfare of mankind. In the course of Metschnikoff's many, varied, and eminently original studies on the comparative embryology of invertebrates, ending with his "Embryologische Studien an Medusen" (Wien, 1886), his attention was focussed again and again on the wandering, amoeboid cells, which play so important a part in the development and physiology of sponges, coelenterates, echinoderms and other invertebrates. Correlating the wandering, digestive, and protective (Messina, 1882) functions of such cells, he asked himself if the leucocytes of vertebrates were not essentially similar elements. With this began his famous discoveries in Pathology concerning the direct and indirect action of leucocytes against invading bacteria.

ELECTION OF OFFICERS:

President—W. F. Prouty.
Vice-President—Otto Stuhlman.
Permanent Secretary—J. M. Bell.
Recording Secretary and Treasurer—H. R. Totten.
Editorial Committee—W. C. Coker, chairman; J. M. Bell, Collier Cobb.

CALLED MEETING—JUNE 2, 1922

A meeting was called to consider some appropriate action in recognition of the late Charles Baskerville. A motion was passed that the next number of the JOURNAL of the Elisha Mitchell Scientific Society (Vol. 38, Nos. 1 & 2) be dedicated to his memory.

THE SEARCH FOR THE ULTIMATE ATOM*

By J. L. Lake

Just when the belief in a primordial atom originated in the mind of man seems difficult to determine. Sometimes it seems like a primal notion. The Encyclopedia Britannica tells us, "The concept of an element as a substance from which all bodies are made or derived was held at the very beginning of occidental philosophy." We are also told that Thales of Miletus, who immortalized himself by recording the fact that rubbed amber would attract light bodies, regarded water as the element of all things, and that his followers accepted his ideas of a primordial substance as the basis of all bodies but that they endeavored to determine some other general elements.

Democritus is regarded as the founder of the atomic theory though we are told that traces of the conception of the grained structure of matter are to be found in Indian philosophy perhaps twelve centuries before the Christian era. As Millikan says of the principles of Democritus as given by Tyndall, with a few modifications and omissions they might almost pass muster today. Yet though his theory was advocated by Epicurus and the Latin poet, Lucretius, the Platonic school prevailed, and, as we know, the Aristotelian philosophy dominated the world of science as well as philosophy till the seventeenth century.

In the time of Boyle and Newton, however, an atomic theory reappeared. We know how forcefully Newton maintained the corpuscular theory of light. He also regarded gases as consisting of small separate particles which repelled one another, and attributed to this supposed repulsion between the particles the tendency of gases to expand. It was Dalton, however, who resurrected the atomic theory and made it a scientific hypothesis to explain experimentally determined facts instead of mere speculation. This was about 1803. Soon after this Prout published his hypothesis—that hydrogen is the primordial atom, that the atoms of all heavier chemical elements are built up from it. Von Meyer in his History of Chemistry (1891) speaks of the baneful effects of Prout's hypothesis. He states the

* Presidential address before the N. C. Academy of Science, May 5, 1922.

hypothesis as follows: "Hydrogen may be regarded as a primary matter from which all other elements are formed by various condensations." Were he stating the present day belief it is doubtful if he could improve on the statement.

Prout's hypothesis, however, was based upon inexact determinations and was unable to stand against the more exact work of Berzelius, Stas, and others. But despite the downfall of this hypothesis the germ idea, the belief in a fundamental, basal substance persisted. Von Meyer says that Prout's hypothesis acted for a long time like a ferment, in that it gave rise to continually renewed speculation upon the connection which existed between the elements and their atomic weights. May it not be that the working of this ferment finally produced the periodic tables of Newlands and Mendeleef? Moreover, does not the table of Mendeleef itself suggest that the various elements are complex and not simple? We know that Mendeleef predicted the discovery of elements to fill certain blanks in his table, and that because of their positions in the table he predicted both their chemical and physical properties. Was not the simple statement of the periodic law, that the properties of an element are periodic functions of its atomic weight, sufficient to warrant the belief in an elemental substance?

The beginning of the new era, which has been so rich in results in the search for the primordial atom, may be said to have its origin in the invention of the Crookes tube. The study of gaseous conduction has been a most interesting one for physicists from the time of Faraday in the hope that it might reveal the nature of electricity. With the advent of the Crookes tube the discharge from the negative electrode, the cathode rays, assumed chief importance. While notable work was done by many with these tubes preëminence belongs to Sir William Crookes, both for results obtained and for the interpretation of these results.

Crookes showed that the cathode rays were deflected by a magnet as if they were negatively charged particles. That they are such was first shown by Perrin and later rigorously by J. J. Thomson. From his studies of these cathode rays Crookes was led to announce his theory of radiant matter or fourth state of matter, which theory no less an authority than the Encyclopedia Britannica says led to the modern electronic theory.

Crookes's studies with the tube which bears his name extended

over a good many years. In 1883 he began the study of the nature and constitution of the rare earths. From his studies of the spectra of yttrium he concluded that there was an actual splitting up of the yttrium into more elementary substances, also he formulated the hypothesis that all the elements have resulted from a primary substance which he termed protyle.

Not only directly but also indirectly was the Crookes tube a potent factor in the establishment of the electronic theory. It was while working with a Crookes tube in 1895 that Roentgen discovered the X-rays which have been so efficient as an aid in establishing this theory. Becquerel was impressed with the similarity in appearance of the phosphorescence produced by X-rays on the glass of the vacuum tube and the phosphorescence produced in some ordinary substances by sunlight.

He thought that possibly these would emit radiations similar to X-rays. Prompted by this idea, in 1896 a few months after the discovery of X-rays he placed several substances wrapped in paper beneath a photographic plate. Of these the only one that acted on the plate was a salt of uranium. He subsequently found that this property of affecting a photographic plate was common to all the salts of uranium and that it was possessed by the element itself. Moreover, he found that this action was a spontaneous one, that it made no difference whether uranium and its compounds were exposed to sunlight or kept wholly in the dark. This was the beginning of radioactivity and the study of radioactive substance. In this study there have been numerous investigators. Becquerel extended his studies further and later found the ratio of $\frac{e}{m}$ for the beta (β) rays of radium and also their velocity. The ratio of $\frac{e}{m}$ he found practically the same as that previously determined by J. J. Thomson for cathode rays. He found, however, that they had varying velocities some moving much faster than others. These differences in the velocities of the beta (β) rays furnished Kaufmann an opportunity to test the electromagnetic theory of mass—that the mass of an electron is due, wholly or in part, to the fact that the electric charge is in motion. The findings of Kaufmann were entirely in harmony with the theory, since $\frac{e}{m}$ decreased as the speed increased.

The most notable workers in the field of radioactivity have been the Curies and Sir Ernest Rutherford. The Curies examined a great many elements and their compounds to see whether they had the radioactive property of uranium. Thorium was the only element that was found to show the effect in a degree comparable to that of uranium. They found that all minerals containing uranium or thorium were radioactive but that several specimens of the uranium ore, pitchblende, were several times more active than uranium itself. Hence they concluded that pitchblende contained some unknown substance or substances which were the cause of this activity. Inspired by this idea they sought for them in pitchblende, using chemical methods. In 1898 their efforts were rewarded by the discovery of two, which they named polonium and radium, each of which is vastly more radioactive than their common parent uranium.

The story of the successive steps by which the Curies were finally led to the discovery of these new elements Fleming characterizes "one of the most fascinating chapters in the history of science."

In 1899 Rutherford showed that the radiation from uranium was complex and consisted of rays easily absorbed, which he called alpha (α), and more penetrating rays which he called beta (β). The beta (β) rays have been thoroughly studied. While their velocities are different for different sources and in the case of radium, as already noted, the particles have unequal velocities, in general their velocities are greater than the velocities observed for electrons set free in vacuum tubes. The swiftest moving beta (β) particles have a velocity closely approaching that of light; but that they are electrons, similar in all respects to the electrons set free in a vacuum tube save in velocity alone, seems to be indisputable.

Rutherford made a thorough study of the alpha (α) particles. He showed first that they carried positive charges. Then he determined the $\frac{e}{m}$ ratio for them and showed that this was only one-half the $\frac{e}{m}$ ratio for hydrogen got in electrolysis. Under the assumption of equal charges for the alpha (α) particles and the hydrogen ions, the mass of the alpha (α) particle would be twice that of the hydrogen ion; but under the assumption of twice the charge, the mass would be four times that of the hydrogen ion. In a classical experiment in which every precaution was taken to eliminate any

misinterpretation of results Rutherford proved that the spectrum of the alpha (α) particles was the spectrum of helium. Thus he clearly demonstrated that alpha (α) particles are helium atoms which have lost two electrons.

While still somewhat removed from a complete theory of atomic structure, we can assert with positiveness that the atom is a structure and, in the case of the heavy atoms, a decidedly complicated one. For the light it has thrown on the nature of this structure the radioactive compounds have been an invaluable aid. The enormous velocities with which alpha (α) and beta (β) particles are ejected from the nucleus shows the atom is a vast store-house of energy. That the thirty odd radioactive substances are the disintegration products of uranium and thorium, that they are in a constant state of disintegration by virtue of forces within the atom, and that lead is the final product of disintegration seems now the general conclusion from experimental data.

The earliest determination of $\frac{e}{m}$ was made in 1897 by J. J. Thomson and Wiechert independently. Thomson's first determination was for the cathode rays, which Crookes claimed to be negatively charged particles. He extended his investigations to the negative ions given off by metal plates when exposed to ultra-violet light, also to the negative ions produced by an incandescent carbon-filament in an atmosphere of hydrogen. He found that the value of $\frac{e}{m}$ for these was the same in all cases, that it was a constant quantity independent of the nature of the gas from which they were produced and of the means used to produce them. These were epoch-making experiments in the development of the present atomic theory. It was with amazement the rank and file of us learned from Thomson that he had discovered corpuscles whose mass was not greater than one thousandth that of the hydrogen atom. The first estimate was subsequently revised by him to about one eighteen hundredth the hydrogen atom. Bucherer's value, now considered the most accurate, makes the mass of the hydrogen atom 1845 times that of the electron, Thomson's corpuscle. These experiments of Thomson's were followed by many others, some performed by himself, others by his pupils, in the development of the electronic theory. In the development of this theory the leading rôle has clearly been played by the Cavendish laboratory,

presided over formerly by him and now by his former pupil, Sir Ernest Rutherford. Among experiments performed by Thomson was one on the canal or positive rays, to which we shall have occasion to refer later. We may note in passing, however, that while for cathode rays whose velocity does not approach that of light he found $\frac{e}{m}$ equal to 1.7×10^8, for the positive rays the greatest value observed was 10^4, which is also the value for the hydrogen ions in electrolysis, thus reënforcing conclusions as to the relative size of the electron.

A series of experiments was performed in the Cavendish laboratory, both by Thomson and his pupils, to determine the value of e, the charge carried by the electron. The value of this most important physical constant has been determined by Millikan in a series of admirably planned and accurately executed experiments which extended over several years. His method was an important modification of one of the Cavendish laboratory experiments. His findings were very concordant, and are accurate to 0.07 of 1 per cent; the value obtained by him is now the generally accepted one.

Rutherford and Geiger devised an electrical method by which they could count the number of alpha (a) particles emitted per second by radium. By measuring the charge on the counted number they found that each alpha (a) particle carried two positive electronic units of charge, a finding in harmony with Rutherford's spectroscopic work, which showed that alpha (a) particles were helium ions. Making use of the rate of emission of alpha (a) particles by radium, Rutherford in 1911, with the aid of Geiger and Marsden, performed another important experiment. He computed the chance that an alpha (a) particle in being shot through thin sheets of gold and other metal foils would suffer a given deflection because of the positive nuclei of these metals. Most of the alpha (a) particles in passing through the foils move in straight lines but some are deviated. Rutherford's theory was that whenever an alpha (a) particle passes sufficiently near the nucleus it will be deflected by the charge of the nucleus and be deviated. The experiment involved finding what fraction of the alpha (a) particles, which were shot through the foils, produced scintillation on a screen at a position which corresponded to the computed angle of deflection. From calculations based on this experiment he concluded that the number of

positive electronic charges on the nucleus equals approximately half the atomic weight. This was the first experimental determination of atomic numbers. The rigorous and exact determination of atomic numbers, however, is the work of Mosley. Millikan has characterized his work as one of the most notable pieces of research in the last fifty years. In his work Mosley made use of X-rays and the crystal grating.

Barkla had previously discovered that when different elements were used as the anti-cathode each gave off X-rays characteristic of the element used. The Braggs had shown that crystals, because of the regular spacing of their molecules, could be used as reflection gratings for X-rays, and that by knowing the distance between the molecular planes and the inclination of the rays to the planes the wave-lengths of the rays could be determined.

Beginning with Al and using the K rays Mosley examined the X-ray spectra of most of the heavier elements. He found that in passing from the lighter to the heavier elements there was a progressive shortening of their wave-lengths, or an increase in their frequencies. The functional relation established by Mosley between frequency and atomic number is accurate to the degree that when the X-ray spectrum of any element is known its atomic number can be determined unequivocally. The work of Mosley has been extended by De Broglie and others with modifications of the Mosley method. While no X-ray spectra for the ten elements below Na have yet been obtained the properties of these elements are so well known we may confidently rely on the correctness of the numbers assigned them.

Since the table starts with hydrogen, 1, and ends with uranium, 92, with six blanks, it seems that the total number of elements is 92 and that six of these are yet to be discovered.

Not only did Mosley's work substitute a scientifically determined table for the empirical table of Mendeleef, but he proved for the first time that the physical and chemical properties of an element depend upon the nuclear charge. The logical inference from his work appears to be that each element differs from the next lower by the addition of a definite amount of electricity to the nucleus and that this addition causes a corresponding increase in the frequency of the characteristic radiation.

As the result of the experimental determinations of Thomson and others the hydrogen ion is considered to be the proton, or positive

unit of electricity. In view of the comparative masses of it and the electron the atomic weight of an element is considered numerically equal to the number of protons in its nucleus. The atomic weight of helium is 4. Since its nucleus has been shown by Rutherford to be the alpha (a) particle it contains 4 protons. While it has been proven by Aston that the mass of the helium atom is not exactly four times that of the hydrogen atom, this loss of mass, due to the packing effect, is in harmony with the electromagnetic theory of mass. That the electromagnetic theory is true, and that the mass of electron is wholly electrical, seem established by the experimental findings of various workers with the beta (β) particles of radium, whose velocities range from 0.3 the velocity of light to approximate equality. While it has been impossible to apply the same test, variation of mass with velocity, to the slower moving positive charges, it seems illogical to assume for them another explanation of mass.

The atomic member, however, is determined by the excess of protons over electrons in the nucleus. Hence we see that atomic structures may have equal atomic numbers and unequal atomic masses. Such bodies were discovered by Rutherford and Soddy in their study of the radioactive substances and were named by Soddy isotopes.

Since the chemical and practically all the physical properties of the atom are determined by its atomic number, isotopes cannot be separated by chemical methods. The most effective means of separating them has been the positive ray method, first devised by Thomson and afterwards modified and improved by Aston. In view of the recent lectures here by the last named it is needless for me to speak of his method further than to say the determinations from his mass-spectra have a very high degree of accuracy. However, I hope I may be pardoned for a few remarks about these recently discovered structures despite the lectures of the distinguished visitor and notwithstanding the illuminating paper recently presented before the Elisha Mitchell Society by a distinguished authority in chemistry.

Many, at least, of the fractional atomic weights can be explained by the presence of isotopes. Neon, with atomic weight 20.2, has two isotopes of mass 20 and 22. The atomic weight can be explained by the assumption of its having these isotopes in the ratio of 9 to 1 respectively. Magnesium with its two isotopes, 24 and 25, and the atomic weight 24.32 can be explained by assuming a ratio of 17 to 8 for the isotopes.

If we write our old friend calomel Hg_2Cl_2, as our chemical friends tell us we should, then since Cl has two isotopes and Hg has six there is a total of 63 ways in which they can combine. Whether Cl and Hg avail themselves of all their privileges I leave it to others to decide. Also whether the physiological effects of the different combinations of isotopes are identical I leave to our biological friends to determine.

Various theories have been advanced as to the grouping of protons and electrons in atomic structures. That the nucleus, save in the case of hydrogen alone, contains both protons and electrons with protons in excess, and that around this nucleus are grouped electrons equal in number to the excess of protons in the nucleus, seem now to be agreed upon by all. From Rutherford's experiment on the scattering of alpha (a) particles the radius of the nucleus appears to be of the order of 10^{-13} of a cm., while the radius of the atom is of the order of 10^{-8} of a cm. Hence the electrons constitute what may be termed a planetary system, with the positive nucleus as the central sun.

Of the theories advanced for the arrangement and behavior of electrons which will explain the chemical and physical properties of atoms, two are of commanding importance.

The Bohr atom, apparently the outgrowth of the atoms of Thomson and Rutherford, was designed primarily to explain the hydrogen atom and the Balmer or visible series of the hydrogen spectrum. The fundamental assumption of Bohr, that the electrons rotate around the nucleus in non-radiating orbits, or that an electron loses no energy while it remains in the same orbit, is in harmony with our theory of magnetism and furnishes a satisfactory explanation of the stability of the hydrogen atom. The law of force assumed by Bohr for the electrons rotating in these non-radiating circular orbits is simply the Newtonian law for planetary motion.

The second assumption of Bohr was that radiation takes place only when an electron passes or jumps from a larger to a smaller orbit. He assumed that the energy lost in this change is proportional to the frequency, that it is always one quantum.

In his energy equation to determine the possible orbits for the electron Planck's constant is again involved. The equation involves this constant, the orbital frequency of the electron and an integer; the equation is so framed as to make the series of frequencies agree with the Balmer series of hydrogen.

That the Lyman series for hydrogen is in accord with the Bohr atom, although Bohr announced his atom before the series was discovered, is not remarkable; but the very close agreement between the experimentally determined value of the constant in the Balmer series and the value of this constant, computed by the Bohr theory, is a fact of significance. Numerous other physical facts are in harmony with the Bohr theory. Whether this theory can be so modified as to furnish a complete explanation of physical and chemical facts remains to be seen.

The Lewis-Langmuir atom, proposed by Lewis and developed greatly by Langmuir, is discussed at length by Langmuir in the June number of the *Journal of the American Chemical Society*, for the year 1919. As in the construction of the Bohr atom the predominant idea was the explanation of physical phenomena, so in the Langmuir atom the predominant idea was the explanation of chemical phenomena. The guiding principle in this construction seems to have been that a system in unstable equilibrium tends to pass into one of stable equilibrium. Adopting an untechnical classification of the chemical element suggested by Mills, we may classify the elements as satisfied, unsatisfied, and dissatisfied. The radioactive elements, which by ejecting alpha (α) and beta (β) particles are constantly changing into other elements and finally end in lead, constitute the dissatisfied. The inert gases constitute the satisfied although the degree of satisfaction wanes as we pass from helium to niton. The atoms between the satisfied constitute the unsatisfied and hence are chemically active.

Between neon, atomic number 10, and argon, atomic number 18, lie the seven elements Na, Mg, Al, Si, P, S, Cl. The first three of these give up electrons and are electropositive, the last three take electrons and are electronegative, while Si, midway between the two, avails itself of its double privilege and is sometimes electropositive and sometimes electronegative.

The Rydberg formula for the atomic numbers of the inert gases is $N = 2\ (1 + 2^2 + 2^2 + 3^2 + 3^2 + 4^2)$. In the construction of his shells Langmuir states he was guided by this formula. Passing through the nucleus of the atom is a plane of symmetry which Langmuir terms the equatorial plane. No electrons lie in this plane. His shells, on which lie the external electrons, are approximately spherical. The first is for helium and its radius is taken as unity. One electron is in each of the hemispherical surfaces called a cell. The elec-

tron can vibrate or oscillate in this cell but cannot depart from it. The second shell has a radius of two and hence four times the area of the first. Since all the cells are equal in area this has a capacity for 8 electrons, 4 in each hemisphere, and we have the shell for neon. Superposed on this shell is another of approximately equal radius and hence of equal capacity. This is the shell of argon. The next two shells, one superposed upon the other, have the radius 3, hence each can contain 18 electrons and we have the shells for krypton and xenon. The next shell with a radius of 4 accommodates 32 electrons and gives us the shell for niton.

There can be no electrons in the outer shell till the inner ones are completely filled. The atoms with the partially filled shells constitute the active elements. The tendency of these outside electrons to combine so as to form stable configurations constitutes chemical action. Quoting from a brief article by Langmuir: "The 8 electrons in the second and third layers are arranged in a symmetrical way like the arrangement of the 8 corners of a cube. This stable group of 8 electrons is called the Octet. The chemical properties of the elements result from the tendency of the individual atoms to take up or give up electrons in order to form Octets."

This theory has been highly successful in explaining chemical phenomena and, says Langmuir, "has made it possible to predict correctly the properties of certain substances before these properties have been determined by experiments."

The real atom must necessarily incorporate whatever is true in both the Bohr and Langmuir atoms. It seems that in all probability it may be a compromise between the two.

WAKE FOREST, N. C.

TWENTY YEARS OF THE NORTH CAROLINA ACADEMY OF SCIENCE

By C. S. Brimley

With this meeting (that of 1922), the North Carolina Academy of Science closes its twentieth year, and at the request of the secretary, Dr. Cunningham, I have prepared a brief review of those first twenty years of its history.

No account of its origin has ever been published, the first printed records being those of the first regular meeting for the presentation of papers at which time the Academy had already been organized for over six months.

The manner of its beginning was in this fashion. W. W. Ashe, at that time State Forester, conceived the idea of organizing such an institution for the State sometime in 1901, and he communicated his thoughts to Franklin Sherman, State Entomologist, and H. H. Brimley, Curator of the State Museum, and later on to F. L. Stevens, Plant Pathologist at the A. and M. College, and Tait Butler, State Veterinarian. These five gentlemen held various conferences and discussions, and the idea also spread among the members of the Raleigh Biological Society of which Dr. Stevens was president. This was mainly during the early part of 1902.

Finally these five gentlemen sent out a call for a meeting to organize a North Carolina Academy of Science, though I am not sure whether the call was signed by others or by these five gentlemen alone, nor do I remember just to whom the appeal was sent. Probably it went mostly to biologists as all the gentlemen interested were biologists themselves, and I have a dim recollection of some discussion as to whether the attempt should be to form an Academy of Science or of Natural Sciences. The former was finally decided upon, but I am not at all sure that that decision was reached before the call was sent out.

However, be that as it may, the call was sent and in response to it there assembled in Dr. Butler's office in the State Agricultural Building at Raleigh on March 21, 1902, four of the five originators (Sherman, H. H. Brimley, Stevens, and Ashe), Dr. Butler being out

of town at the time, and five others, namely: W. L. Poteat, Professor of Biology at Wake Forest College, T. Gilbert Pearson of Guilford College, B. W. Kilgore, State Chemist, J. L. Kesler, Professor of Science at the Baptist Female University (now Meredith College), and the writer.

Dr. Stevens presided till the permanent officers were elected and Mr. Sherman acted as secretary. Two sessions were held, one in the afternoon and one at night. After much discussion it was agreed to go ahead with the organization of an Academy of Science, although there was a doubt in the minds of some as to whether it might not be advisable to wait until a larger representation of the scientists of the State could be secured. The majority, however, feared that any delay might prove to be permanent and it was decided to proceed and organize the Academy at that meeting.

Consequently the North Carolina Academy of Science was organized then and there with a constitution, a full set of officers and twelve charter members. The charter members were the five originators (Ashe, H. H. Brimley, Sherman, Stevens, and Butler), the others present at the meeting (Poteat, Pearson, Kilgore, Kesler, and I), and two others (Dr. H. A. Royster of Raleigh, and Dr. H. V. Wilson, Professor of Zoology at the University). Of the twelve charter members, six have retained their membership to the present time, the others having with one exception left the State. The first officers were: W. L. Poteat, President, T. G. Pearson, Vice-President, Franklin Sherman, Secretary. An executive committee was also elected, consisting of nine members, including the president and secretary. It may be added that at first there was some idea that the Academy was intended by its founders to be a Raleigh institution and for some three or four years the majority of the executive committee was from Raleigh as also were the first two secretaries. However no such idea was present in the minds of the charter members and with the election of Dr. Gudger as secretary in 1907 it finally sank into oblivion.

I should be inclined at this distance of time to give a larger part of the credit for the success of the organization meeting to Messrs. Poteat, Sherman, and Stevens, than to the other members, although I know it is somewhat invidious to discriminate in such matters.

Twenty regular meetings for the presentation of papers have

been held since that memorable day, the first two in the fall, the others in the spring.

Twenty-one presidents have held office, namely: W. L. Poteat (Wake Forest College, Zoology), C. W. Edwards (Trinity, Physics), Charles Baskerville (University, Chemistry), F. L. Stevens (A. and M. College, Botany), J. F. Lanneau (Wake Forest, Astronomy), Collier Cobb (University, Geology), T. Gilbert Pearson (State Normal, Ornithology), Tait Butler (Agricultural Department, Veterinarian), W. C. Coker (University, Botany), W. H. Pegram (Trinity, Chemistry), H. V. Wilson (University, Zoology), C. S. Brimley (Raleigh, Zoology), Franklin Sherman (Agricultural Department, Entomology), J. J. Wolfe (Trinity, Botany), A. S. Wheeler (University, Chemistry), F. P. Venable (University, Chemistry), W. A. Withers (A. and M. College, Chemistry), E. W. Gudger (State Normal, Zoology), A. H. Patterson (University, Physics), Z. P. Metcalf (State College, Entomology), J. L. Lake (Wake Forest, Physics).

It will be seen from this list that the University contributed 7 presidents, Trinity, Wake Forest and the State College, three each, the State Agricultural Department and the State Normal College, two each, and private life one. As to the branches of science represented there were seven chemists representing both organic and inorganic chemistry, seven zoologists, (including two entomologists and one ornithologist,) three each botanists and physicists, one astronomer, one geologist, and one veterinarian.

The place of meeting has from the first rotated between Trinity College, Wake Forest College, State College, the University and the State Normal (now the North Carolina College for Women) usually in the order named, there having been five meetings at the State College, three at the State Normal and four at each of the other institutions.

The proximity of these five institutions of learning, united to the fact that the State Department of Agriculture, Elon College, Guilford College, and several other smaller institutions fall within the same area, is one of the causes that made the existence of a successful Academy of Science an accomplished fact in North Carolina. I do not wish to minimize the work of those who organized the Academy nor of those who have successfully piloted it through its twenty years of existence, but if these institutions had been scattered all over the

State their work would have been much harder and might not have succeeded.

The first meeting at Trinity College was quite a success but the second at the University (in the fall of 1903) was rather a frost, only two persons outside of the University, the president, Dr. Edwards, and I being in evidence on the first day of the meeting, though a few more turned up next day. Even the secretary was away in Texas attending a cotton boll weevil meeting or convention. Nevertheless the meeting was by no means a failure and the successful meeting at Wake Forest next spring dispelled all doubts as to the success of the Academy.

During its early years, in fact up to 1910, the membership of the Academy averaged about forty to fifty, but in that year an intensive campaign for new members was put on and the membership doubled. Since then the membership has oscillated between seventy and eighty but in the last two years has gone well over a hundred and shows signs of never again dropping below that number. It may be noted here that the campaign for membership was incited by the uneasiness of our esteemed secretary, Dr. Gudger, who was easily depressed by a slight drop in the Academy's bank balance, which, however, never at any time got dangerously low.

Of the Academy's hard working secretaries (Franklin Sherman, 1902-1905, F. L. Stevens, 1905-7, E. W. Gudger, 1907-1918, Bert Cunningham, 1918-1919, and 1921-. . . ., and R. W. Leiby, 1919-1921), two deserve especial mention, Mr. Sherman who piloted the Academy through its first perilous years, and Dr. Gudger who for eleven years faithfully sat at the receipt of custom, always with a genial smile, always on the job, and always with a nice little balance to the Academy's credit, though its occasional downward trend invariably disturbed his equanimity for the time being. His departure from the state was a great loss and he will long be missed by his old associates.

In its course of existence the Academy has lost quite a number of its prominent members, a few by death, more by removal from the state. Thus Mr. Ashe and Professor Kesler left the state very soon after its organization, Messrs. Stevens, Butler, Baskerville, Pearson, and Gudger, each shortly after the expiration of his presidential term. Dr. J. J. Wolfe and Dr. J. S. Lanneau, both ex-presidents and both sturdy pillars of the Academy, as well as Dr. Baskerville have died within the past three years.

Among those who have been more conspicuous in the Academy the following deserve notice: Charles Baskerville, H. V. Wilson, W. C. Coker, Collier Cobb, A. H. Patterson, and A. S. Wheeler of the University; C. W. Edwards, J. J. Wolfe, and Bert Cunningham of Trinity; W. L. Poteat, J. S. Lanneau, and J. L. Lake of Wake Forest; T. Gilbert Pearson and E. W. Gudger of the State Normal; F. L. Stevens, W. A. Withers, and Z. P. Metcalf of the State College; Franklin Sherman, Tait Butler and R. W. Leiby of the State Agricultural Department.

In 1904 the annual meeting was held in conjunction with the spring meeting of the North Carolina section of the American Chemical Society, largely through the efforts of Dr. Baskerville, and the arrangement has proved so acceptable to both organizations that it has been continued, with an occasional lapse, ever since.

"Behold the field that seemed barren,
How great a harvest have the years revealed."

RALEIGH, N. C.

SOME PHASES IN THE DEVELOPMENT OF CHRYSEMYS CINEREA*

By Bert Cunningham

Plates 2-4

Introduction

The egg production, egg-laying habits, nest building, and the development of the embryo through the gastrulation stage in *Chrysemys cinerea* are dealt with in this paper. A satisfactory method of artificially incubating the eggs has made it possible to secure consecutive stages of development in such numbers that careful study could be made of many points which have caused dispute.

Many details of turtle embryology have been worked out, but there has been little collection or unification of these data. Since several forms of turtles were used by the various writers, it will be impossible to limit the discussion of the literature to even a single genus, and the contradictory opinions of these writers as to developmental history probably resulted from the uses of a variety of forms.

As early as 1828 Tiedmann published a report upon two eggs of *Emys amazoni.* This was followed by the description (exact title unknown) of a turtle egg seven days old by Carus in February, 1829. In the same year Berthold discussed the absence of the chalaza in the egg of *Emys.* An account of a young egg of *Emys europaea* was published by Von Baer in 1834. Three years later he published "Ueber Entwicklungsgeschichte der Thiere," Teil II, in which he points out the similarity of structure of the eggs of the chick and the turtle, and the greater time required for the development of the latter. His conclusions were based upon the observations of Carus and Tiedmann. He noted also that while the ovary and oviduct of the chick is single, that of the turtle is paired. Peters (1838) published an article upon a young "Schildkroete." Rathke, who is often credited with the first embryological work on Chelonians, began his contributions to embryology in 1832 with an account of the "Wolffscher"

* The writer wishes to express his appreciation to the Zoological Staff of the University of Wisconsin, especially to Dr. E. A. Smith, Dr. M. F. Guyer, and Dr. A. S. Pearse for helpful suggestions and criticisms.

bodies of the turtle. The results of his later investigation were published (1848) under the title "Entwicklung der Schildkroeten." In this work he deals chiefly with gross anatomy of various stages of development, especially of the muscles, the carapace, and the alimentary canal.

Nothing more of importance appeared on this subject until 1857 when the classic work of Agassiz was published, which, according to Davenport (1898), "stands today with its many unverified facts as an incentive to the reptilian embryologist." Since Agassiz's time no one has attempted to work completely over the field of turtle embryology, although numerous short articles have been written.

THE COLLECTION OF MATERIAL

The materials used in the preparation of this paper were collected in the vicinity of Madison, Wisconsin. The territory around Lake Wingra furnished most of the specimens taken on land. Collections were made also on Lake Mendota, Lake Monona and on Mud Lake. A number of turtles were taken from high land, since the object was to capture them when nest building, but the majority were caught with dip nets in the water.

There seems to be considerable confusion as to the synonymy of four of the so-called "species" of *Chrysemys,* viz. *Chrysemys marginata* Agassiz; *C. bellii* Gray; *C. cinerea* Bonnaterre; and *C. picta* Hermann. *Chrysemys cinerea* was named by Bonnaterre probably between 1790 and 1800. *Chrysemys bellii* was named by Gray early in the nineteenth century, while *C. picta* was designated as *Testudo picta* by Hermann before 1792.

Agassiz recognized the validity of all four species. His differentiation, however, was built largely upon the color pattern which may easily be shown to be a false basis. In his description he indicates that the arrangement of the vertebral plates in *C. picta* differentiates it from all other forms. While some of his figures bear out this idea, the others do not. An examination of figures 1 to 6 will make this clear. Figure 2 is *C. marginata* while all the other are *C. picta.* The similarity of figures 2 and 5 is so striking in regard to vertebral plate arrangement that no one would think of making them into two species. Figures 1, 3, and 5 seem to form a graded series from the typical *C. picta* to the typical *C. marginata.*

Gadow's (1901) figure of *C. picta* (figure 7), is intermediate be-

tween figures 1 and 2. Hegner (1916) copies Gadow's figure. Ditmars (1914) says of *C. marginata* "size and structure of the shell, like the preceding (i e., *C. picta*), differs only in coloration." If color pattern were the only difference this form could well be grouped as a variety of *C. cinerea* as will be shown later. However, in his text descriptions Ditmars has overlooked the most characteristic difference shown in his drawings, (figs. 8 and 9) namely, that in *C. marginata* the neural scutes alternate with the costal. This is not true in *C. picta*. Since there was no opportunity to examine a large number of specimens on this point, it is assumed that this arrangement of the vertebral plates as indicated by Hermann (see figure 14) is sufficient to separate *C. picta* from the other species, and that *C. picta* is best represented by this figure.

Of the three remaining species Ruthven (1912) considers *C. marginata* as synonymous with *C. cinerea*. He adopted the latter specific name on the basis of priority, and thus describes but two species, *C. cinerea* and *C. bellii*. These two species were separated by certain carapace and plastron markings. Applying Ruthven's descriptions to the forms occurring at Madison, the separation of the two species was impossible. Carapace markings were examined and found to be variable and uncertain, in fact, carapace markings typical of *C. bellii* occurred in animals having a typical *C. cinerea* plastron, and *vice versa*. The conclusion that these carapace markings are no longer of any systematic value was confirmed by communications from Ruthven. Differentiation, therefore, must be based wholly upon plastron marking. Figs. 15 and 16 are copies of the plastron drawings of these two species as shown by Ruthven. The former represents *C. bellii* and the latter, *C. cinerea*. While there are individuals occurring here that have typical *bellii* plastrons, and others which have typical *cinerea* plastrons, individuals have been found with plastron markings intermediate between these two "species." More than seven hundred turtles were examined, and practically every degree of variation of plastron marking was found, ranging from the typical *C. oregoniensis*, a common species upon the West Coast, to a form with considerably less color pattern than that shown by Ruthven for *C. cinerea*. Life size drawings were made (see figs. 17-24) of eight selected specimens showing some of these variations. If plastron markings alone are to be the determining factor, where

should the line be drawn to separate these forms into two species? Furthermore, females having one type of plastron may produce offspring of entirely different markings. Unfortunately, the plastron markings of turtle No. 25, from which embryos No. 115 and No. 116 were secured, is not known; however, these embryos, the plastrons of which, drawn to scale, are shown in figures 25 and 26, were taken from the same clutch. The former shows a typical *C. bellii* plastron while the latter shows the plastron typical of *C. cinerea.* There were two other embryos in this clutch which are not figured; one has a plastron marking smaller than that shown in figure 22, while the other is intermediate between figures 21 and 22. There is, evidently, only one species occurring near Madison, or else there is a hopeless hybridization. If the latter be true, it is unaccompanied by any partial sterility such as is usually the case. The relation of these color patterns to geographical distribution in Wisconsin has not been worked out. In Michigan (Ruthven) *C. bellii* occurs in the upper peninsula while *C. cinerea* occurs in the other parts of the state. It would be interesting to find the results in other regions where both forms occur. It seems probable that in regard to these animals the case is similar to that of the song sparrow. In the central region of the distribution we have a mixture of all forms which, west of the Mississippi River, grades through *bellii* into *oregoniensis,* and eastward, into *cinerea* and possibly into *picta.* On this basis the classification would be *Chrysemys cinerea* and *Chrysemys cinerea* var. *belli.* If this classification is adopted or even the rule of priority is applied, then the work of Allen (1904-1906) and that of Van Alten (1914-16) should be designated as being upon *Chrysemys cinerea* rather than *Chrysemys marginata.* In this paper the forms are designated as *Chrysemys cinerea* and no effort is made to differentiate the varieties.

During the collection of the material opportunities were afforded to observe the egg-laying habits of this turtle. In 1919 this species was found to be laying between June 8 and June 26. One female was taken upon high ground June 28, but no nest was found to prove that she had just laid. Dissection showed no eggs in the oviduct.

Collections during the summer of 1920 gave slightly different results. The first turtle taken in oviposition was collected June 8. However, the laying time was considerably extended. No turtles

were found in oviposition later than June 25th, but as late as July 7th turtles bearing fully formed eggs were found crushed upon the road as they were seeking high ground for laying. This latest observation was made by Dr. E. M. Gilbert, but similar previous cases were observed by the writer as late as July 1. The latest date previously reported for these turtles with eggs is July 1, when Ruthven (1910) collected a turtle with ten eggs in the oviduct.

The eggs are usually deposited during the afternoon or evening. One turtle was found packing the hole of the nest at 4:00 p. m., which indicates that the work of nest building was begun before noon. None were found in oviposition in the morning but a number were taken at 4:30 p. m., and a few were just beginning the work of nest building as late as 6:00 p. m.

These turtles select high ground in which to build their nests. Sometimes this is a considerable distance from the water or, where the banks are high, it may be only the distance of a few feet. Usually the ground chosen is hard and dry but a sandy beach may be used. The dirt is first moistened with water from the supernumerary bladder. *This is shown by the fact that the dirt in the hole and surrounding it closely is moist while that farther away is hard and dry. The moistened dirt is worked up and thrown out by the hind feet. It was impossible to determine whether or not the tail was used in digging the hole, as some investigators have reported, since it was always either in the hole or turned up under the plastron while the work was being done. When the hole has reached a depth of from three to four inches a small cave-like excavation is made at one side into which the eggs are dropped without any reference to position. They frequently are found standing on end but more often they are lying on one side. After the last egg has been deposited the dirt is pushed loosely around them and the neck of the nest is packed with wet dirt which is tamped down with the plastron. The nest is then scratched over and is made to resemble the surrounding

* It was considered desirable to determine whether the great quantity of water found in the supernumerary bladder was water removed from the circulation stream or drawn in through the cloaca, since the quantity of liquid in the supernumerary bladder increases markedly during the laying season and decreases after the laying season is past. While the evidence on this point is incomplete, it is thought best to present it at this time. The urine from five turtles was centrifuged and microscopically examined, and since neither diatoms, green algae or protozoa were found, it is doubtful if this is other than excreted water. Chemical examinations were made to determine the percentage of nitrogen compounds in the urine. It was found, in the summer, to be .00055%. Materials for fall determination were lost in transit.

ground so closely that it is difficult to find, especially after the place has become dry.

In the beginning it was deemed best to allow the eggs to incubate under normal conditions. A plan of marking the nests with stakes was adopted. Soon it was found that these nests and many others were opened by some animal, or animals, and the contents of the eggs consumed. Nests were frequently found where the empty shells had been replaced and covered over with loose dirt and sticks. Because of this, the plan of marking the nests was abandoned and all the eggs were brought into the laboratory for artificial incubation.

In the chick the eggs are so produced that they mature at consecutive intervals of time, approximately from twenty-four to forty-eight hours apart, and are laid individually from day to day over a considerable period. An examination of the ovary of the chick shows a graded series of the eggs from the smallest ovarian egg up through sizes to those with fully developed yolks just ready to be shed from the ovary. In *Chelydra serpentina* this is not the case. Here, where a large number of eggs are to be fertilized and laid a brief period of time, are found two types of eggs: the small ovarian egg and the mature egg which is ready to receive the white. The mature eggs of *C. serpentina* are evidently developed simultaneously from the ovarian egg in the season. In *Chrysemys cinerea,* however, a much greater period of time is required to build up the mature egg, possibly four years, since, according to size, the eggs usually occur in four groups. The largest group is composed of eggs the yolks of which are nearly as large as those in fully developed eggs. The second group contains eggs about half as large as the first and the other groups of eggs decrease in size correspondingly. Agassiz noted this fact in *C. picta* and he assumed that it takes four years for the egg to reach the stage where it is ready to receive the white. He stated also that the number of eggs of a given size must represent the number of eggs in a clutch laid by the species. This latter statement seemed a valid assumption but present evidence from *Chrysemys cinerea* shows it to be doubtful. Although specimens were dissected which contained but one egg of a given size, many had groups of two or three eggs. Since never fewer than four eggs were found in the nest or the oviduct of the turtles examined, it would appear that the small eggs may mature rapidly.

The eggs deposited by different individuals vary in number from four to fourteen, with an average of seven. Inasmuch as the size of a turtle is an indicator of its age, comparisons were made to determine whether there is any relation between the age of the turtle and the number of eggs laid. No definite relation is apparent if isolated cases be studied but when the average production of the various sizes is taken a gradual increase in egg number occurs with increasing size, as is shown in the following table:

Length mm.	No. of Individuals.	Av. of Eggs.
130	1	5
135	1	6
140	13	6.38
145	10	7.7
150	5	9
155	10	9.4
160	10	9.9
165	4	10.5
170	2	13.5

The size at which turtles begin to lay is not at all uniform. In *C. picta,* Agassiz states that copulation begins about the seventh year and egg-laying about the eleventh, or at the time that the turtle has reached 80 mm. in length. He estimates that other species begin to lay when from eleven to fourteen years of age. Newman (1906) says of *Graptemys,* that he has never found one nesting when less than 190 mm. in length, or when about fourteen years of age. In *C. cinerea* nesting may begin when the carapace length is only 130 mm.; but oviposition may be delayed until after the length is 150 mm. In the case of one specimen, 187 mm. long, an examination of the ovary revealed the presence of only very small eggs, indicating that the turtle would not lay within a couple of years. This case may have been abnormal.

In some species it is possible to determine the age of turtles by the growth rings on the dorsal plates, much as the age of the fish is determined by the growth rings upon the scales. This method is not applicable to *C. cinerea* since in this species no growth rings are evident. Agassiz noted these rings on some species which he does not name and used a novel method of calculation. Forms in which the rings occurred were measured and from the number of growth rings he determined the age. This standard of measure-

ment was then applied to species in which growth rings were not evident and the age was determined by measuring the length. It seems possible that this calculation proved satisfactory for *C. picta,* since Agassiz held this species under observation for ten years. By this method he determined that egg-laying begins about the eleventh year in *C. picta,* or when the turtle has reached a length of 80 mm. On the basis suggested by Agassiz, a specimen of *C. cinerea,* 130 mm. in length, would be considerably over twenty-five years of age. The great majority, which begin laying when the carapace length is 150 mm., would be very old. In fact, Agassiz cites one case of *C. bellii* as being "very old" with a carapace length of 155 mm.

Through the kindness of Dr. A. S. Pearse, we have been able to secure some data as to the growth in *C. cinerea.* For the past few years turtles have been caught, measured, tagged, and then returned to Lake Mendota. Two such turtles which were caught and tagged August 6, 1917, were again taken on September 12, 1919. Two others that had been tagged September 24, 1919, were taken again; one on May 8, 1920, and the other on June 6, 1920. The data concerning these four turtles is given in the accompanying table:

Date tagged.	Date retaken.	Interim.	Size a	Size b	Increase.
Aug. 6, 1917	Sept. 12, 1919.	2,1, 6.	130 mm.	138 mm.	8 mm
Aug. 6, 1917	Sept. 12, 1919.	2,1, 6.	130 mm.	137 mm.	7 mm
Sept. 24, 1919	May 8, 1920.	0,8,14.	91 mm.	92 mm.	1 mm
Sept. 24, 1919	June 6, 1920.	0,9,12.	66 mm.	70 mm.	4 mm

While these data are insufficient, it has been used as a basis and it has been calculated that a turtle measuring 130 mm. in length would be from eleven to fifteen years of age. If this be true, even approximately, then there is a difference in the growth rate of *C. picta* and *C. cinerea.*

The relation of the length of the turtle to the beginning of egg-laying, based upon the data of 1919 is shown in the accompanying table:

Length.	115 mm.	130 mm.	135 mm.	138 mm.	140 mm.	145 mm.	150 mm.	187 mm.
Total No. of specimens.....	4	4	4	5	6	8	4*	1*
No. with small eggs present.....	4	2	..	..	1	..	..	..
Large eggs present but would not lay in 1920.....	..	..	..	4	..	..	2	1
No. that would lay in 1920.....	..	1	1	..	..	..	2	..
No. having eggs in oviduct.....	..	..	3	1	4	3	..	..
No. taken on nest.....	..	1	..	..	1	5	..	..

* Specimens of this size with no eggs found in oviduct.

From present evidence it appears that there is also a considerable difference in growth rate between the males and the females of *C. cinerea*. The average size of the males taken during the two summers was 117 mm., while the average for the females, for the same time, was 143 mm. The largest female caught measured 187 mm., while the largest male was 175 mm. Another fact which seems to support the idea is that the males become sexually mature by the time they have reached a length of 88 mm., while no females have been found which were sexually mature under 130 mm. A male turtle was considered as being sexually mature when active spermatozoa were found in the *vas deferens*. Sexual maturity in the female is indicated when the first set of eggs begins to enlarge. In the face of these facts, one must assume that there is either a differential growth rate or that the male matures several years earlier than the female. It is to be expected that light will be thrown upon this subject when the hundreds of turtles which have been measured, tagged, and returned to the lake are retaken from year to year.

It has not yet been determined when nor how the eggs are fertilized. It seems a very difficult matter to collect *C. cinerea in copulo. Chelydra serpentina* has been observed copulating in the laboratory but this has not been observed for *C. cinerea*. A number of catches were made in the lake when a male and a female were taken together, plastron to plastron, the female being above, usually with the head above water. These were supposed to be copulating. In all such cases the males were much smaller than the females. Two copulating seasons were observed during the year; one in the fall and another in the spring. The opening of the spring copulating season is indicated by the arrival well out in the bay of rather timid individuals. Some of these have been caught with great difficulty and were found to be males. As the season progresses, the females appear in the swampy parts of the lake and are there sought out by the males. Both males and females now become less timid and are easily taken. Soon after the spring copulation laying begins. During September and early October there is a similar congregation of individuals, and spermatozoa can again be found in the oviducts which had been free from them during the latter part of the summer. It was this semi-annual copulation together with the appearance of the eggs in groups that led Agassiz to formulate his theory of progressive ferti-

lization. This theory is contrary to the modern concept of fertilization, and seems untenable, at least in the case of *C. cinerea,* although there is no specific evidence bearing on the case.

There is, however, some contributory evidence. If turtles be taken from their native haunts before the spring copulation season, they produce wholly infertile eggs, and it is only after spermatozoa begin to appear in the oviducts of turtles in their native habitat that fertile eggs are found. It would seem reasonable that the fall copulation should be the fourth for some considerable number of individuals, and hence should initiate cleavage. But no such cleavage is found.

The foregoing observations lead also to the conclusion that the fall copulation is ineffectual for fertilization. The idea that the spermatozoa are retained in the body of the female during the winter and are capable of fertilizing the mature eggs in the spring is also erroneous. In a few weeks after the close of the fall season a careful examination of the uterus, oviducts, bladder and body fluids of a number of specimens failed to reveal any spermatozoa. This leaves still unexplained the presence of a "food mass" observed on the spermatozoa by Glascock (not yet published) which might have been interpreted as an adaptation for this purpose.

As had been suggested, the males and the females are of considerably different sizes when copulation begins. Whether this is due to a differential growth rate or a different age for reaching sexual maturity is undetermined, but the evidence presented here appears to sustain the former idea. That copulation does not begin until sexual maturity has been reached by the females, at least, is evidenced by the fact that the spermatozoa were not observed in the oviducts of sexually immature individuals. One turtle 125 mm. taken after the copulation season was well under way showed no traces of spermatozoa while another, 130 mm. in length, taken five days later, produced fertile eggs. Since, as already shown, the males may have active spermatozoa in the epididymus when they reach a length of 88 mm., it is safe to assume that copulation begins in the male when a carapace length of 85 mm. has been reached. In the case of females, no spermatozoa were found in the turtles with a carapace length of less than 130 mm., therefore copulation must begin about that time.

Development to a certain stage takes place in the oviduct. The great majority of eggs removed from the oviduct had attained the

blastopore stage and remained in that stage. Evidently some condition arrests the development of most of the eggs about the time the blastopore is formed. Several attempts were made to determine the factors which inhibited development. It was thought at first that possibly the egg absorbed water from the soil, since soon after deposition the egg became turgid. To test this idea, uterine eggs were weighed immediately upon their removal from the oviducts, then placed under incubation conditions and weighed from time to time. There was a slight decrease in weight indicating that water was not absorbed from the outside during the development of the egg. Eggs were also incubated under moist conditions without contact of soil and were found to develop normally, indicating that soil has nothing to do with the initiation of development. This left only the assumption that either the gases of the air or those dissolved in water were responsible for the renewal of embryological processes. Whole oviducts containing the eggs were removed, tied at each end and placed under incubation conditions, but without results. The failure of these eggs to develop, however, might reasonably be traced to the decay of the tissue of the oviduct. Further experimentation will be carried out along this line. It is quite possible that the physical change in the shell from the hard, inflexible shell in the oviduct to the soft, flexible shell in the nest permits a freer flow of gases. At any rate, this renewal of development is co-incident with a change in the albumen from a thick to a thin substance, with a corresponding increase in pressure.

While as a rule the eggs taken from the oviduct are in the blastopore stage, some of them are found in the cleavage stages and others in the earliest flexure stages. Embryo No. 38, fig. 33, was found to be in this flexure condition. This was the second egg to enter the oviduct and it was opened immediately upon its removal. This embryo shows a greater development than those behind it in the oviduct.

Agassiz noted that a turtle might lay eggs that had been retained for a considerable time. He found, however, that in most cases such eggs developed into monstrosities.

This is not necessarily true as is shown in the following experiment. A turtle was caught, June 12, in the act of digging a nest. She was placed in a tank of water, without sand, and kept until July 10, when she was dissected. Of the seven eggs covered by shells,

four were opened and found to be in blastopore stages. One of these is shown in fig. 27. It is to be noted that this egg, although retained for a month, had not passed beyond the blastopore stage, and it seems reasonable to suppose that the development of the three unopened eggs was about the same. The three unopened eggs were placed under incubation conditions. Figure 10 was made from one of the eggs from this clutch, artificially incubated for forty-eight days. Figure 11 is a drawing of a specimen from a non-retained egg which was incubated for forty-three days. A comparison of these two embryos shows that no unsatisfactory results came from such retention. In order to determine how long they could be forced to retain their eggs, turtles collected early in June were kept in tanks of water without sand until the latter part of July, when some of them, at least, laid their eggs in the water and presumably ate them, for the only evidence of such deposition was the empty egg shells. Dissections of a number of individuals at a later time showed no traces of eggs.

Artificial Incubation

Up to date, efforts to incubate artificially the eggs of turtles and terrapins have not been very satisfactory, although several successful attempts have been reported. One of these cases is related by Pease (1910), who carried home some newly laid eggs to show the children. These eggs were carelessly left in a tin box on the pantry shelf and in due time they hatched. Neither the species nor any other detail was given. Another plan, used commercially, is reported by Moulton (1914) who states that the eggs of the diamond-back terrapin are collected from the sandpiles in which they are laid, placed in boxes of sand, and sprinkled with water weekly until they hatch. Little data is given. Hochstetter (1906) mentions the artificial incubation of some fifty eggs for embryological purposes, by a method similar to that reported by Moulton.

Before any of the papers mentioned above had come to the knowledge of the writer, the following experiments had been successfully carried out. The first effort of the writer to incubate Chelonian eggs, artificially, was made in the summer of 1918 at Trinity College, Durham, North Carolina. Four eggs, secured from a potato hill near Farmville, Virginia, about the middle of August, were

placed in a box of sand, without any reference to their previous position, and carried about one hundred miles to the laboratory, where they were placed in a bucket of moist dirt which was covered with a bell jar. About the middle of September four little terrapins of an undetermined species made their appearance. It is surprising, when the careless handling of these eggs is considered, that they hatched, for if such treatment had been given the eggs of *Chrysemys cinerea,* the embryos would have died. This indicates a fundamental difference in the egg structure of these two forms; the blastodisc of this terrapin egg, like that of the hen's egg, did not stick to the shell membrane but rotated as the egg was placed in various positions. In the summer of 1919 the eggs of the painted turtle were brought into the laboratory of the University of Wisconsin and placed in buckets of dirt, covered with bell jars. From such eggs embryos were secured. In these experiments newly laid eggs (not over a few hours old) and uterine eggs were used. The former were frequently collected before the the completion of the packing of the hole of the nest but never before the laying was finished. Uterine eggs were removed directly from the female. A summary of the results of the incubation of the uterine and the laid eggs for the first summer is here given:

	Total No. Clutches	Total No. Eggs	Total No. Embryos	Per Cent Development
Laid	6	32	11	34.4
Uterine	19	135	99	73.3

During the second and third summers practically none but uterine eggs were used, but owing to the fact that many turtles were taken before the copulating season began, the data on fertility would be unreliable, and is therefore not included.

Uterine eggs of other species have been examined by other students, but no reports have been found which would indicate that the incubation of uterine eggs had ever been attempted. The value of such incubation will be pointed out later in the paper.

Although it is necessary to kill the turtle to secure the uterine eggs, this has its recompense, since from four to ten eggs are secured from each turtle. These represent various stages of development between early cleavage and the first flexure stages. Such a variety of phases in a single individual does not seem to be available in any other animal. If the turtle is taken early in the breeding sea-

son cleavage stages are very likely to be found, although the majority of eggs will be in the blastopore stage. This condition makes the turtle an excellent animal from which to secure the blastopore stages of the discoidal cleavage type for class work, since a single turtle may produce six or more eggs in this stage, whereas the hen, which must also be killed in order to secure the blastopore stage, will produce but a single egg in this condition.* The use of turtle eggs permits of a comparative study of the development of eggs of a clutch which have, in the very nature of things, much more in common than any group of hen eggs. Furthermore, turtle eggs may be placed under identical incubation conditions immediately upon removal from the oviduct, while the hen eggs, which are laid from day to day, are subject to varying external conditions before incubation.

For incubation, the eggs of *Chrysemys cinerea* are buried to a depth of about one inch in horizontal position in a battery jar of moist sand. Each group is labeled with a peg bearing the number of the turtle. The embryos are numbered as they are removed from the eggs and fixed.

A few precautions are necessary in the artificial incubation of *C. cinerea* eggs. In the first place, if eggs which have been laid are to be incubated, they must be secured early after deposition, since in from twenty-four to thirty-six hours after laying the embryonic disc comes to lie just above the yolk level, either at the top or the side or at the end of the egg, and attaches itself to the shell membrane. Any change in the position of the egg, even as little as a quarter of a turn, after this, may cause the yolk to settle over the embryo and the development will cease, or become abnormal. This probably accounts for the failure of many attempts at artificial incubation where the eggs are brought in from the field several hours after deposition.

A proper moisture content also is essential for success. Eggs of the painted turtle exposed to the air of laboratories soon become wrinkled and finally collapse. In the case of the snapping turtle, the shell is much tougher and the shriveling does not take place but the moisture leaves the egg and the yolk becomes a hardened mass within the shell. Seven "snapper" eggs were completely dried at

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* Recent work by Riddle (1921) would indicate that blastopore stages may be secured from live hens by intramuscular injections.

the close of twenty-eight days. Eggs from the same clutch, kept under moist conditions, continued to develop.

Temperature, of course, plays its part, although a room with a southern exposure gives sufficient heat for reasonably rapid development. In this connection it was thought desirable to determine the effect of cold upon the rate of development. For this experiment the eggs from turtles No. 128 and No. 129 were placed under the usual incubation conditions except that they were put in a refrigerator. After a period of about one month one of these was opened and found to be in the blastopore stage, indicating that development does not proceed at temperatures near the freezing point. The eggs, however, were not injured by the cold, for when placed under the natural heat conditions of the room they began to develop in the normal manner. In order to determine the relative rate of development, indoors and out, three eggs from each of the specimens No. 36, No. 37, and No. 38 were buried in an artificial nest out of doors, exposed to all natural conditions. The remaining eggs from each of these specimens were placed under incubation in the laboratory. From time to time these eggs were opened. Embryo No. 88, fig. 11, was incubated in the laboratory forty-three days, while embryo No. 100, fig. 12, was incubated out of doors in an artificial nest for forty-seven days. Development proved to be about as rapid in the laboratory as outside.

The presence of soil around the egg is not necessary. This has been tried out in one case with the eggs of the "snapper." Five eggs from a clutch of eleven were placed in a finger bowl without sand or water, (see a, in table below). The remaining six were placed in moist sand, (see b, table below). The two bowls were placed in a glass dish which contained a small quantity of water and covered with a bell jar. Incubation was allowed to go on for a few days and then the eggs were opened with the following results:

(a) 5 eggs—3 embryos, 1 dead, 1 egg infertile.
(b) 6 eggs—3 embryos, 1 dead, 2 eggs infertile.

Although the eggs develop without soil, nevertheless, it serves the useful purpose of holding the eggs in position during development.

The rate of development of the uterine egg is about the same as that of the laid egg. An examination of the drawings of embryo No. 68, fig. 34, which was incubated twenty days, and of embryo No.

69, fig. 37, incubated seventeen days, shows that the latter, which is from a laid egg, is slightly more in advance, as would be expected. Comparison of embryo No. 92, fig. 10, and No. 99, fig. 13, shows that the former, which is from a uterine egg, is more advanced. In this case, also, the laid egg was incubated three days longer than the uterine egg.

Even among uterine eggs there is a variation in the rate of development. Two eggs were placed under identical incubation conditions, one day apart, and were opened on the same day. From these embryos No. 80, fig. 39, and No. 81, fig. 38, were obtained. Embryo No. 80 is considerably more developed than No. 81 would be if it had been incubated for the same time. Such difference may possibly be due, in some degree, to the extent of the egg development in the uterus, but more likely it is due to the different developmental rates.

Altogether one hundred and sixty-seven eggs were incubated the first year. From these one hundred and ten embryos, or slightly over sixty-six per cent, developed. During the second summer, three hundred and five eggs were handled from thirty-five clutches. Since a number of these clutches were taken from turtles collected before the spring copulation season began, there is a rather high percentage of infertility, some ten clutches failing to have any eggs develop.

The ease with which turtles may be secured and incubation carried on, and the high percentage of fertility, make the turtle an excellent subject for embryological work.

PREPARATION OF MATERIAL

Some of the eggs collected were opened immediately and some were artificially incubated according to the method just described. The embryos were all killed in Bouin's fluid, stained in Alum Cochineal *in toto* and sectioned in paraffine. In this manner some two hundred and forty embryos have been prepared for study.

DEVELOPMENT HISTORY THROUGH GASTRULATION

As stated earlier in this paper, many of the eggs studied were removed from the oviduct and artificially incubated. No fertilization stages were found.

CLEAVAGE

Since *Chrysemys cinerea* deposits its eggs in an advanced stage, considerable difficulty was experienced in finding cleavage stages. Two eggs were taken having sixty-four or more cells arranged in a discoidal plate. In appearance they were similar to those of the pigeon eggs photographed by Miss Blount and published in Lillie's (1908) text, page 45, fig. C. On account of the hardness of the embryos, sections were not secured.

FORMATION OF BLASTULA

The formation of the blastula in Chelonians has been studied by Agassiz (l. c.), Will (1893) and Mitsukuri (1896). The sections show a layer of rather large cells, co-extensive with the blastodisc, and underlying these, a layer of more spherical cells. The former is at once recognized as the ectoderm and the latter as the yolk endoderm. There is sometimes a cavity present which may be called a segmentation cavity. In the earlier works it was called a Baerische Höhle, and was figured by Will (l. c.).

SOME OBSERVATIONS UPON GASTRULATION AND THE FORMATION OF THE BLASTOPORE

Keibel (1905) raised the question as to the advisability of dividing the process of gastrulation into two parts. He suggested that the part involving invagination or involution be considered as the first part and the formation of the mesoderm as the second. This plan has been adopted in this paper.

Mehnert's work (1892) concerning the process of gastrulation is by far the most complete, and carries an excellent bibliography. Mitsukuri (1893) published a preliminary note upon this process, which was more fully treated by him in 1894. There is nothing unusual in the process. The views of these writers will be given later.

The earliest stage of gastrulation is shown by the first invagination of the ectoderm to form a small cup. This is commonly known as the blastopore stage. No trouble was experienced in securing it, since by far the greater number of eggs opened immediately were found to be in this condition. Altogether, twenty such embryos have

been mounted whole or sectioned. In *Chrysemys cinerea,* the blastopore is well within the germinal disc and is usually located asymmetrically in reference to length, about one-third of the total length distant from the posterior end. Figure 30 shows a typical case. In some species the blastopore seems to be in such a position as to extend beyond the end of the disc, as figured by Mitsukuri (1894). Several stages of the closing of the blastopore are shown in the mounted specimens. The opening, which was originally round, comes to form first an oval and then an almost straight slit which later becomes slightly curved with the points of the crescent towards the anterior part of the body.

The cavity formed by the invagination at first pushes directly downward and then suddenly bends cephalad, forming two layers of ectodermal cells, the small space between which is probably the segmentation cavity. The space continuous with the blastoporic canal is the archenteron, the roof of which is formed by the invaginated cells and the floor by the cells of the yolk endoderm. Mitsukuri (1894) was the first to identify this cavity in *Trionyx* as the archenteron. Older specimens were found in which the endoderm had disappeared from the floor and the invagination cavity was continuous with the space at the top of the yolk. Will (1893) and Mitsukuri have had considerable argument as to the extent of this archenteronic cavity before its entrance into the yolk cavity. The former held that it was co-extensive with the disc while the latter maintained that it was in no way approximately equal in size to the disc. Observations upon *Chrysemys cinerea* confirm the idea of Mitsukuri. However, Will may also be correct for the form which he discussed, since generic differences have been shown to exist.

The primitive knot is on the posterior side of the blastopore. When it is not covered with ectoderm it is considered a yolk plug. Such an uncovered knob was found by Mitsukuri and Ishikawa in 1886 in *Trionyx japonicus,* which is one of the snapping turtles. They at once formulated the idea of homology of the yolk plug in reptiles and amphibians. Robinson and Assheaton (1891) disagree with the homology suggested by Mitsukuri and Ishikawa. Kupffer (1882) did not find the yolk plug in reptilia. *Chelydra serpentina* is also a species of the "snapper," and shows this yolk plug as is seen in figures 31, 32, 35, and 36. These drawings were made from mounts already in the University of Wisconsin embryological collections.

They show essentially the same features as are figured by Mitsukuri and Ishikawa.

Similar conditions are not found in *Chrysemys cinerea,* since the yolk is plainly covered with ectoderm for some distance down into the blastoporal canal (see fig. 29). This is brought about in the following manner: At the posterior end of the primitive plate, before the beginning of invagination, there is proliferated a group of cells of endodermal origin. These are covered over with a layer of ectoderm. When invagination begins, the ectoderm forms a cup which seems to sink into these lower cells. Ultimately the ectodermal cells break and the part forming the anterior wall of the blastoporal cavity turns cephalad, forming a layer of cells under the ectoderm. In *Chrysemys cinerea* this rupture of the ectoderm takes place at the bottom of the cup when it has reached its greatest depth before turning cephalad. This leaves a part of the endodermal cells of the primitive knob covered with ectoderm, as indicated above. On the other hand, Mitsukuri (1896) found in the forms which he studied, (*Trionyx Japonicus* and others), that the primitive knob was never completely covered with ectoderm but that when the ectoderm had spread over about one-half the outer surface it began to invaginate, leaving the latter half of the primitive knob uncovered. To this uncovered part he applied the term yolk plug. Earlier in this paper such a condition has been shown to exist in *Chelydra serpentina.* This was the basis upon which Mitsukuri constructed his theory as to the homology of this structure in *Elasmobranchii, Chelonia, Amphibia* and *Mammalia.* He states that no such structure (i. e., yolk plug) has been reported for birds, "probably due to the fact that nobody has looked for it." He finds a closer analogy between *Elasmobranchii* and *Chelonia* than between *Amphibia* and *Chelonia.* In the examination of several species he found that the more specialized the Chelonian studied, the less distinct was the yolk plug. If this be true, the non-occurrence of yolk plugs in *Chrysemys cinerea* means that this species is farther removed from the ancestral type than *Trionyx japonicus* and *Chelydra serpentina.* Other facts concerning these two forms lead to the same conclusion.

Soon after invagination begins there is a thickening of the ectoderm in the median longitudinal line. This represents the primitive plate. Previous to this thickening the head fold becomes visible at the anterior end of the disc, but it is not nearly so marked as is

figured by Agassiz (1. c.). In fact, Agassiz (see Agassiz, plate 9-e) makes the head fold the first to develop. Certainly, such is not the case in *Chrysemys cinerea.*

SUMMARY

1. *Chrysemys cinerea* is shown to be the only species occurring in the vicinity of Madison, Wisconsin.

(a) There are no constant differences of markings in the forms occurring there by which *C. cinerea* and *C. bellii* can be separated.

(b) *Chrysemys marginata* and *Chrysemys cinerea* have been previously combined as a single species, the latter name being adopted on the basis of priority. The impossibility of differentiation between *C. cinerea* and *C. bellii* requires that but one species be recognized. Priority designates it as *C. cinerea.*

(c) While hybridization is possible, the undiminished fecundity of these forms indicates that they are not hybrids.

(d) It is more probable that geographical varieties occur in different regions, as is the case with the song sparrow.

2. The egg-laying period was found to extend from June 8 to June 26, with a possible extension of time to July 7. Turtles were observed in oviposition from 3:30 p. m. to 6:00 p. m., but indications were that egg-laying may be carried on any time from 12:00 m. to 10:00 p. m.

3. It was found that the supernumerary bladder is used for moistening the soil in digging the nest. That the water contained therein was excretory in nature.

4. The number of eggs in a clutch varies from four to fourteen. The number of eggs in the "groups" in the ovary varies from one upwards to fifteen.

5. *Chrysemys cinerea* may begin laying when it reaches a length of one hundred and thirty millimeters and, apparently, there is a relation between the size of the turtle and the number of eggs laid.

6. The nests are opened by some unknown animal which destroys the eggs. This led to the use of artificial incubation.

7. The possibility of artificial incubation has been shown and successful methods have been described.

8. Uterine eggs may be used with even better results than can be obtained with laid eggs.

9. Contrary to general opinion, no great care is necessary in handling turtles or their eggs, provided uterine eggs or newly laid eggs are used. Embryos may be opened in normal saline without distortion.

10. Eggs that have been retained by a turtle for a month will produce apparently normal embryos when incubated.

11. Development in the oviduct ceases about the time the blastopore is formed, but may be arrested in the cleavage stages, or may proceed to the first flexure stage.

12. The rate of development is approximately the same in artificial incubation as it is under normal conditions. There is probably quite a difference in the development rate of various eggs of the same clutch.

13. Cleavage in *Chrysemys cinerea* is similar to that of any discoidal cleavage form.

14. In the blastula the lower part is formed by yolk endoderm while the upper part is formed by ectoderm. There is a cavity between them similar to the cleavage cavity of other forms.

15. In *Chelydra serpentina* a yolk plug occurs but it does not occur in *Chrysemys cinerea*. This, with other considerations, indicates that *C. cinerea* is more specialized than *Chelydra serpentina*.

16. The rounded blastopore in closing forms first an oval and then a crescent.

17. The blastopore is formed by an invagination of the ectoderm.

18. In *Chrysemys cinerea*, as in *Trionyx*, the anterior part of the blastoporeal canal forms the archenteron.

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PLATE 2

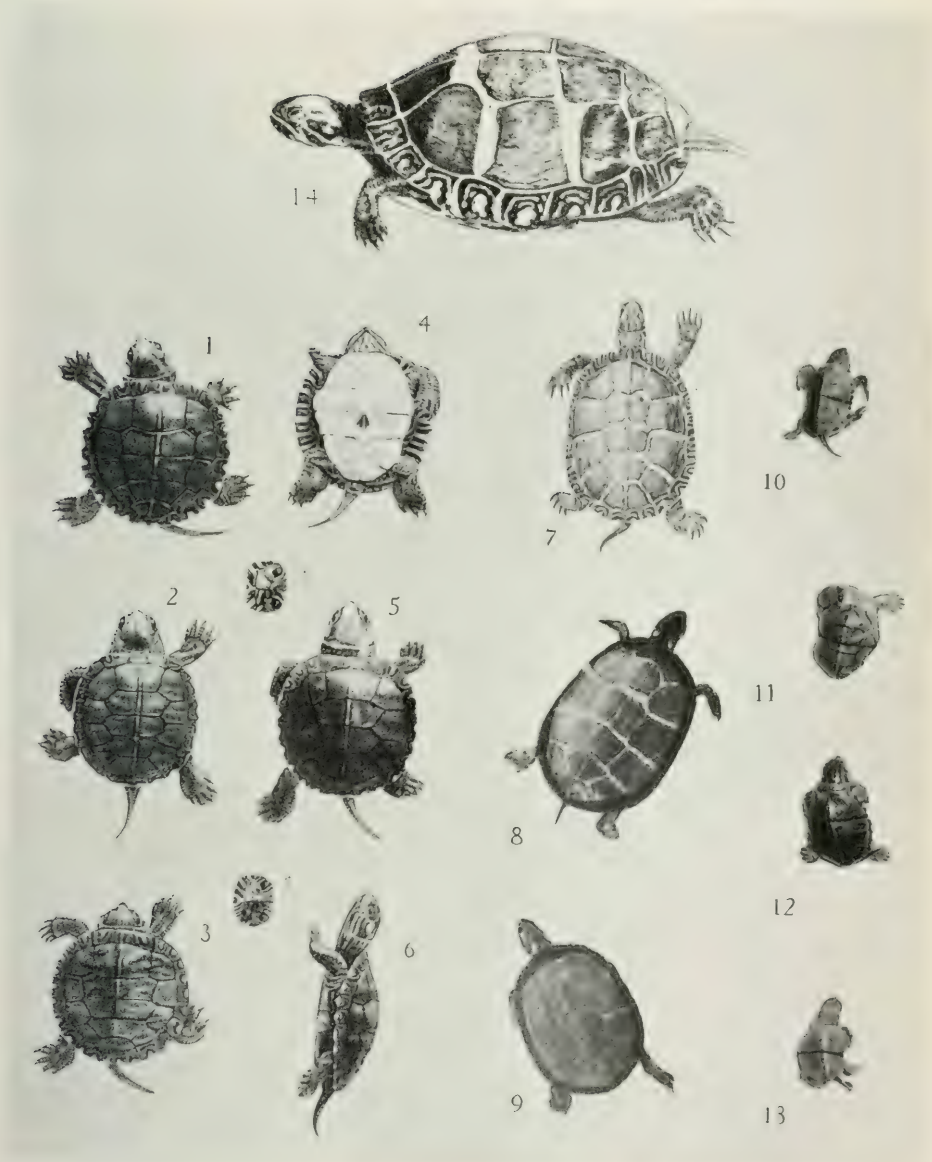

PLATE 3

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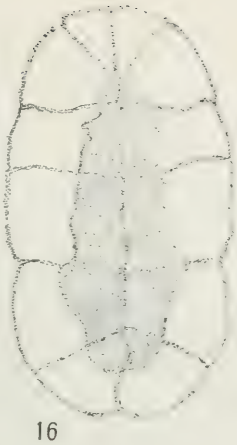

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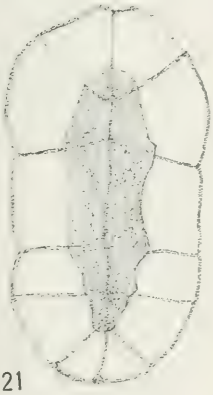

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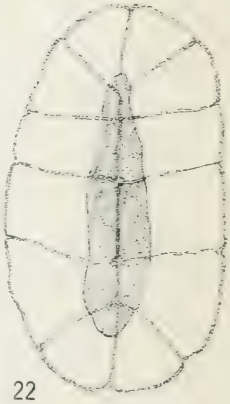

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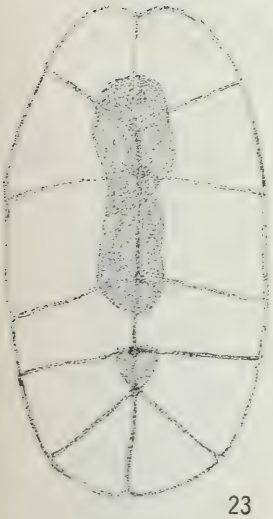

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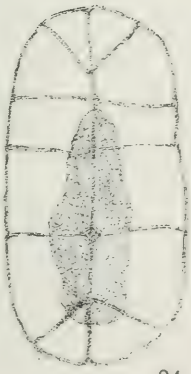

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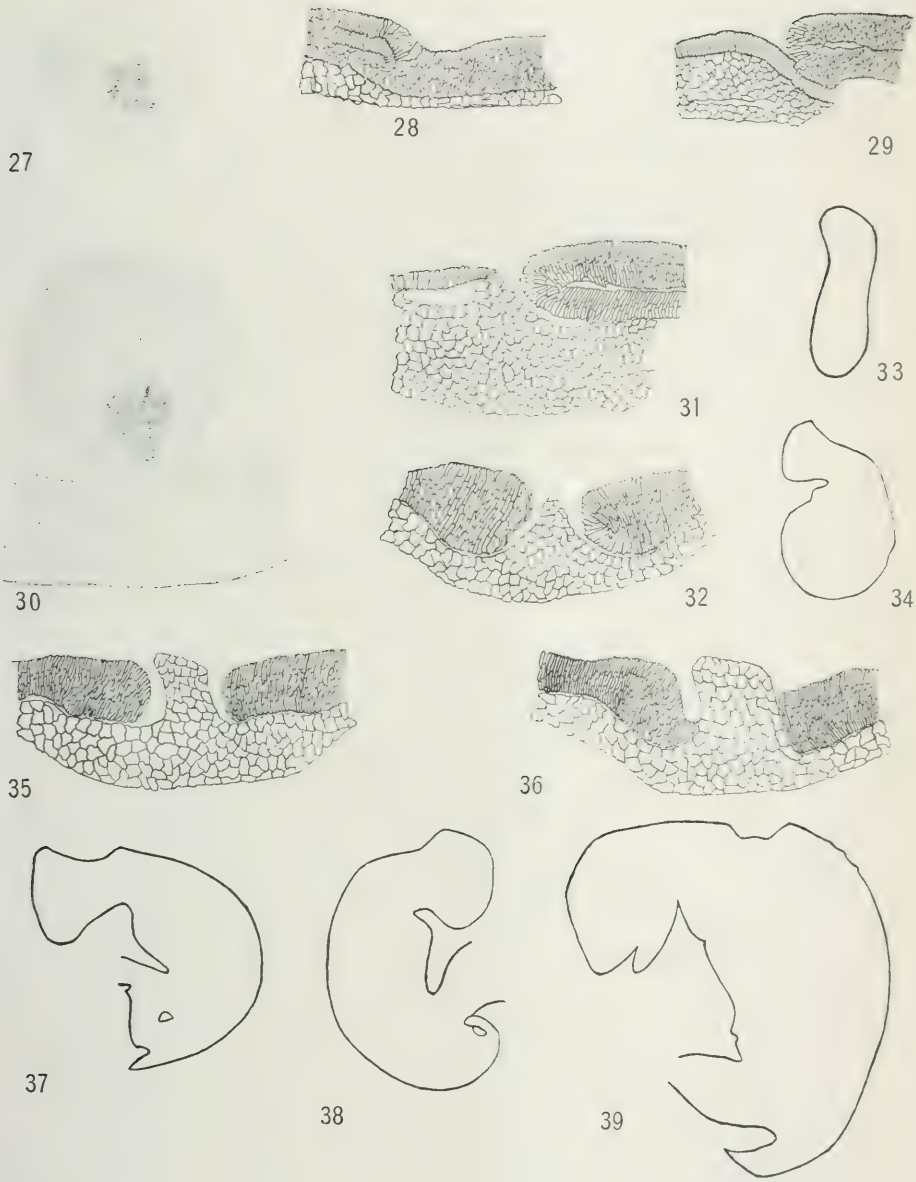
PLATE 4



EXPLANATION OF PLATES 2-4

Figs. 1, 3-6, *Chrysemys picta* after Agassiz.
Fig. 2, *Chrysemys marginata* after Agassiz.
Fig. 7, *Chrysemys picta* after Gadow.
Fig. 8, *Chrysemys picta* after Ditmars. Photographs by permission.
Fig. 9, *Chrysemys marginata* after Ditmars. Photographs by permission.
Fig. 10, Photograph of *C. cinerea*. Uterine egg retained for 30 days. Incubated 48 days.
Fig. 11, Photograph of *C. cinerea*. Incubated 43 days out-of-doors.
Fig. 12, Photograph of *C. cinerea*. Incubated 47 days indoors.
Fig. 13, Photograph of *C. cinerea*. Laid egg incubated for 45 days.
Fig. 14, *C. picta* Hermann, after Schoepff.
Fig. 15, Plastron of *C. bellii* after Ruthven.
Fig. 16, Plastron of *C. cinerea* after Ruthven.
Figs. 17-24, Drawings of plastrons of various specimens showing gradations of plastron markings between these figured in 15-16.
Figs. 25-26, Drawings of plastrons of two specimens from the same clutch.
Fig. 27, Blastopore stage of *C. cinerea*. Egg retained 30 days.
Fig. 28, Transverse section showing invagination of *C. cinerea*.
Fig. 29, Sagital section of a later stage showing ectodermal cells posterior to blastopore.
Fig. 30, Blastopore stage typical of *C. cinerea*.
Figs. 31, 32, 35, 36, Yolk plug of *Chelydra serpentina*.
Fig. 33, Early flexure stage. Egg opened upon removal from oviduct.
Fig. 34, Outline drawing of embryo of *C. cinerea*. Uterine egg incubated 20 days.
Fig. 37, Outline drawing of *C. cinerea* embryo. Laid egg incubated 17 days.
Fig. 38, Outline drawing of *C. cinerea* embryo. Uterine egg incubated 28 days.
Fig. 39, Outline drawing of *C. cinerea* embryo. Uterine egg incubated 30 days.

Figs. 10-13, slightly reduced; 15-24 reduced ½; 25-26 x 2½; 27 x 12; 28-29 x 50; 30 x 20; 31, 32 x 50; 33 x 8; 34 x 4; 35, 36 x 50; 37 x 6; 38 x 5; 39 x 3.

REACTION OF METHANE AND ALSO OF ACETYLENE UPON ZIRCONIUM TETRACHLORIDE

By F. P. Venable and R. O. Deitz

The reactions of zirconium tetrachloride with certain hydrides as ammonia, phosphine, and hydrogen sulphide have been investigated in so far as the changes taking place in the zirconium compound are concerned. There are first formed with ammonia addition compounds which on heating yield nitrides and hydrogen chloride. With phosphine zirconium phosphide is formed and with hydrogen sulphide the product is zirconium sulphide.

As zirconium carbide is somewhat imperfectly known, it seemed of interest to examine the reaction between zirconium tetrachloride and certain hydrocarbons. The carbide was prepared by Troost,[1] who heated powdered zircons with carbon in an electric furnace, obtaining a substance which on analysis yielded results agreeing fairly with the formula ZrC_2, but no distinction was made between free and combined carbon. Moissan[2] prepared the carbide by fusing zirconia with carbon, varying the amount of carbon in different fusions and obtaining a substance of consistent composition agreeing with the formula ZrC. Wedekind[3] later confirmed the work of Moissan. So it may be concluded that normally zirconia reacts with carbon at high temperatures, forming a carbide containing one atom of each of the combining elements in the molecule.

For the following experiments zirconium tetrachloride was prepared and freed from traces of iron by the method used by Venable and Bell.[4] It was retained in a hard glass tube where it could be volatilized by means of an electric sleeve. Every precaution was taken to avoid the presence of traces of water which would hydrolyze the tetrachloride.

Methane was prepared by heating anhydrous sodium acetate and soda lime and was dried before admission to the reaction tube. This tube contained about 5 grams of $ZrCl_4$ which was volatilized during the passage of the methane. Apparently no reaction took place

[1] Compt. rend. 116, 1227. 1893.
[2] Compt. rend. **116**. 1222. 1893.
[3] Ann. **395**. 149. 1912.
[4] Amer. Chem. Soc. **39**. 1598. 1917.

below the temperature of vaporization. The tetrachloride began to darken at about 400°. About 13 l. of methane were used in a slow stream. After about one-third of the methane had been used no further volatilization of the tetrachloride was observed. When the reaction tube was opened after cooling there was observed a peculiar odor resembling that given off when sulphuric acid through which methane has been bubbled is diluted with water. This may indicate the formation of condensation hydrocarbons either in the drying train containing P_2O_5 or in the reaction tube in the presence of heated $ZrCl_4$.

The contents of the reaction tube were washed out with water to remove zirconium chlorides and after thorough washing three undissolved products were distinguished under a magnifying glass as follows: (1) Black particles, (2) lighter brownish particles which were easily blown about by slight air currents, and (3) masses which were largely colorless but held small black particles disseminated through them. The total yield was only a small fraction of a gram, showing that in spite of prolonged heating with an excess of methane the reactions taking place were quite limited in extent. From two runs of 5 g. $ZrCl_4$ each, 0.51 g. of the black particles were obtained and the separation could not be looked upon as complete.

Separation of these different particles by flotation in various liquids was attempted but proved unsatisfactory. Various solvents were tried also without success. Concentrated nitric acid reacted upon the mixture, as also did sulphuric acid. After partial separation by flotation followed by picking out the particles as far as possible under a magnifying glass about 0.5 gram of the black particles were secured and analyzed. The percentage of carbon found was 32.09. Later the experiment was repeated with some additional precautions and a sample obtained yielding 28.11 p.c. carbon. From these analyses it was concluded that the black particles contained a considerable admixture of free carbon, since the percentage for ZrC is 11.69 and for ZrC_2 20.95.

The investigation of the reaction with acetylene showed that it began on gentle heating and was exothermic. Gradations in color from brown-red to black were observed in the product and on washing with water a mixture apparently similar to the above was obtained.

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SOME PHASES OF STRUCTURE AND DEVELOPMENT OF GARDEN PEA AND WHITE SWEET CLOVER SEEDS AS RELATED TO HARDNESS

By L. Edwin Yocum

Plates 5 and 6

Hard seed coats are very common among the *Leguminosae.* Guppy (7) mentions 32 legume seeds in a list of 43 plants whose seeds are more or less hard. Harrington (8) has found in hand hulled seeds the following percentages of hard seeds: alsike clover, 92%; red clover, 92%; white clover, 98%; and white sweet clover, 98%. Therefore, it is of vast economic importance to determine some way of inducing all the legume seeds to germinate soon after sowing rather than months or years later, which is often the cause of a poor stand of clover. The purpose of this paper is: (1) to trace the development of the garden pea and white sweet clover seed coats, and (2) to find out the chemical composition of the cell walls. It is hoped that these factors may throw light on the cause of hardness and suggest some method of overcoming the hardness of the seed coats which will be more practical to the farmer than any of the present methods. The Malpighian cells have been found to be most important as regards hardness, and therefore most emphasis will be put on the study of that layer of cells.

Hard seeds are considered as those failing to absorb water when under favorable conditions for three or more days.

Historical

Seed coats have been investigated from time to time since 1667 when Malpighi described the cells now bearing his name. Russow, 1871, studied the light line with polarized light and came to the conclusion that it had less water than other parts of the cell. Pammel, (12) 1885, examined several of the *Leguminosae,* and again, Pammel, (13) 1899, published a monumental work on the anatomical characters of the *Leguminosae,* with excellent figures, and an extensive bibliography.

Workers began to turn their attention to the treatment of hard seeds about 1890. Kuntz and Huss used sand paper as a scratching machine. Other investigators have used various forms of sand paper scratchers. In the past ten years most investigators have used some modification of throwing or blowing seeds against sharp points or needles as a means of puncturing the seed coat. Carruthers, (2) 1911, was able to guarantee 98-100 per cent germination of clover seed with a machine of this type. Rose, (14) in 1915, explains a device where seeds are blown against a pad of needles, which very effectively improves germination. Prof. Hughes of Iowa State College has invented a similar but less complicated machine which is fairly satisfactory and is in use by some seedsmen.

Harrington, (8) 1915, shows the effectiveness of clover hullers as scratching machines. He finds that while hand hulled white sweet clover has 98 per cent of hard seeds, machine hulled has only 20 per cent of hard seeds. Hulling, however, injures some of the seed when set to get the maximum scratching results.

Hot water treatment has been recommended for a number of years. Jarzymowski, in 1905, used it with some success with legume seeds. Bolley, (1) in 1910, reports success with hot water provided the treatment was not so long as to injure the embryo.

Chemical treatments are receiving more and more attention. Rostrup, (15) in 1896, treats *Lathyrus sylvestris* seeds for one minute in sulphuric acid and had 100 per cent germination. Bolley (1) has used sulphuric similar to the way it is used by Love and Leighty, (11) in 1912, who treated seed for 10 to 30 minutes to get maximum results. Periods of more than one hour usually injure the seed.

Many other chemicals have been used; however, the lower alcohols seem to be most effective. Verschoffelts thinks the water will not wet the cell walls, but alcohol can do this more easily. After the walls are wet they can absorb water. Coe and Martin (3) find that the alcohol treatment is not effective with white sweet clover.

Several explanations have been offered for dormancy or poor germination of seeds. Crocker, (4 and 5) in 1916, gives a representative list of probable causes. He attributes dormancy in many cases to the hard seed coat, which keeps out water and possibly oxygen. The impermeable portion may be the cutin or the light line. Coe and Martin (3) show by staining whole seeds that the light line is undoubtedly the limiting factor of absorption, since the stain enters

readily to, but does not stain, nor pass beyond the light line. The light line is very much harder than other portions. They have found that while the outer portion of the seed is readily eaten by sulfuric acid, the light line is not destroyed by it. The paper also contains a very extensive list of the important literature.

Some work has been done on the hereditary possibilities of hardness. Harrington (8) gives an account of the tests on the experimental farms, 1909-14. He says the percentage of hard seeds has been as great from seeds when only 5 per cent were hard as from seeds when 95 per cent had been hard.

Hiltner and Kinzel (10) find that the percentage of hard seeds is higher in some years than others, and that perhaps weather conditions have an effect. They also find that rapid drying, 30° to 40°C. increases hardness. Harrington (8) and Coe and Martin (3) have not found a seasonal relation.

MATERIAL AND METHODS

All stages of development of garden peas and white sweet clover seed coats, except those fully mature, were killed in chromoacetic acid, imbedded, cut and finally stained with either safranin and light green, or haematoxylin and safranin. Mature stages were taken from free hand sections. In some cases the flowers were tripped and age of seed figured from date of tripping, in other cases it is estimated from the time the flower wilts which is considered as the time of fertilization.

All microchemical work was done on fresh material grown in the green house. The methods followed were those outlined by Zimmermann, Hass and Hill, and Tunmann.

In this work hardness in peas was determined by soaking for three days. Less than 1 per cent of most peas are hard. Some few, however, appear to have hard seed coats, but admit water at the hilum, as shown by swelling around that region first, as well as by staining. Sweet clover seeds were placed in germinator for 10 days and those not swelled were considered hard.

DEVELOPMENT OF SEED COAT

These legumes have their seed coats made up almost entirely of the outer integument. The inner integument in sweet clover never

develops more than two or three rows of large cells. The garden pea forms six to eight rows of cells in the inner integument but never forms the cells so compactly as in the outer integument; however, the two gradually shade off together. The inner integument in both cases soon partially breaks down.

The outer integument in sweet clover is made up of from five to eight rows of cells. The garden pea has from six to ten layers of cells in the outer integument. The former number is common at the time of fertilization and the remainder are added soon after.

The sweet clover seed coat has almost cubical Malpighian cells at the time of fertilization, with thin walls slightly thicker at the outside. In six days the Malpighian cells begin to elongate and divide so as to become very narrow. This elongation and division goes on very rapidly for about eight days, when it appears that possibly the total number of cells have been formed and that these get wider to accommodate the later growth of the seed.

The cell walls begin to thicken soon after fertilization, and decided thickening takes place on the outside at the time the cells elongate. The domes begin to thicken in nine days and are completely formed in about twenty days. The light line does not appear until the seed is nearly mature.

A very striking contrast is found between hard and soft seeds. Hard seeds have their walls thickened so much below the light line that the lumen extends only part of the way from the base to the light line. In soft seeds a fairly large lumen extends to the light line. This may allow larger pores to extend through the light line.

The thickening of the cell walls of sweet clover and peas is similar in that both are thickened in ridges leaving crevices between the various thickened portions. The crevices are usually very narrow.

In the garden pea the cell walls are generally thinner, especially in young stages, than in sweet clover. The Malpighian cells change very little for several days after fertilization. The remainder of the cells of the integument enlarge very much. In about six days the Malpighian cells elongate to several times their width and thicken a very small amount. Thickenings come in very rapidly at the time the seeds are nearly mature.

The cells sometimes entirely close up due to thickenings, as in the case of hard seeds. Seeds which are not hard usually have the

lumen extending nearly the length of the cell, although the walls are very much thickened.

CHEMICAL COMPOSITION OF CELLS IN GARDEN PEA

In very young flowers where the anthers were not open, light green stains the walls nearly equal around the ovule. Ruthenin red shows very little staining at any point. Methylene blue stains cell contents, walls lightly if any. Cupro-ammonia destroys the walls entirely in one hour. Chloroiodide of zinc stains brown color. This indicates generally cellulose but not definitely.

At the time of fertilization, all the cells except those of the micropylar region remained the same. At the micropyle the light green does not stain. Ruthenin red stains distinctly at micropyle. Methylene blue stains cell walls deep blue, and destains in alcohol. In cupro-ammonia micropyle cells are more resistant, remain intact after two hours. This indicates presence of pectin appearing in micropyle at time of fertilization.

After fertilization the cell walls of the Malpighian cells modified very rapidly in structure and took stains with difficulty. Chloroiodide of zinc, one week after fertilization, stains brownish yellow except at micropyle where it is blue. In half grown seeds it stains violet at base and brown at outer part of cell. Iodine and phosphoric acid give no distinct stain one week after fertilization. Iodine and sulphuric acid on a mature seed gave a yellowish brown color at outer part of the cells or the region of the cutin and blue in the inner half of the cell, outer half unstained. Cupro-ammonia has little or no action on cell walls. This indicates a cutin on the outside, inner part cellulose, and outer part more impermeable.

Mild hydrolysis was tried. Seeds of three ages were boiled slowly for 20, 50 and 80 minutes in 5 per cent HCl solution with reflux condenser. These were then tested with chloroiodide of zinc. Cell walls all stained deep blue. Cupro-ammonia rapidly dissolved the walls. On mature seeds iodine and sulphuric acid gave a deep blue color with much swelling, on young seeds gave a violet color. This distinctly indicates pure cellulose after treatment for 20 minutes in weak HCl acid solution. Since this substance was so easily hydrolyzed it seems likely to have been a hemi-cellulose. Hemi-celluloses are usually either some paragalactan or pentose. Untreated seed

coats were tested with phloroglucin and HCl acid and then heated to test for a paragalactan substance. No action. This would indicate a pentose substance in the hardest part of the seed coat.

With the above observations in mind, nearly mature and mature white sweet clover seeds which were very impermeable to stains were treated as above with HCl acid solution. When tested with iodine and sulphuric acid and chloroiodide of zinc the domes took a very deep blue color, indicating as in the garden pea the presence of a pentose. The light line and the portion covering the domes were unattacked, except slightly. The light line does not readily yield to hydrolysis.

The work of Coe and Martin was confirmed as to the distance a stain will penetrate a hard seed in white sweet clover. The domes were readily stained to the light line but no trace of stain passed into the light line.

Pammel and others have indicated a light line in Garden Peas in about the position it is commonly found in the *Leguminosae*. Tunmann shows a light line in the shape of a cap over the end of the cell. In this work no distinct light line was observed in the Garden Pea. Testing by immersion in stains showed that the impermeable portion of the pea is in the cutin, since stains do not pass through the cutinized layer.

I wish to express my appreciation of the encouragement and helpful suggestions given me by Dr. J. N. Martin of the Iowa State College while I pursued this work.

SUMMARY

In sweet clover and garden peas the Malpighian layer of cells begins to thicken very much about a week after fertilization. Thickenings are in ridges leaving crevices between.

Sweet clover develops a light line which is more impermeable to water than the outer part of the cell. The pea does not have this region but in some cases had an impermeable cutin.

Pectin is deposited in the cells around the micropyle at about the time of fertilization in the garden pea.

The outer portion of the Malpighian cells of sweet clover and garden peas is a hemi-cellulose, very likely some form of pentose. The inner portion is cellulose.

The impermeable portion of a hard pea seed is located in the cutinized layer as compared with the light line in sweet clover.

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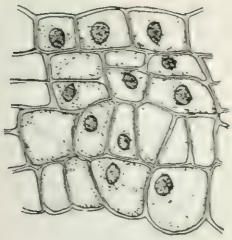
EXPLANATION OF PLATES

Plate 5. Melilotus alba.

Fig. 1. Ovule wall forty-seven hours after pollination and just before fertilization. (x 1500).
Fig. 2. Ovule wall after first division of the egg cell. (x 1500).
Fig. 3. Ovule wall five days after pollination, suspensor well developed. (x 1500).
Fig. 4. Ovule wall six days after pollination. (x 1500).
Fig. 5. Malpighian cells nine days after pollination, cotyledons well developed. (x 1500).

PLATE 5



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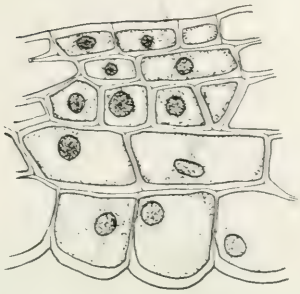

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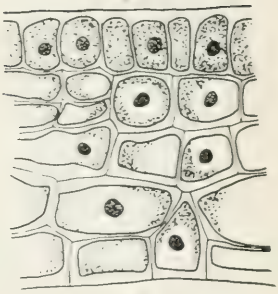

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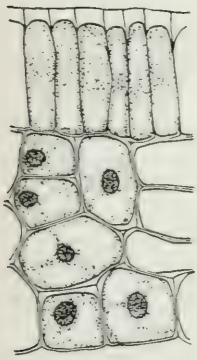

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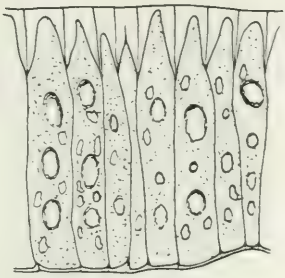

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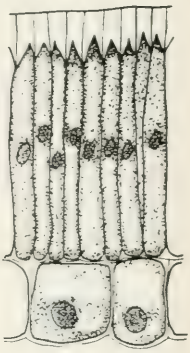

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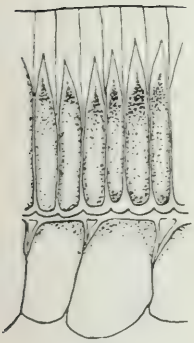

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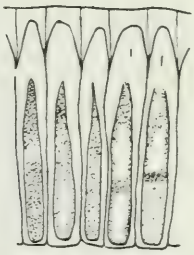

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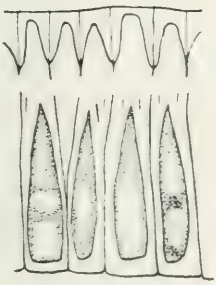

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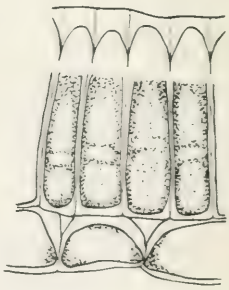

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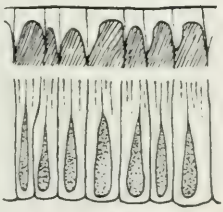

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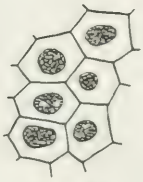

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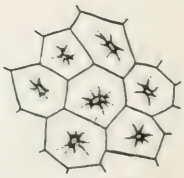

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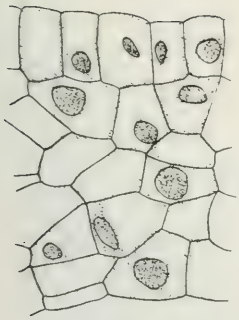
PLATE 6



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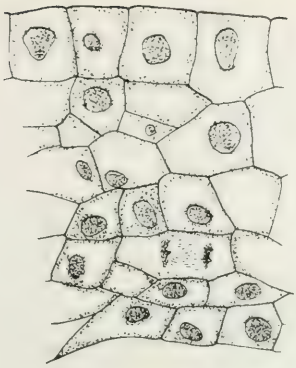

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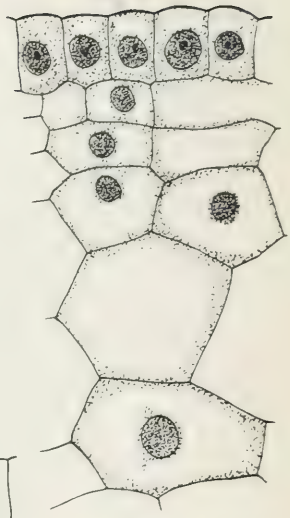

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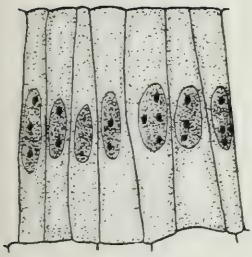

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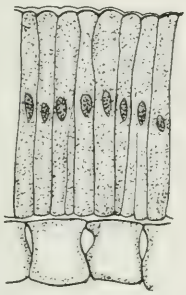

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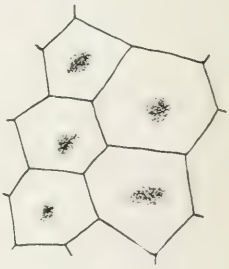

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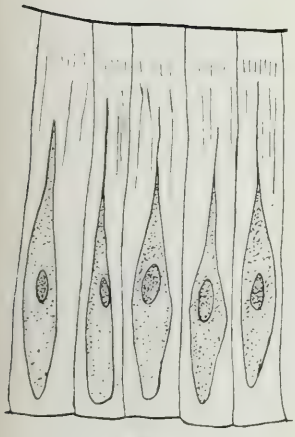

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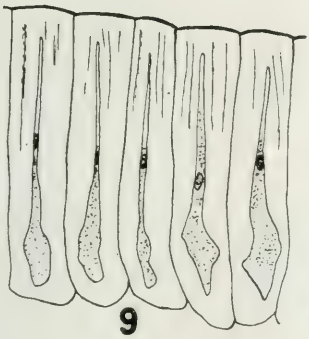

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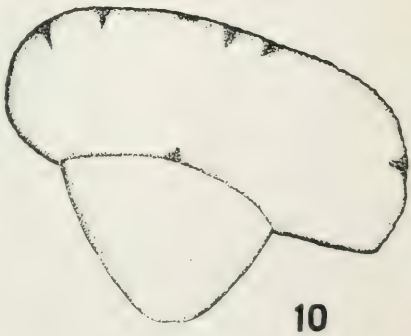

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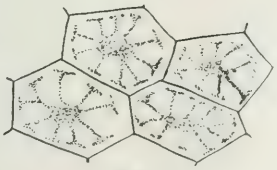

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Fig. 6. Malpighian cells and osteosclerid cells fourteen days after pollination. (x 1500).
Fig. 7. Malpighian and osteosclerid cells sixteen days after pollination. (x 1500).
Fig. 8. Malpighian cells of a medium hard seed showing the first appearance of the light line. (x 1500).
Fig. 9. Malpighian cells of a hard seed with wider light line and smaller proportion of lumen. (x 1500).
Fig. 10. Malpighian and osteosclerid cells of a soft seed, showing narrow light line and large lumen. (x 1500).
Fig. 11. Malpighian cells of a hard seed stained in mass, domes heavily stained but none has passed into or through the light line. (x 1500).
Fig. 12. Cross section through domes. (x 1800).
Fig. 13. Cross section just below the light line. (x 1800).

Plate 6. Pisum sativum.

Fig. 1. Ovule wall before pollination. (x 1500).
Fig. 2. Ovule wall shortly after fertilization. (x 1500).
Fig. 3. Portion of ovule wall about four days after pollination. (x 1500).
Fig. 4. Malpighian cells about ten days after pollination. (x 1500).
Fig. 5. Malpighian and osteosclerid cells about fifteen days after pollination. (x 640).
Fig. 6. Malpighian cells of a mature seed. (x 1500).
Fig. 7. Cross section of Malpighian cells just under the cuticle. (x 1800).
Fig. 8. Malpighian cells of a hard seed, very much reduced lumen. (x 1500).
Fig. 9. Malpighian cells of a soft seed, with lumen extending nearer the cuticle. (x 1500).
Fig. 10. A single Malpighian cell treated with iodine and sulphuric acid. Much swollen, and blue except at triangular shaded portions which are yellow. (x 1500).
Fig. 11. Cross section of Malpighian cells where the lumen appears. (x 1800).

VARIATION OF PROTEIN CONTENT OF CORN

By H. B. Arbuckle and O. J. Thies, Jr.

I. Influence of Climate

Corn is now the greatest feed crop in the United States, and is relied upon for the production of most of the beef, mutton, and pork marketed in this country, and exported to foreign countries. For fattening butcher stock on the farms and in the big feed yards corn is the most efficient food, but for breeding stock, and young animals, it must be used with caution. Grains of higher protein content, such as oats, soybeans, wheat (in form of bran) must supplement the corn.

Many attempts have been made to increase the protein content of corn with a view to removing its deficiency, but despite all these efforts the protein content of corn in general remains the same. By careful seed selection some varieties have acquired the reputation of possessing higher protein content, but after a few years it is found that it has dropped back to its former standard. Hayes and Garber, in 1919, completed some experiments extending through a period of several years, in which, by self-fertilization, followed by crossing and seed selection, they were able to increase the protein content as much as two per cent, thus making it almost the equivalent of oats in protein. The yields, however, were greatly cut down, and the corn developed showed a tendency to revert to the lower protein standard. Such experiments, and other similar observations, raise the question as to whether the protein content in a given variety of corn is a fixed factor.

If the protein does change, can this change be controlled? What is the effect of climate, season, soil, fertilizer, tillage?

The object of this investigation begun a year ago by the authors is to determine, if possible, how certain conditions may modify the protein content in a given variety of corn. This preliminary paper presents the results of our first year's investigation of the effect of climate. We have chosen three varieties of corn, and will supervise the seed selection each year. The first variety is a white corn, Silver King, which has been grown for four years on the farm of

one of the authors in West Virginia. Analysis for three years shows approximately 8.5% protein. This corn has shown little change during these years. It has been grown on the same land under uniform conditions of rainfall and tillage.

The second variety is a white corn of high protein content. The seed was raised in North Carolina, and the corn analyzed was grown in North Carolina. Its protein content is 9.6%.

The third variety is a yellow corn, Golden Dent. This seed was raised in North Carolina, and the corn analyzed was grown in North Carolina. The protein content is approximately 6.7%.

In each case several grains were taken from different parts of a number of ears, and a composite sample was secured by mixing and grinding.

This year we made an analysis of a sample of the first variety, Silver King, secured from ears grown in North Carolina. The seed, however, was raised in West Virginia. It is our purpose to grow this corn, Silver King, for a number of years in North Carolina, reporting results, and also to grow the North Carolina varieties in West Virginia, reporting results.

We were limited in our choice of varieties, as the growing period in West Virginia is only about 110 days.

The altitude at which this corn was grown in West Virginia was 2500 feet. The altitude of Davidson, N. C., where the corn was grown, is 800 feet. The season of North Carolina is approximately 30 days ahead of that in West Virginia. This should furnish such a marked difference in climate that any variation in protein due to this cause should be clearly shown.

Our first experiment showed a marked change in the protein content, but in the direction that is exactly opposite to that generally expected. It has been thought that warmer climates produced higher protein in corn. No satisfactory reason, however, has been given for this supposition. Quite recently it has been shown by a number of experiments that the sugar content has been raised by planting corn in colder climates.

The analyses are given below:

Analysis of the white corn, Silver King, grown in West Virginia.

Percentage of Nitrogen (2 gram sample)	Percentage of Nitrogen (3 gram sample)	Percentage of Protein
No. 1 1.418	No. 4 1.371	8.534
No. 2 1.365		
No. 3 1.376		

Mean, 1.383% N_2

Analysis of the white corn, Silver King, grown in North Carolina.

Percentage of Nitrogen (2 gram sample)	Percentage of Nitrogen (3 gram sample)	Percentage of Protein
No. 1 1.251	No. 4 1.233	7.700
No. 2 1.247	No. 5 1.217	
No. 3 1.213		

Mean, 1.232% N_2

Analysis of the white corn, White Plume, seed raised and grown in North Carolina.

Percentage of Nitrogen (3 gram sample)	Percentage of Nitrogen	Percentage of Protein
No. 1 1.543		9.619%
No. 2 1.531		
No. 3 1.543		

Mean, 1.539% N_2

Analysis of the yellow corn, Golden Dent, seed raised and grown in North Carolina.

Percentage of Nitrogen (3 gram sample)	Percentage of Nitrogen	Percentage of Protein
No. 1 1.095		6.687%
No. 2 1.028		
No. 3 1.087		

Mean, 1.070% N_2

It may be of interest to some to know the method of nitrogen determination employed. After experimenting with several modifications of the Kjeldahl, including the use of potassium perchlorate, we finally adopted as the most satisfactory method of determining nitrogen in corn the following: 3 grams corn, finely ground, is introduced into a Kjeldahl flask, 0.3 gram copper sulphate, C. P. added, and then 20 cc. sulphuric acid with phosphorous pentoxide. After digesting till the material in the flask has assumed a liquid form, 10 grams potassium sulphate, C. P. is added slowly. By this plan samples were completely digested and ready for distillation in times ranging from 26 to 40 minutes. This included five minutes for

digestion after contents of the flask had cleared. We found that the chief factor in the time saving was the introduction of the potassium sulphate at the proper time after the digestion had gotten well under way. This allows the use of comparatively high heat from the beginning without serious foaming of the contents of the flask.

T. B. Osborne, at the Connecticut Agricultural Station, has given us the best data on the protein content of corn and recommends 6.25 as the protein factor. We have used this factor in our calculations. If we succeed in establishing a marked change in the protein, we shall endeavor to show which form of protein found in corn is affected. We append for convenience of reference Osborne's analysis.

Proteins in Corn:

Soluble in Water	Proteose,	0.06%
Soluble in Salt Solution	Globulin,	0.04%
	Maysin,	0.25%
	Edestin,	1.10%
Soluble in Alcohol	Zein,	5.00%
Insoluble in above, but soluble in 0.2% KOH		3.15%

Summary:

1. Plan of investigating influence of climate on protein content of corn is outlined.

2. The analyses of the varieties of corn chosen for experiment are reported.

3. The result of planting of West Virginia grown corn in North Carolina for the first year shows a marked reduction in protein.

4. The modification of the Kjeldahl method which was employed for the determination of nitrogen in corn is given.

DAVIDSON COLLEGE, N. C.

GEOLOGY OF THE MUSCLE SHOALS AREA, ALABAMA

By W. F. Prouty

The Tennessee River at its confluence with the Ohio is the larger of the two streams. The Tennessee represents, about as perfectly as any stream known, a shift of course through successive river capture. Rejuvenation has caused the down-cutting of the Tennessee into its old peneplain. In the neighborhood of Florence, Alabama, where the stream makes a considerable bend toward the north, the older and more resistant rocks of the Nashville arch outcrop and cause the Muscle Shoals, which have a fall of more than 140 feet in the course of a few miles. In the Waldron Ridge the lower part of the Pennsylvanian and upper part of the Mississippian rocks are well exposed. In the Muscle Shoals area proper the lower portion of Mississippian is alone seen along the stream.

In this portion of the State the Fort Payne series is composed of the Tuscumbia limestone above and the Lauderdale chert, limestone and shale below. The very resistant Lauderdale chert forms the bed of the stream throughout the area of the shoals. This rock dips more steeply than the stream so that in going from the head to the foot of the shoals one passes from the bottom to the top of the heavy Lauderdale chert beds. As these beds are jointed, they break off into steps which form the riffles across the stream, usually at a considerable angle to the flow of the stream.

The big or Wilson dam, now under construction, is located near the foot of the shoals and near the top of the Lauderdale chert. At this locality the river runs south of west, the 4000 foot dam runs a little west of north and the dip of the formations is practically due south. At this point the dip is unusually large, being about 60 feet for the width of the river. As a result of this the bed of the stream and the north bluff are composed entirely of the Lauderdale chert formation while the bluff at the south end of the dam is made up in part of the less resistant chert of the Lauderdale, and at higher levels of the more soluble limestone of the Tuscumbia formation. It is in the portion of the proposed flooded area occupied by this more soluble limestone that trouble from leakage is anticipated and it was

because of this threatened leakage that the writer was asked to make a geological report to the Government concerning the dam foundation during the war period.

Although there is a considerable area of the Tuscumbia which will be flooded by the Wilson dam, the trend of the rocks is such that no great danger from leakage is to be expected except in the area near the dam, where considerable pressure grouting will be necessary.

The proposed Dam No. 3 is to be located near the head of the Big Muscle Shoals. At this point the Lauderdale chert occupies the southern bluff while a shale and a very soluble crinoidal limestone, lying below the Lauderdale chert, occupy the northern portion of the stream bed and the northern bluff. At this locality the northern end of the proposed dam is the weak one and the weakness is of greater concern than at the south end of the Wilson Dam.

The strata throughout the area show a number of small, rather sharp folds. These run nearly with the strike. One such fold is seen in the bed of the stream near the north end of the Wilson Dam. It does not here constitute a line of weakness. Another such sharp fold cuts diagonally across the river at Bainbridge Eddy, here bringing up the less resistant shale and limestone which have yielded the deep and narrow channel.

The upper Lauderdale in places contains small cavities containing oil residues. That gas is also present, in small amounts at least, is also demonstrated by the secondary explosions which were so common following blasts made at the location of the new power plant on the south side of the river below the Wilson Dam.

CHAPEL HILL, N. C.

AZALEA IN NORTH CAROLINA

By W. W. Ashe

Key to Eastern Species following that of Small's Flora of the Southeastern United States. Only the species in italics in the key are known to occur in North Carolina.

Corollas expanding with or before the leaves
- Corollas red or orange or yellow
  - Flowers with the leaves
    - Corolla tube glandular outside.....(1) *A. calendulacea* Mx.
    - Tube merely pubescent outside.....(2) A. speciosa Willd.
  - Flowers before the leaves.....(3) A. austrina Small
- Corollas white, pink, or purplish
  - Low stoloniferous shrubs, under 5 dm. high
    - Flowers white, tube glandular, funnel-form.....(4) *A. atlantica* Ashe
    - Flowers purplish, only back of lobes glandular, tube cylindrical (5) *A. neglecta* Ashe
  - Not stoloniferous, more than 5 dm. high
    - Leaf blades pubescent beneath
      - Corolla tube pilose, dilated above middle
        - Leaves not glaucescent under pubescence (6) *A. rosea* Lois.-Desl.
        - Leaves glaucescent under pubescence (7) A. alabamensis* n. c.
      - Corolla tube villose, apex abruptly expanded (8) *A. canescens* Mx.
    - Leaf blades strigose only on midrib beneath.....(9) *A. nudiflora* L.

Corolla expanding after the leaves
- Leaf blades glabrous beneath or with scattered hairs (except var. of (10)
  - Midnerve strigose beneath at maturity.....(10) *A. viscosa* L.
  - Midnerve glabrous at maturity
    - Leaves serrulate.....(11) A. serrulata Small
    - Leaves with ciliate margins
      - Corolla glandular pilose.....(12) *A. arborescens* Pursh.
      - Corolla nearly glabrous.....(13) A. prunifolia Small

Azalea speciosa should be looked for in North Carolina near the base of the Blue Ridge between Jackson and Polk counties.

The following varieties have been reported from or should be looked for in North Carolina:

A. nudiflora glandifera Porter. It has the pedicels and corolla tubes more or less glandular pubescent.

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* *Rhododendron alabamense* Rehd. Azal., 141. 1921.

A. atlantica luteo-alba Coker. It is distinguished by its finely pubescent leaves.

A. viscosa glauca Ait. It differs from the type in its glaucus leaves. It should occur in the coastal plain.

A. viscosa tomentosa Hort. (*A. tomentosa* de G. Bot. Cult., 2nd. ed., 3: 336. 1811). This has the leaves more or less pubescent. (Cumberland Co., near Manchester).

A. viscosa hispida Wood. The branchlets are hispid. It has not been found south of Pennsylvania but might occur in mountain swamps in North Carolina.

A. viscosa montana n. c. (*Rhododendron v.* var. Rehd. Azal., 164. 1921). This has been found only in the mountains of North Carolina. It differs from the type chiefly in the pubescent winter buds.

A. arborescens Richardsonii n. c. (*Rhododendron a.* var. Rehd. Azal., 168. 1921). This is a shrubby form which occurs on the summits of high mountains in North Carolina.

The following varieties which have been reported from further south do not occur in North Carolina:

A. canescens candida n. c. (*Azalea candida* Small. Bull. Torr. Bot. Club 28: 360. 1901). Differs from the type in the glaucescent and densely pubescent leaves.

A. serrulata georgiana n. c. (*Rhododendron s.* var. Rehd. Azal., 156. 1921). This differs from the type chiefly in its densely pubescent winter buds.

A. viscosa aemulans n. c. (*Rhododendron v.* var. Rehd. Azal., 165. 1921). This variety, which has been found only in Randolph County, Georgia, differs from the type chiefly in its larger leaves.

NOTE ON RHODODENDRON—During the past year considerable additional information has been secured concerning the two small early flowering rhododendrons of the southern Appalachians. *Rhododendron carolinianum* Rehd., the rose flowered plant, is not uncommon, particularly on dry standstone sites, in North Carolina and Tennessee to the north of the French Broad river valley. To the south of this valley, and particularly to the south of Mill Creek along the Blue Ridge at relatively low altitudes on moist cool sites, occurs the white flowered plant, *Rhododendron Margarettae* n. c. (*R. carolinianum* var. *Margarettae* Ashe, Rhod. **23**: 177. 1921) which on account of its different habitat and distinct distribution can probably best be regarded as specific.

FOREST SERVICE,
WASHINGTON, D. C.

NOTES ON THE REPRODUCTION OF HYDRA IN THE CHAPEL HILL REGION

By H. S. Everett

In the course of an investigation dealing with the germ cells of *Hydra* during 1920-1921, a number of observations were made on the occurrence and habits of hydras in the region around Chapel Hill. The work continued over a period from October until June, and it is the purpose of this article to record briefly such data as may be of general use and interest to the worker on *Hydra* in the Chapel Hill region.

Two species, *H. viridis* and *H. grisea,* were found throughout the period in collections of leaves, trash, and green algae from pools and swamps near the town. In the spring they occurred in much greater abundance out of doors than in the fall and winter.

H. grisea was always found budding vigorously, but showed no sex organs until late in May, when some specimens which had remained in aquaria in the laboratory for about two weeks developed gonads. Although green hydras were not found in a sexual state out of doors until April, animals could be found in the laboratory with gonads at nearly all seasons. This species *(H. viridis)* appeared in three aquaria, the material of which was collected early in October. The hydras underwent a period of vigorous budding, after which about the first of December large numbers developed sex organs. This sexual period lasted about a month. After it had ceased the animals in two of the aquaria seemed to be well-nourished and continued to bud for some months, but never returned to the sexual state. Those in the third aquaria seemed to be underfed, budding practically ceased, and they began to grow smaller. A careful examination of them about February the first revealed the fact that eighty-two per cent of them possessed male sex organs. This observation was in complete agreement with the statement often made that the spermaries are produced as a result of starvation. But though this may be one stimulus for the production of the sperm, it is certainly not the only one, at least in *H. viridis,* for the ovaries are never

found without the spermaries also, and the ovaries are found only in well-fed animals.

The period, then, most favorable to sexual reproduction in *Hydra* in this region begins in April and continues through May, and since no cessation was noted at the time observations were discontinued, we may conclude that it probably extends on into the summer.

The course of the development of the egg in *Hydra viridis* was followed in some detail. The egg arises from numerous ordinary interstitial cells, which first enlarge beneath the epithelial ectoderm and then coalesce to form a single egg. One nucleus persists as the egg nucleus, the rest degenerate. The coalescence is at first by simple fusion of the central cells to form a large central mass, which then ingests the peripheral cells in an amoeboid fashion.

My observations are in general accord with those of Jannreuther (Biological Bulletin 14, 16) and Wager (Biol. Bull. 18).

The subsequent development has been often described and is well known. The time required for the development of the egg until its extrusion through the ectoderm is about four days, while about three weeks are consumed after the extrusion through the ectoderm before the young hydra is hatched. These observations were made on animals kept in laboratory vessels where it was also found that the number of extruded eggs which fail to develop either from non-fertilization or other causes is very large. It was not possible to determine whether these same facts hold for the out-of-door environment.

CHAPEL HILL, N. C.

CHEMISTRY IN ITS RELATION TO THE STATE WATER SUPPLIES

By G. F. Catlett

Twenty years ago in comparison to the possible development the chemist and applied chemistry were utilized very little in solving industrial problems. It has been interesting and gratifying to observe how the utilization of the chemist has broadened until in recent years most large corporations and big industries have their own research laboratories and control by chemists over their processes and raw material.

In the field of municipal utilities the late Dr. Baskerville in his book "Municipal Chemistry" has covered very fully how chemistry is concerned very essentially in most all of our municipal activities. In particular may be mentioned water supply and water purification, sewage disposal, waste and garbage disposal, gas supply, quality of materials such as cement and paving materials. While the application of the chemical data, except in very large organizations, is usually made as part of the work of the sanitary engineer, the solution of the chemical problems must rest with the chemist.

Almost as far back as the history of the science dates the chemists have developed analytical methods and made investigations that cover the properties and quality of natural waters for domestic and industrial uses.

As the cities and town have grown and the population has collected in more or less congested groups, it has become necessary, in North Carolina as elsewhere, to utilize sources of water supply which require very elaborate purification to render them suitable for domestic and industrial purposes. It has also been necessary to devise treatments of sewage and wastes in order to prevent their contaminating these public water supplies.

North Carolina now has over fifty towns and cities where it is necessary to filter and purify an unacceptable surface water in order to obtain a suitable public drinking supply. In general only the very smallest towns are able to utilize natural underground water supplies, and even those frequently require chemical sterilization. As

the towns grow the number of purification plants are rapidly increasing.

Almost the universal method for purification is the so-called mechanical or rapid sand filtration involving the coagulation of the water with aluminum hydrate and the preparation of a film of this chemical as a medium through which the water is filtered. In conjunction with this is chemical sterilization with chlorine. These processes are basically chemical ones, and difficulties encountered in their use must be largely solved through chemistry. The mechanical features in both cases have been very highly developed, and such lack of efficiency as is found is chiefly due to the chemical features.

When mechanical filtration first began to be utilized aluminum sulphate (commonly called filter alum) was used and the hydrate serving as coagulent prepared by adding soda ash sufficient to react with the aluminum sulphate required and to furnish sufficient excess to insure complete precipitation of the alum.

While the process was in general recognized as a success, different waters reacted differently using the same amount of chemicals, and on the same type of water poor coagulation was frequently experienced and in many cases the reaction involved did not complete itself until after passing the filters with precipitation in the water mains. These troubles were experienced particularly in the case of waters with considerable vegetable stain such as are found in eastern North Carolina.

About the year 1915 several engineers, including the writer, called attention to the fact that what was involved in the whole process was so-called "colloidal chemistry." It was well recognized that aluminum hydrate was precipitated in colloidal condition and its coagulation followed the known action of such physical condition. The finely divided clay and organic matter was obviously in colloidal condition, and Thorndike Saville, working in the Harvard Laboratory, proved that the vegetable coloring matter was in colloidal suspension. It was also determined that the clay was negatively charged and aluminum hydrate and coloring matter positively charged. It was suggested that the proper application of aluminum sulphate and the ratio of this to alkali present was one of ionization balance.

Due largely to the fact that "colloids" and "ions" represented something surrounded by impenetrable mystery to the average engi-

neer and water works man, a proper investigation of the matter has been very slow to start. During recent years, however, a great deal of interest has been awakened, and we find no convention of water works people whose program does not include at least one paper on hydrogen ion determination in the control of water treatment. Quite a little work is being done on the subject in various parts of the country and with recent development of simple methods for determining hydrogen ion concentration value, the outlook is good for some valuable data of practical value. At present there is very little useful information developed regarding the whole matter.

Another problem, entirely a chemical one, is trouble experienced in the corrosion of mains and plumbing or the deposition of incrustants in these mains. With the natural waters we felt as if we knew the causes of this and remedies. With the chemical and physical condition of the water disturbed by the artificial means employed for purification, the matter is very much complicated. Such data as has been collected would indicate that the hydrogen ion concentration figures would solve this difficulty. The field at present, however, has been very little explored, the most important contribution to the subject being a very interesting paper by some Dutch chemists. In the case of chlorine sterilization the chief difficulty is to prevent chemical combination of the chlorine with waste by-products causing tastes and odors.

A fourth very important state problem, which we must look chiefly to our chemists to solve, is the interference with sewage disposal plants by dye house wastes. From various parts of the state we are having complaints of the functioning of municipal sewage disposal plants being entirely or partially destroyed by dye house wastes from textile plants. The chief trouble seems to be from bleach, sizing, and dyestuffs, of which the sulphur blacks seem to be the worst offenders. If we cut these out of the municipal sewerage and deposit in some adjacent small stream a nuisance is the usual result. The problem is how to treat these wastes so as to render them non-injurious to the disposal plant process, or how to change the disposal plant process so as to handle them, or else how to treat them separately and secure disposal without nuisance.

Upon inquiry there seems to be little information developed in other parts of the country in regard to the matter, chiefly because most of the textile communities that might have investigated have

larger streams for disposal than in our state. North Carolina, as you are aware, is a leading textile state and the problem is one of importance to us and of general interest.

Some of the other states, notably Massachusetts, have contributed to a large extent to our knowledge of such subjects, largely through coöperation with their institutions of learning, through State Departments and the scientist concerned. There are certain features of the problems cited, especially in regard to the treatment of colored waters and the textile waste, which are peculiarly North Carolina problems.

These problems have been brought to your attention with the hope that the chemists may interest themselves in their solution. If it is not possible to do actual work upon them, the clearer understanding of such problems by virtue of chemical knowledge will put the chemist in better position to influence coöperation in their solution. There are no state funds available at present for such work, but the Department of Engineering at the University has offered to coöperate and the State Board of Health through its various bureaus concerned is always willing to lend any assistance in its power.

RALEIGH, N. C.

THE LACCARIAS AND CLITOCYBES OF NORTH CAROLINA

By W. C. Coker and H. C. Beardslee

Plates 1 and 7-33*

Laccaria

Cap fleshy, thin, usually depressed or umbilicate in center; gills thick with blunt margin, broadly adnate, in our species usually notched at the stem (sinuate), colored conspicuously, whitened by the abundant spores which are subglobose, white or faintly lavender, and echinulate; stem central, fibrous and toughish. Volva and veil wanting. Gregarious or cespitose. Our four species of this genus are very closely related, so much so that certain authors (Ricken, Die Blätterpilze 2: 382. 1915) consider *L. laccata*, *L. amethystea* and *L. tortilis* all forms of the same species, and from our observations in several sections of the country it is impossible to define any one of these three species so as to exclude forms of the others. In the vicinity of Chapel Hill we find that *L. laccata* can be distinguished usually by its thinner, closer, less irregular gills which are nearly always paler than in the other two, where the variations are more confusing.

The genus differs from *Clitocybe* in the globose, asperulate spores and thicker gills which are more broadly attached, often sinuate and not decurrent except by a little tooth. The attachment of the gills is about as in *Tricholoma*, but that genus is separated by thinner gills and different spores. In *L. ochropurpurea*, *L. amethystea* and *L. tortilis* the mature gills are conspicuously white-dusted by the spores, but in the commonest forms of *L. laccata* this character is not well shown.

Important American Literature

Kauffmann. Agaricaceae of Michigan, p. 747 (as *Clitocybe*). 1918.

Morgan. Journ. Cincinnati Soc. Nat. Hist. 6: 66 (as *Clitocybe*). 1883.

Murrill. N. Am. Flora 10: 1. 1914.

Peck. Bull. N. Y. St. Mus. 157: 90. 1912.

* In the colored plate, figures 1, 6 and 7 were painted by Miss Dorothy Coker, figures 2 and 5, by Miss Cornelia S. Love and figures 3 and 8, by Miss Alma Holland. All spore drawings are by Miss Holland. Unless otherwise stated photographs are by Coker and are natural size. Those by Beardslee are noted "Photo by B." The written matter is by Coker unless otherwise stated.

PLATE 7

LACCARIA OCHROPURPUREA. No. 641.

KEY TO THE SPECIES

Plants usually more than 5 cm. broad.....*L. ochropurpurea* (1)
Plants less than 5 cm. broad
  Cap not marked by lines; plants larger than *L. tortilis*
    Gills pinkish lilac.....*L. laccata* (2)
    Gills deep violet-purple.....*L. amethystea* (3)
  Cap distinctly striatulate; plants small; growing in wet places.....*L. tortilis* (4)

1. **Laccaria ochropurpurea** (Berk.) Peck.

PLATES 7 AND 33

Cap 6-13 cm. wide, almost smooth or slightly scaly, often irregular and contorted, bright tan or clay color with a very light tint of pink from the flesh which is light pink, thick in the center and thin on the margin.

Gills purplish-lilac, changing to grayish purple and powdered by the spores, distant, very wide, thick, wavy and irregular, usually sinuate and slightly decurrent by a tooth.

Stem stout, usually crooked, variable in length and thickness, tough and firm, solid, color of cap, longitudinally marked with pinkish fibers.

Spores (of No. 1311) globose, minutely asperulate, 6.8-8.5μ in diameter. A thick spore print of No. 4675 shows a decided tint of pale lavender like the gills.

Not rare in uplands along banks, roads and margins of woods.

For other illustrations see Peck, Bull. N. Y. St. Mus. **116**: pl. 106, figs. 7-11. 1907; McIlvaine, Am. Fungi, pl. 24, figs. 1-4. 1900; Hard, Mushrooms, pl. 11.

100. In Battle's Park, October 8, 1904.
179. In mixed woods near creek, Glen Burnie Farm, October 1, 1908.
181. Under log in damp ground, October 1, 1909.
641. From under the sides of rocks by a road, October 28, 1912.
761. Along "Fern Bank," September 14, 1913.
1311. By road through deciduous woods, October 7. 1914.
4675. Mixed woods near Pittsboro road, October 15, 1920. Spores pale lavender, spherical with sharp straight mucro, minutely echinulate, 7.2-9.5μ thick.

Asheville. Rather common. Beardslee.

2. **Laccaria laccata** (Scop.) Berk.

PLATES 1, 8 AND 33

Cap about 3 cm. broad on the average, running up to 6.5 cm., deeply depressed in center and often irregular and split, hygrophanous, surface light tan or reddish buff or buffy cinnamon when not soaked, a deeper reddish-ochraceous when soaked, rarely striatulate, squamulose-scurfy or only somewhat channelled and fibrous. Flesh very thin, tough and elastic, a light pink color, taste slightly woody, odor none.

Gills broad, up to 1.2 cm. wide, not crowded, sub-distant or distant, thickish and wavy, entire, or at times fragmented and irregular, notched at the stem, slightly decurrent by a tooth, pinkish with a tint of lilac.

Stem 2.5-9 cm. long, 3-6.5 mm. thick, sub-equal or irregular, at times bulbous, hollow, tough, elastic, fibrous, color of cap with a tint of flesh.

Spores (of No. 854) spherical, echinulate, 6.6-7.6μ in diameter not including the spicules. Basidia (of No. 5118) 7.4-8μ thick, 4-spored; hymenium about 48μ thick, with a few crystals; threads of the gill flesh 3.7-7μ thick, constricted at the septa, and parallel in section.

The species is common in pine and not rare in deciduous woods, growing often in populous colonies and sometimes in fairy rings. It is distinguished from *L. tortilis* by stouter form, thinner, closer and more regular gills, usually non-striate cap, and preference for upland woods. It differs from *L. amethystea* in absence of deep purplish color and thinner, closer and more regular gills.

For other illustrations see Cooke, Ills. Brit. Fungi, pl. 139; Hard, Mushrooms, figs. 76 and 77; McIlvaine, Am. Fungi, pl. 24, fig. 10. 1900; Murrill, Mycologia 3: pl. 40, fig. 4. 1911; Peck, Rept. N. Y. St. Mus. 48: pl. 25, figs. 1-13. 1895.

854. Growing abundantly in a large fairy ring about twenty feet in diameter under pines, September 18, 1913.

1413. Under pines near Piney Prospect, October 24, 1914.

1435. Under pines near Piney Prospect, October 28, 1914. Spores spherical, echinulate, 6.8-7.6μ.

1495. Under pines, Glen Burnie Farm, December 8, 1914.

2960. On ground in pine woods, December 3, 1917.

2993. On ground in pine woods, March 25, 1918.

3176. Low place in deciduous woods east of cemetery, October 3, 1918. Spores 6.3-8.5μ thick.

PLATE 8

LACCARIA LACCATA. No. 854.

3181. Among pines near branch southeast of campus, October 5, 1918. Spores white, spherical, papillate, 7-9μ.

3246. By branch in deciduous woods, Lone Pine Hill, May 25, 1919. Spores 7-9.3μ thick.

5118. By branch south of campus, May 19, 1922. Typical. Spores spherical, minutely spinulose (less so than in *L. tortilis*), 6-8.2μ thick.

Asheville. Very common. Beardslee.
Blowing Rock. Atkinson.
Reported by Curtis.
South Carolina: Hartsville. In pines and in a field, December 26, 1918 (No. 72. W. C. Coker, coll.).

3. **Laccaria amethystea** (Bull.) Murrill.

PLATES 1 AND 33

Cap 1-5 cm. broad, irregularly crumpled and lobed, in age the margin uplifted or reflexed; the center depressed or plane; surface like rougish leather, the margin finely scaly, not squamulose all over as typically in *L. laccata*, color when not soaked avellaneous to vinaceous buff (Ridgway); when young and when soaked almost as purple as the gills, the margin retaining the purple longer. Flesh very thin, up to 1 mm., toughish, concolorous, taste and odor musty-fungoid.

Gills distant, thick and leathery, up to 3.3 mm. thick, irregular, broadly adnate and decurrent by a tooth, color at all ages deep violet purple (about dull Indian purple of Ridgway), at maturity dusted with the spores.

Stem 3-5 cm. long, 2-5 mm. thick, sub-equal or enlarged below or above, crooked, tough, color of cap or whitish with a scurfy surface; in youth purple; stuffed then hollow.

Spores white, spherical, minutely spinulose, 7-10μ thick. Basidia 5.5-8.5μ thick, 2-4 sterigmata. Hymenium 48μ thick, with many crystals. Threads of the gill flesh 3.7-8μ.

In damp places in woods; rather rare. This plant has been considered a species or a variety or only a form of *C. laccata*. Peck treats it as a good species, Kauffman as a variety and Ricken as only a form. Careful comparison in the fresh state of this and the common form of *C. laccata* shows the latter to differ in broader, thinner, less distant and notched gills of a pinkish-lilac (much paler) color, cap more squamulose and buffy-cinnamon in color. For other illustrations of *L. amethystea* see Mycologia **10**: pl. 8, fig. 2. 1918;

Bulliard, Herb. Fr., pl. 198; Bolton, Hist. Fung. Halifax, pl. 63. 1788.

3622. In pine woods by Bowlin's Creek, November 9, 1919.
5046. Among moss on side of stream, May 8, 1922.
5119. On earth by ditch in deciduous woods, May 19, 1922.
5178. By branch south of campus, June 6, 1922.

Asheville. Occasional. Beardslee.

4. **Laccaria tortilis** (Bolt.) B. & Br.

PLATES 1, 9 AND 33

Caps usually irregular, often cespitose, 0.5-2.3 cm. broad, rounded or nearly plane to depressed in center, usually slightly unbilicate, nearly smooth or minutely fibrous roughened, hygrophanous, and, when water-soaked, of a dull fleshy-brick color with a distinctly deeper-colored line over each gill (striatulate); when dry pale fleshy buff and not striatulate or very faintly so. Flesh colored like the surface, brittle, very thin and translucent, only one-third mm. thick near stem; taste rather nutty.

Gills broadly adnate, usually sinuate, sometimes squarely attached, very slightly decurrent, distant, thick, irregular, the margin blunt, deep flesh color and distinctly powdered with the white spores.

Stem 1.2-3.5 cm. long, 1-2 mm. thick, equal, often twisted and bent, sometimes flattened; surface pruinose, flesh tough, fibrous, a small hollow, color of cap, the base often somewhat swollen and at times white with mycelium.

Spores white, spherical, echinulate, 7.4-10.3μ, (up to 11μ, counting the spines) usually about 9.2μ in diameter. Basidia (of No. 5121) 9.7-12.5 x 30-37μ with 4 long, curved sterigmata.

Frequent in damp depressions in woods and along wet ditches. The spores of our plant are smaller than the dimensions given by Peck, but they are distinctly echinulate and also very variable in size in the same plant. The striatulate cap, small size, irregular shape, thick distant and leathery gills, large spores and swampy habitat would indicate this species. Patouillard describes and figures the basidia as two-spored (see below). They have not been so in the plants we have examined.

For other illustrations see Mycologia 10: pl. 8, fig. 4 (as *L. striatula*). 1918; Bolton, Hist. Fung. Halifax, pl. 41. fig. A (as *Agaricus tortilis*). 1788; Patouillard, Tab. Fung., No. 105.

LACCARIA TORTILIS. No. 1954.

1951. In grass in moist place in Arboretum, November 1, 1915.
2454. Swamp of New Hope Creek, September 28, 1916.
2886. Swampy woods near Strowd's pasture, October 8, 1917. Spores spherical, echinulate, 7.4-10μ thick, not counting spines, 8.4-11μ counting spines.
3199. Low place with moss, October 7, 1918. Spores 7.4-9μ thick.
3344. In moss by creek below Glen Burnie Farm, June 11, 1919. Spores 7-10μ thick.
3612. Damp ground near swamp, Strowd's low grounds, November 8, 1919. Cap 5-13 mm. broad, almost glabrous, striate when moist, deep reddish-ochraceous.
5121. On earth by branch south of campus, May 19, 1922. A very small lot; gills sometimes decurrent, spores spherical, spinulose, 7.7-10.5μ thick.

Asheville. Rare, usually in damp places. Beardslee.

CLITOCYBE

Cap mostly depressed in center or infundibuliform, the margin involute to near maturity. Gills narrowed toward the stem, typically decurrent, but often only slightly so and rarely they are even a little notched at the stem. Stem fibrous externally, more or less elastic, not brittle, sometimes hollow, continuous with the flesh of the cap. Spores typically white, but flesh color in *C. cerussata* and tinted pinkish-lavender in *C. cyathiformis*, elliptic, pip-shaped or rarely subspherical, smooth in all species here included, said to be minutely echinulate in *C. pulcherrima, C. albissima* and *C. maxima*. Volva and annulus wanting. Growing on the ground or among leaves or on rotting wood. One species, not yet found here (*C. nebularis*), is the host of a parasitic *Volvaria* (*V. Loweiana*. See Mycologia 8: 65. 1916) and another (*C. peltigerina*) grows on the lichen *Peltigera*. This is not always an easy genus to determine as the gills are variable, in some cases approaching *Tricholoma*, in others *Collybia* or *Omphalia*. A few of the species are poisonous, as *C. illudens* and *C. morbifera*, but these are not classed among the deadly mushrooms. *Clitocybe sudorifica* causes profuse perspiration.

IMPORTANT AMERICAN LITERATURE

Kauffmann. Agaricaceae of Michigan, p. 715. 1918.
Morgan. Journ. Cincinnati Soc. Nat. Hist. 6: 66. 1883.
Murrill. N. Am. Flora 9: 396. 1916; Mycologia 7: 256, pls. 164-166. 1915.
Peck. Rept. N. Y. St. Mus. 23: 75. 1872. Bot. ed. Also Rept. 157: 59. 1912.

KEY TO THE SPECIES

Plants growing from bases of stumps or from underground wood; densely cespitose and usually large
  Plant brownish or honey-colored.....*C. tabescens* (3)
  Entire plant orange colored.....*C. illudens* (5)
Plants not wood-loving, or if so not densely cespitose and smaller
  Plants with a distinct odor of sweet fennel or anise
    C. odora var. *anisaria* (14)
  Not with an odor of sweet fennel
    Gills golden yellow; cap fibrous lined.....*C. ectypoides* (15)
    Gills not golden yellow
      Cap white or tan or buff or fleshy-buff (see also *C. infundibuliformis*)
        Cap large, up to 7-11 cm. broad
          Gills broad, margin of cap lobed or crenate.....*C. gigantea* (1)
          Gills narrow, crowded, margin of cap even; plants strongly cespitose.....*C. cerussata* (4)
        Cap smaller
          Cap marked by more or less concentric rivulose lines..*C. rivulosa* (20)
          Cap not so marked
            Growing in open grassy places, cap light buff or fleshy-buff.....*C. dealbata* (19)
            Growing in woods among leaves and sticks, or on much decayed wood
            Growing among pine needles.....*C. pinophila* (17)
              Not growing in pine woods
                Stem base with radiating hairs; spores 2.7-3 x 3.8-4.2μ.....*C. setiseda* (18)
                Stem base without hairs.....*C. adirondackensis* (11)
      Cap chestnut red or reddish when young, often ochraceous or lighter in age
        Center of cap cracked into minute, inherent scales *C. sinopicoides* (10)
        Center not cracked.....*C. infundibuliformis* (9)
      Cap blackish-brown or grayish-brown or grayish buff or umber or drab when moist
        Taste and odor strongly farinaceous, the cap brown or smoky
          Stem long, white below.....*C. cyathiformis* (16)
          Stem shorter, not white below.....*C. subnigricans* (8)
        Taste and odor not farinaceous
          Strongly cespitose, usually with stems fused below into a solid mass
            Cap grayish-brown to sordid brown.....*C. tumulosa* (6)
            Cap smoky gray to nearly white.....*C. conglobata* (7)
          Not strongly cespitose
            Gills very narrow, not over 2 mm. wide.....*C.* sp. (2)
            Gills over 3 mm. wide
              Stem base much swollen.....*C. clavipes* (12)
              Stem base not swollen.....*C. media* (13)

1. **Clitocybe gigantea** Sowerby.

Paxillus giganteus (Sow.) Fr.

PLATE 10

Solitary or gregarious; cap up to 11 cm. wide, depressed in center, the margin incurved when young, drooping at maturity, usually very irregular and much lobed; surface whitish to light tan or buff, darkest in center, smooth or somewhat pruinose in angles. Flesh white, soft, mild.

Gills not crowded in our plants, irregular, thick, wide, up to 8 mm., many short ones, none forked, decurrent, but ending abruptly and bluntly and therefore somewhat resembling a *Tricholoma*. The gills are slow to develop and in young plants are very narrow.

Stem short, about 5 cm. long, 1.5-2 cm. thick, the outer part fibrous, the inner softer and often cavernous, usually bent at base; surface smooth, color of cap, pure white at the very top.

Spores white, smooth, elliptic, 3.5 x 5-6μ.

A peculiar plant that is not closely related to other species of *Clitocybe*. It is said to reach a breadth of over a foot. The thick and irregular gills remind one of a *Paxillus*, but they do not separate easily from the cap.

This agrees well with *C. gigantea* in the sense of Kauffman except that the gills are not very crowded. Ricken does not give the spores.

For other illustrations see Gillet, Champ. Fr., pl. 124 (100); Quélet, Champ. Jura et Vosg. 1: pl. 3, fig. 3. 1872; Cooke, Ills., pl. 106; Juillard-Hartmann, Icon. Champ. Sup., pl. 31, fig. 5.

1765. Low damp woods near pines at foot of Lone Pine Hill, September 12, 1915.
1832. In woods loam by branch south of Raleigh road, Rocky Ridge Farm, September 20, 1915.

Asheville. Rare. Beardslee.
Reported by Schweinitz.

2. **Clitocybe** sp. ?

PLATES 11 AND 33

Cap 4-13 cm. broad, broadly depressed in center, the margin plane or crimped and drooping, surface quite glabrous, sub-shining, viscid when wet; color buffy drab, between drab and wood-brown of

Ridgway. Flesh white, only up to 1 cm. thick at stem, very thin toward margin, pliable, taste mild and sweetish, odor faint.

Gills crowded, very narrow, hardly up to 2 mm. wide, fading to a line toward the stem and barely reaching it; color exactly that of the cap.

Stem 2-4.5 cm. long, 1.3-1.8 cm. thick, color and surface of cap, solid, soft and pliable, the base sub-bulbous.

Spores white, smooth, sub-elliptic to pip-shaped, 2.2-3 x 4-5μ.

A peculiar plant, sharply marked by the uniform gray-buff color, soft, tough flesh and peculiar gills. In the absence of young stages and with only one collection we prefer not to name it as yet. It may possibly be a form of *C. nebularis*, but a plant of that species from Peck has gills broader and much darker in the dried state. It cannot be *C. geotropa*. In his Funghi Mangerecci, pl. 39, Bresadola shows an obviously different plant and the spores are nearly globose and rough. A plant from his herbarium, so labelled, has spores that are rough, but they are 3.7-4.6 x 5-7μ and are not like those of our plant. Ricken gives the spores at 5-6 x 6-7μ and does not mention roughness. *Clitocybe geotropa* is also recognized as being a paler plant than ours and as being umbonate or gibbous and it could hardly be brought to the thinness in center shown by No. 3210. (See Bresadola as cited above; Ricken, pl. 101, fig. 1; Bulliard, pl. 573; and Dumée, Atlas Champ., Ser. 2, pl. 15). *Clitocybe lenticulosa* Gill. is also easily different, with its rough cap and white, long decurrent gills (Champ. Fr., p. 144, pl. 130).

3210. In sandy humus near branch west of Meeting of the Waters, deciduous woods, October 9, 1918.

3. **Clitocybe tabescens** (Scop.) Bres.

Pleurotus caespitosus B. & C.
Clitocybe caespitosus (B. & C.) M. A. C. Not *C. caespitosa* Pk.
Clitocybe monadelpha Morg.
Agaricus gymnopodius Bull.

PLATES 12 AND 33

Plants densely cespitose at bases of old stumps, and from underground wood. Cap up to about 7 cm. broad, usually between 4 and 6 cm., expanded and broadly umbonate; tawny or honey color, edge

PLATE 10

CLITOCYBE GIGANTEA. No. 1765.

CLITOCYBE. No. 3210.

PLATE 12

CLITOCYBE TABESCENS. No. 1342.
Reduced about one-fifth.

often water-soaked and darker, the surface with small scales in center, elsewhere nearly smooth or squamulose-fibrous.

Stem long, dark grayish-brown, tapering to a point at the crowded base, solid, tough, fibrous, bent and usually twisted.

Gills decurrent, not crowded, pale flesh color, often with brown stains.

Spores variable in size in the same plant, white, subspherical to elliptic, smooth, (of No. 1342) 4.8-7.4 x 6.5-10μ.

This plant, which is very common around stumps from July to cold weather, is much like *Armillaria mellea* in habit, color, texture and general appearance, and is easily confused with it in passing. The entire absence of a veil in *Clitocybe tabescens* will, however, serve as an easy distinction between the two plants. Pure cultures of these two species grown on wood, agar and other media by one of our students, Mr. H. R. Totten, Instructor in Botany, shows that *C. tabescens* is certainly distinct from *A. mellea*. In agar, the rhizomorphs of the latter are blackish, while those of the former are white. (Jour. E. Mitchell Sci. Soc. 33: 96. 1917).

There seems no doubt that Bresadola is right in considering the American plant the same as the European. His good figure is just like our plants (Fung. Trident. 2: 84, pl. 197. Bulliard's plate, No. 601, is less good). Other synonyms given by Bresadola are *Agaricus socialis* DC., *Agaricus inarmillatus* Schulzer, *Lentinus caespitosus* Berk. Still other names, according to Murrill (N. Am. Flora 9: 420. 1916), are *Clitocybe aquatica* Banning and Peck and *Armillaria mellea exannulata* Pk. See a note by Lloyd in Myc. Notes 6: 54. 1901.

While not of first-class quality, this species is edible and on account of its great abundance could probably be made valuable to the housekeeper. It can be easily dried and put away for future use.

For other illustrations see Morgan, Journ. Cinn. Soc. Nat Hist. 6: pl. 4, 1883; McIlvaine, Am. Fungi, pl. 27 (as *C. monadelpha*), 1900: Hard, Mushrooms, pl. 12 (as *C. monadelpha*), 1908.

182. On underground wood, campus, September 27, 1908.

188, 198, 1342, 1373, 2453, 2457. All around stumps or from underground wood in October. Spores of No. 2457 elliptic, smooth, 5-6.5 x 6-8.5μ, of No. 1373, 4-6 x 5.5-8μ.

Asheville. Not common. Beardslee.

Reported by Curtis (as *C. cespitosus*).

4. **Clitocybe cerussata** Fr.

Clitopilus caespitosus Pk.

PLATE 13

The following is by Beardslee:

Strongly cespitose; cap 3-10 cm. broad, round convex, becoming expanded and plane or depressed, white with a silky luster, often grayish white with a water-soaked appearance with age, margin thin, even or obscurely striate, inrolled at first. Flesh white to watery white.

Gills white becoming dingy or flesh-color, narrow, crowded, many shorter and a few forking, sinuate-adnate to adnate-decurrent.

Stem 7-10 cm. long, usually about 1 cm. thick, spongy stuffed becoming hollow, silky fibrillose.

Spores 2.5-3 x 4-5μ ellipsoid, flesh color in mass.

This is without doubt Peck's *Clitopilus caespitosus.* In many ways, however, it is more suggestive of *Clitocybe* than *Clitopilus.* It is true that the spores have a rosy tint when they are viewed in mass, but they are much lighter than is usual in *Rhodosporae.* In fact if care is not taken to secure a good spore print they may easily pass for white. The fact that a number of species of *Tricholoma, Clitocybe,* and *Pleurotus* have spores that are not pure white lead to the belief that this plant might be known in Europe as a *Clitocybe.* Specimens and photographs were accordingly submitted to Bresadola who positively identified our plant as *C. cerussata* Fr., our usual form being variety *difformis.*

We are therefore referring our plant to this species especially as its large size, fragile flesh and light colored spores seem to indicate a closer relationship with *Clitocybe* than *Clitopilus.*

Asheville. In large masses in the margins of woods. Beardslee.

5. **Clitocybe illudens** Schw.

PLATES 14, 15 AND 33

Cap up to 15 cm. broad, expanded then depressed in center, bright orange or golden yellow; margin elevated or drooping, surface smooth and glabrous. Flesh yellowish, taste and odor rather strong.

Gills close, strongly decurrent, color of cap.

PLATE 13

CLITOCYBE CERUSSATA. Asheville. Photo by B.

PLATE 14

CLITOCYBE ILLUDENS.
Near east gate of campus. Reduced.

CLITOCYBE ILLUDENS. No. 557. Reduced.

Stem long, solid and elastic, bent, tapering downward, color of cap.

Spores (of No. 183) white, sub-globose, smooth, 4-4.6μ thick.

A large and very striking species growing in densely cespitose clusters from the bases of stumps of deciduous trees or from roots near the surface of the ground; not rare in September and October. It was first described by Schweinitz from this State. The entire plant is brightly colored and may be seen from a long distance. It is poisonous to most people though not classed among the deadly species. It is a severe emetic and may also cause intestinal derangement. For cases in detail see Fischer in Kauffman's *Agarics of Michigan*, p. 486. The gills exhibit a marked phosphorescence which may be easily shown by looking at the plants in a dark room.

For other illustrations see White, Bull. Conn. Geol. & Nat. Hist. Surv. 3: pl. 18. 1905; McIlvaine, Am. Fungi, pl. 29a. 1900; Hard, Mushrooms, pl. 10; Mem. N. Y. St. Mus. 4: pl. 68. 1900; Marshall, Mushroom Book, pl. opposite p. 70. 1904.

183. On an oak stump near east gate of campus, September 14, 1910.
184. Near Meeting of the Waters, on a stump, September 30, 1908.
557. By a stump on Cameron Avenue, October 14, 1912.
Blowing Rock. Atkinson.
Asheville. Very common. Beardslee.
Reported by Curtis.

6. **Clitocybe tumulosa** (Kalchbr.) Sacc.

Agaricus multiformis Schaeff., plate 14.

PLATES 16, 17 AND 33

Plants cespitose or gregarious. Cap up to 10 cm. wide, convex, smooth, not viscid, quite irregular, the margin incurved nearly to maturity, remaining bent down, usually strongly lobed and crenated, color grayish-brown or sordid-brown, lighter on the margin, turning nearly black in age. Flesh about 8 mm. thick near stem, very thin on margin, sordid white, tender, tasteless, odorless.

Gills not crowded at stem but much closer at margin, where there are very many short ones, rather narrowly adnate to the stem, not sinuate and varying from *not decurrent* in some plants to distinctly so in others, up to 6 mm. wide in middle, dingy white at maturity and somewhat dingy even when quite young. The gills are very sus-

ceptible to the attacks of insects or snails and are usually almost entirely eaten away before maturity.

Stem up to 6 cm. long, often bent at the base, in our plants usually fused with others into a solid basal mass, sometimes nearly equal above the base, again strongly expanding near the cap; when not fused with others the individual stems are usually decidedly swollen or bulbous below, but base not enlarged in the fused stems except as they expand into the mass; surface smooth, generally with ridges and grooves, almost silky-shining, dull or sordid white; flesh rather fragile, fibrous, solid, but softer-fibrous inside.

Spores white, short elliptic, lateral apiculus at one end, smooth, 4-5.4 x 5.4-6.8μ.

In Chapel Hill this species grows only in ashes, usually where piles of trash have been burned, a fact I have not seen mentioned by others.

Cooke's illustration of *C. tumulosa* (pl. 105) and Schaeffer's of *A. multiformis* (pl. 14) leave little doubt that their figures represent our plant. This is also true of Bresadola's pl. 32 in Fungi Tridentini, published as *C. conglobata* but later said by him in a letter to Beardslee to represent *C. cinerascens*. *Clitocybe fumosa* Fr. is lighter in color and has a more expanded cap. Peck's *C. multiceps* might well be this, but is described and figured (Bull. N. Y. St. Mus. **139**: pl. 117) as being much whiter, and photos by Kauffman (Agaricaceae of Michigan, pl. 157) and Clark and Kantor (Mycologia **3**: pl. 52. 1911) show a denser mass of plants. From these interpretations it would seem that *C. multiceps* is nearer *C. conglobata* than *C. tumulosa*, if indeed the two latter are really different. Ricken considers them, as well as *Tricholoma pes-caprae* Fr., the same. Gillet's pl. 689 under the last name is just like our Chapel Hill plant. *Clitocybe multiformis* Pk. does not seem to be different from *C. multiceps* (see Mycologia **7**: pl. 164. 1915).

Beardslee agrees that our Chapel Hill plants are *C. tumulosa* and that *C. multiceps* Pk. is the same. He believes that *C. conglobata* is different and we are giving his notes and photographs of this species as he understands it.

1941. In leaves and trash under oaks, October 22, 1915. Spores elliptic, smooth, one oil drop, 5 x 6-7.2μ.

1989. On burnt over ground with *Funaria* moss, oak woods east of athletic field, November 17, 1915.

PLATE 16

CLITOCYBE TUMULOSA. No. 1941.

CLITOCYBE TUMULOSA. Asheville. Photo by B.

2001. In ash pile, south of campus, November 23, 1915.
2006. In ash pile, southwest of campus. Spores 3.7-5 x 5-7.4μ.
2007. In soil containing ashes with moss *Funaria*, woods southwest of athletic field, December 6, 1915. Spores elliptic, smooth, hyaline, 3.6-4 x 5.8-6.7μ.
2008. In soil containing ashes, burnt-over place in woods southwest of athletic field, December 8, 1915.

7. **Clitocybe conglobata** Vitt.

PLATE 18

The following is by Beardslee:

Cap 2-5 cm. broad, at first rounded convex, becoming expanded with the fleshy center somewhat prominent as an obtuse umbo, smoky gray to almost pure white, usually darkest at the center, marked with darker fibrils. Flesh white, thin at the margin, rather fragile; no marked taste or odor.

Gills white, close, moderately narrow, varying in attachment from adnexed to adnate decurrent.

Stem white, solid, curving, furfuraceous at the top, springing in large numbers from a solid, white-fleshed, tuberous mass 10-12 cm. thick.

Spores globose, 6-7μ thick.

This species was found twice at Asheville, and seemed very different from the related species with globose spores, which we have referred to *Clitocybe tumulosa*. Specimens and photos were submitted to Bresadola who referred them as above, with the statement "*C. conglobata* Vitt. Funghi Mangerecci, tab. 34, not Fungi Tridentini, tab. 32, which is *C. cinerascens* Bull."

The first figure will be found to represent our plants well. It shows the cap white to pale gray, and the same densely clustered stems springing from a dense subterranean mass. The figure in Fungi Tridentini does not show these features. We are referring our plants to *C. conglobata* Vitt., therefore, in the sense of Bresadola's later views. As we find it the plant seems amply distinct and well worthy of a specific name.

Asheville. Densely cespitose in thick woods. Beardslee.
Linville Falls. In humus, August 24, 1922. No. 5758. Coker, coll.).

8. **Clitocybe subnigricans** Pk.

PLATES 1, 19, 20 AND 33

Cap 7-11 cm. broad, irregular, the center plane or depressed, margin broadly drooping and more or less zoned by light terraces, much crimped and lobed; surface dry, nearly glabrous in places, but still showing in areas a fine felted tomentum, (under a lens a light, fragmented, inherent pellicle is visible); color a peculiar buffy drab with blackish places where rubbed. Flesh color of cap, tough, elastic, very thin on marginal half, up to 6 mm. thick near stem, odor slight, taste rank and farinaceous.

Gills close, many lengths, not branched, about 6 mm. wide, adnate or mostly decurrent, none sinuate, color of cap, then soon smoky in an irregular way, the distal ends remaining light longest, finally blackish.

Stem 5-7 cm. long, 11-16 mm. thick, nearly equal, tough, solid, surface smoothish to roughish, color of cap at first, then blackish; base deeply inserted in the leaves and without a definite end.

Spores (of No. 3165) white, elliptic, smooth, 4-6.2 x 7.4-10μ.

This interesting plant has been compared with the type and found to agree, both in appearance and spores, which in the type are smooth, elliptic, 4.2-6 x 7-9.5μ.

3165. Deciduous woods by Battle's Branch, October 3, 1918.

3357. In moss bed by path to Meeting of the Waters, June 21, 1919. These two young plants are undoubtedly the same as above. They show that in the young state the cap is covered with a fine squamulose felt. The gills are sinuate and, when young, decurrent by a little tooth. Spores 3.7-4.4 x 6.6-7.7μ.

3361. Same place as No. 3357, June 25, 1919. Spores smooth, elliptic, 3-3.7 x 6.2-7.4μ.

3552. Mixed woods by Battle's Branch, October 29, 1919. Gills very crowded.

9. **Clitocybe infundibuliformis** (Schaeff). Fr.

PLATES 1, 21, 22 AND 33

Gregarious or cespitose among leaves in woods or in piles of turf. Cap 4-8.5 cm. broad, soon depressed in center or broadly infundibuliform, usually undulately, lobed and uneven, when young the margin strongly inrolled and distinctly lined by being pressed against

CLITOCYBE CONGLOBATA. Asheville. Photo by B.

PLATE 19

CLITOCYBE SUBNIGRICANS. No. 3165.

PLATE 20

CLITOCYBE SUBNIGRICANS. No. 3165.

the gills just as in *C. odora,* these lines still visible or absent at maturity; surface finely puberulent when young and in protected places until maturity, usually becoming smooth or nearly so from the collapse of the tomentum; color in youth deep reddish tawny, but soon fading to a dull brownish tan, the margin pale and sometimes zoned. Some plants are decidedly flesh color at maturity. Flesh white, soft, 4-10 mm. thick in center, gradually thinning outward, taste fungoid-musty; odor slight, similar.

Gills crowded, slightly decurrent, 2-2.8 mm. wide, some branched, and in No. 2512 abundantly and conspicuously veined in most of the plants (a few with inconspicuous veins); color pale creamy, in drying becoming more like the cap color.

Stem variable in size, 2.5-3.5 cm. long above ground, 5-15 mm. thick, often deeply inserted, nearly equal, color of gills, nearly smooth where exposed, but covered with soft cottony mycelium where protected and bound firmly to the substratum with it, center softly stuffed and often hollowed by grubs.

Spores (of No. 2512) not abundant, smooth, pip-shaped with the small end curved, 2.4-4.5 x 5-7μ.

We are referring this to *C. infundibuliformis* because of its deep reddish color (fading to tan), only slightly tomentose cap, crowded, narrow gills, and spores like those of the European plant. A specimen from Bresadola is just like ours and has spores 3.5-4 x 5.2-7.4μ. Bresadola thinks that *C. adirondackensis* Pk. is the same, and they are certainly very close. A collection of the latter by Peck from Bolton, N. Y., is just like our plants in the dried state and has the same spores (3.5-4.2 x 4.5-7μ). However, there is a milk white plant found at Asheville (Beardslee) and Blowing Rock (Coker) that is very smooth and may conveniently be separated as *C. adirondackensis* (which see).

This species is very near *C. sinopicoides,* from which it may be distinguished only in the most typical forms. In such cases the stouter stem, larger size, more glabrous surface and the vein-like ridges on the margin in youth and often until maturity serve to mark it. The spores are alike, and I have come to the conclusion, after several years of observation, that the two are only different forms of the same species, the larger veined form growing most often under cedars and pines, the smaller with smooth margin under deciduous trees, but not confined to them. The latter often has short, obscure

ridges or a series of dots near the margin which are intermediate between the smooth and veined extremes; smooth plants also occur among the veined ones of cedars. The two forms occur in abundance at the same time and are exactly alike in color, shape, odor, taste, gills and spores.

For illustrations see Dumée, Atlas de Champignons, pl. 16; Cooke, Ills. Brit. Fungi, pl. 107; Gillet, Champ. Fr., pl. 107 (126) and pl. 127; White, Conn. Geol. and Nat. Hist. Surv. Bull. 3: pl. 19. 1905; Hard. Mushrooms, pl. 9, fig. 65; Kauffmann, Agaricaceae of Michigan, pl. 158; Peck, N. Y. St. Mus. Rept. 48: pl. 24, figs. 1-6. 1895; McIlvaine, Am. Fungi, pl. 24, fig. 11.

2512. In a pile of rotting turf by road at cemetery, June 11, 1917.
2767. Same spot as No. 2512, July 24, 1917.
2841. From woods on right of Durham road, October 1, 1917.
3248. In grass lawn of President's house and by sidewalk near, May 28, 1919.
3258. Under cedars in cemetery, May 30, 1919. All these plants except one were distinctly veined on margin. One was quite smooth.
3260. Same spot as No. 2512, May 30, 1919.

Blowing Rock. Atkinson. Coker.
Asheville. Very common. Beardslee.
Reported by Curtis.

10. **Clitocybe sinopicoides** Pk.

PLATES 23 AND 33

Cap up to 5 cm. broad, usually about 3-4.5 cm., depressed in center, or almost plane, sometimes approaching infundibuliform; surface when young minutely pruinose-tomentose, the margin more distinctly tomentose, dry and chestnut red, becoming more or less squamulose and sometimes rivulose when old and fading to ochraceous-buff or even lighter, often with darker dots, margin usually irregular and very wavy, inrolled when quite young. Flesh white, soft, flexible, very thin, about 1 mm. thick half way to margin, much thicker over the stem; taste mild and slightly earthy, not farinaceous.

Gills very decurrent, white, changing to creamy and drying when mature to ochraceous buff, close or moderately so, very thin and narrow, only 1.5 mm. wide in center, many short, some forked, in large plants their sides sometimes veined.

Stem color of cap or lighter, smooth, tapering slightly downward, firm at surface and stuffed with soft, dense, white material like the

PLATE 21

CLITOCYBE INFUNDIBULIFORMIS. No. 2512.

CLITOCYBE INFUNDIBULIFORMIS. No. 2512.

CLITOCYBE SINOPICOIDES.
Upper three on right, No. 1140; other four, No. 1414.

cap flesh, tough or rather brittle, about 2-3 cm. long and 2-5 mm. thick, attached firmly to the ground with white mycelium. When mature the entire plant dries to a pretty ochraceous-buff.

Spores white, smooth, pip-shaped, 3.4-4.6 x 4.2-7.4μ.

In humus or grass or on rotten wood, in woods and groves.

We have examined Peck's type of *C. sinopicoides* and cannot distinguish it from our plants. The caps distinctly show the squamulose center and the spores are exactly the same except that a few of the former are a little longer (3.2-3.8 x 7-8.5)μ. In the presence of squamules and cracks on the cap in age the present species is like *C. sinopica*, but a European plant of that species from Bresadola has distinctly larger spores, 3.8-5.5 x 7-9.3μ and differs further in far less crowded gills and smoother cap. This is almost certainly the plant listed by Schweinitz as *C. gilva*, but according to Ricken that species has spherical, spiny spores. The present species is doubtfully distinct from *C. infundibuliformis*, which see for discussion.

614. On a very rotten log, October 24, 1912. Stem eccentric in several of these plants, but not hairy.
1068. In damp grassy place in woods, October 18, 1913. Spores white, oval, smooth, 3.7-4.6 x 5.5-7.4μ.
1140. In clusters, some cespitose, in a shaded lawn, July 16, 1914.
1414. Under pines in burnt over woods, near Piney Prospect, October 24, 1914. Spores 3.4-3.8 x 4.2-5.9μ.
2039. Among shrubs by path west of President's house, June 5, 1916.
2103. Deciduous woods, June 22, 1916.
2273. Oak woods, Lone Pine Hill, June 28, 1916. Spores pip-shaped, 2.4-4 x 5-6μ.
3262. By path on campus, May 29, 1919.
3264. Under oaks in cemetery, May 30, 1919. Margin not marked by lines but some with dots. Spores pip-shaped, 3-4 x 6-7.8μ.

11. **Clitocybe adirondackensis** Pk.

PLATES 24 AND 33

The following is by Beardslee:

Cap 2-7 cm. broad, thin, becoming deeply infundibuliform, dingy white, becoming white when dry, with a narrow marginal zone when moist; flesh thin, white, 2-3 mm. thick.

Gills thin, white, very narrow, scarcely more than 1 mm. thick, forking, long decurrent.

Stem slender 2-4 cm. long, 5-7 mm. thick, stuffed, then hollow.

Spores ellipsoid-ovate, 3-3.5 x 4-5μ.

Asheville. On old leaves; not rare. Beardslee.

Blowing Rock. In leaf mould, Aug. 19, 1922. (No. 5585. Coker, coll.).

12. **Clitocybe clavipes** Fr.

Cap up to 10 cm. wide, plane to depressed in center or cup shaped in age, glabrous, straw drab to buffy drab, hygrophanous. Flesh soft, pure white, 1.5 cm. thick near center; taste slightly acid, odor distinctly fragrant when wilting, rather like jessamine.

Gills close, 4.5 mm. wide, cream color when fresh, a deeper honey yellow when dry, slightly decurrent, edges entire.

Stem 3-5 cm. long, usually 6-10 mm. thick above, smooth, color of cap above; expanded below into a bulb which is up to 3 cm. thick, white and felted with the mycelium which holds the leaves.

Spores white, ovate-elliptic, smooth, with a very distinct oil drop, 3.7-4.2 x 6.5-8.2μ.

Our plants have been compared with *C. clavipes* as understood by Peck (Bolton, N. Y.) and are identical. The spores of the latter are 3-3.8 x 6-8μ. A preference for coniferous woods is noted by Peck, Kauffmann, Gillet and Ricken. Descriptions of these authors do not agree in all particulars, but it seems clear that our plant must be this species. Ricken says that the spores are roughish, but they are certainly not so in the American form.

For illustrations see Peck, Mem. N. Y. St. Mus. No. 4, 3: pl. 46, figs. 1-6. 1900; Gillet, Champ. Fr., pl. 115; Hard, Mushrooms, fig. 69.

Blowing Rock. Under dense white pine growth, Chetola, August 21-22, 1922. (No. 5651 and No. 5677. W. C. Coker, coll.).

13. **Clitocybe media** Pk.

PLATE 33

Cap about 5-8.5 cm. wide, gibbous or nearly plane at maturity, smooth, dull and with appearance of leather, slightly viscid when damp, margin incurved then expanded, often irregular; color brownish-gray all over, between smoke-gray and drab of Ridgway. Flesh white, soft and spongy, gradually thickening toward the stem, tasteless and odorless.

Gills distant to sub-distant, slightly decurrent or adnate, 5-6 mm. wide, ventricose, veined, none branched, pallid and more or less tinted with the cap color.

PLATE 24

CLITOCYBE ADIRONDACKENSIS. Asheville. Photo by B. [above].
CLITOCYBE SETISEDA. No. 1782. [below].

Stem 2.5-5 cm. long, 1-2 cm. thick in center, tapering downward, often flattened, color of the cap or lighter, smooth or pruinose above, flesh solid and like that of the cap.

Spores (of No. 2992) white, smooth, elliptic, 4-5 x 6-7μ, with a large oil drop.

The cap margin is at times marked by darker spots in a row as in *Tricholoma russula*. The species is new to the South, having been reported only from New York and Wisconsin.

For illustrations see Hard, Mushrooms, fig. 64. 1908; Peck, Rept. N. Y. St. Mus. 42: pl. 1, figs. 9-12. 1889; 48: pl. 23, figs. 1-7. 1896.

2992. On ground among leaves, Battle's Park, deciduous upland woods, March 19, 1918.

14. **Clitocybe odora** (Bull.) Fr. var. **anisaria** (Pk.) Kauffman.

Agaricus (*Clitocybe*) *anisarius* Pk.

PLATES 25, 26 AND 33

Plants cespitose or solitary in rotting leaves in woods. Cap up to 7.5 cm. broad, convex at first, but soon flat and then plane-depressed or somewhat umbilicate in center, not infundibuliform; margin inrolled when young, then plane or somewhat curved downward; surface dry, roughish with firm inherent squamules which are tipped by fine upright wisps of fibers, the margin covered with short hairy tomentum which is most easily observed in youth. Squamules and tomentum may both become practically invisible after maturity (as in No. 4669). Just back of the margin is also observable in youth a distinct circle of spots which correspond to the little cogs on the stem where the margin touched it. Color light pallid tan or brownish tan or whitish gray at maturity. When young a light bluish olive-tan, the marginal dots deeper smoky-blue-green. The center is darkest at maturity, a smoky drab or dull green, sometimes faded and not much darker than remainder. Flesh white, very brittle, 4 mm. thick near center, gradually thinning to margin. Taste mild, pleasant, like that of *Agaricus campestris*. Odor distinct and exactly like that of sweet fennel or of anise.

Gills crowded, slightly decurrent, and usually a little notched at stem, none branched, numerous short ones of any length, scarcely 2 mm. wide, color nearly white, then light tan, margin usually eroded in marginal half and nearly even near the stem.

Stem 4-5 cm. long, up to 5 mm. thick, nearly even below, coated with and fading into the thick white mycelium. Color of cap, when young nearly white. At top finely granulose and usually with a little collar of cogs about 1 mm. below the tip, middle region faintly fibrous, basal coated with white mycelium. Texture fibrous, rather brittle, inside stuffed, sometimes partially hollow in age.

Spores (on No. 1881) decidedly cream in bulk, elliptic, smooth, 4.5-5 x 5-7.2μ.

Our plants differ from the typical *C. odora* in the roughish-squamulose cap, quite close gills, hairy margin marked with dots. The loss of greenish color at maturity may also occur in the typical form. Peck's description of his *C. anisaria* (N. Y. St. Mus. Rep. **32**: 26. 1879) is much more like our form, with narrow, crowded gills and the cap "adorned with minute, innate fibrils, slightly pruinose and substriate on the margin." In some of our collections this squamulose tendency is carried much further than this, the cap being furnished with rough, raised lines which meet in pairs and end in a free upright wisp. These wisps may disappear in age. The margin, too, is distinctly short-hairy, with hairs arranged in two or three more or less distinct concentric lines about 1 mm. apart. We find the spores of Peck's type to be 4.2-5.5 x 7.4-8μ.

For illustrations see Murrill in Mycologia **7**: pl. 166. 1915 (as *C. virens*. This shows a rough cap); McIlvaine, Am. Fungi, pl. 24, fig. 9; Marshall, Mushroom Book, pl. 15 (as *C. virens*); White, Conn. Geol. and Nat. Hist. Surv. Bull. **3**: pl. 17. 1905. For the European form of *C. odora* see Gillet, Champ. Fr., pl. 113 (85, 134); Sowerby, Engl. Fungi, pl. 42; and Bulliard, Herb. Fr., pl. 556, fig. 3; Patouillard, Tab. Fung., No. 404. 1886.

457. On dead bark and leaves near Battle's Branch, September 28, 1912. Spores light creamy ochraceous, 4.9 x 7.4μ.

1881. Among decaying oak leaves, Lone Pine Hill, October 3, 1915.

1883. Under pines and cedars south of the iron mine, October 3, 1915.

3562. Mixed woods west of Pittsboro Road, October 31, 1919. Odor distinct, margin ridged, olive colors in youth.

4669. Mixed woods by Fern Walk, October 3, 1920. Spores pale buff, smooth, elliptic, with one large, distinct oil drop, 3.7-5 x 5-7.4μ.

4896. On bank of Battle's Branch, October 5, 1921.

Reported by Schweinitz as *C. odora*.

PLATE 25

CLITOCYBE ODORA VAR. ANISARIA. No. 3562.

CLITOCYBE ODORA VAR. ANISARIA. No. 1881.

15. **Clitocybe ectypoides** Pk.

PLATES 27, 28 AND 33

Very persistent and slow to decay. Cap up to 9.8 cm. wide, usually 2-3 cm., hygrophanous, deeply umbilicate, the margin inrolled, or at maturity reflexed, often with a sinus on one side, and frequently splitting in age into several parts; surface distinctly lined radially with fibrous streaks; when young, distinctly but sparsely squamulose, especially toward the margin, with small tufts of darker fibers which terminate the fibrous lines; color when water-soaked dull ochraceous with a superficial tint of purplish-red; when not soaked the purple-red color is much more distinct and as it is confined mostly to the fibers and squamules it is much plainer on the margin. In old age this superficial tint becomes almost or quite invisible to the naked eye, but with a lens can be detected at all times on the margin. Flesh quite thin, 1.5 mm. thick near stem, ½ mm. thick near margin, whitish, tough, nearly tasteless.

Gills rather close to sub-distant, not venose-connected, some forking and occasionally anastomosing, narrow, only about 2 mm. wide at best, the edges blunt; color nearly the same at all ages, a clear golden yellow (about mustard yellow of Ridgway). On account of the shape of the cap the gills are apparently decurrent, but in section it will be seen that they are not at all so, but end at a slight ridge at the top of the stem.

Stem up to 2.5 cm. long and 4.5 mm. thick, equal, quite firm and tough, solid at all ages, surface smoothish, faintly lined longitudinally, pale, soaked-ochraceous, very light when dry, lighter than cap at all times, *never yellow.* The tip is nearly white and the base enlarged by the soft white, compacted mycelium.

Spores (of No. 1421), white, ovate, very hyaline, at first sight only the bright oil drop visible. 3.8-4.2 x 5.9-8.5μ.

On rotting pine logs, not common.

Others have failed to mention the reddish-purple color of the cap fibers, but as in all other respects our plant is unmistakably *C. ectypoides,* a clearly marked species, I have no doubt that this character has been overlooked. The species has the size and somewhat the appearance of *Omphalia strombodes* but easily differs in the purplish red tint to the cap, the solid stem, and in the gills being

only apparent decurrent. The present species should be compared with *Omphalia xanthophylla* B. & C. which is represented in the Curtis Herbarium by two plants from S. C. (Ravenel). I could get no good spores from them.

1421. On rotting wood by Bowlin's Creek, October 26, 1914.
1774. On a very rotten pine log half way down Lone Pine Hill, September 14, 1915.
3781. On pine logs in woods, November 20, 1919. Largest cap 9.8 cm. broad. Gills golden, cap squamulose.

Asheville. On old logs, usually cespitose. Beardslee.

16. **Clitocybe cyathiformis** (Bull.) Fr.

PLATES 1, 29 AND 33

Cap 2-5.5 cm. broad, convex on margin, the center broadly umbilicate; smooth, not viscid, strongly hygrophanous, not striate, deep brown, sayal brown of Ridgway when not water-logged, the margin becoming a darker coffee color. Flesh paler, thin (1.5 mm.), elastic, fibrous and toughish; odor and taste strongly farinaceous.

Gills close, decurrent, arcuate, 5 mm. broad, margin even, venose connected, color of cap, with a faint or distant lavender tint and a pale sheen.

Stem long, up to 9 cm., enlarged downward, flattened or irregular, about 5-8 mm. thick above, color of cap above but white below with mycelium and with white silky lines from superficial fibers except at the minutely pulverulent tip; texture tough and fibrous, stuffed with white fibers, dark near surface.

Spores (of No. 4934) faintly pinkish-lavender on a heavy print, smooth, elliptic, very granular when first shed but soon showing a very large oil drop, 4.2-6.2 x 9-12.2μ. Basidia 5.5-7.4μ thick, clavate, 4-spored. Hymenium 40-45μ thick. Context of gills rather close, the threads about 4.5-5.5μ thick. Scattered rather sparsely among the normal basidia are cells of the same size and shape, but peculiar in having two longer and unequal projections without spores; the longer projections about 14μ long, the shorter about 11μ. If abnormal basidia, their regularity is remarkable.

Very rare in Chapel Hill and apparently occurring only in late fall or winter. According to Ricken it appears in Germany only after frost.

CLITOCYBE ECTYPOIDES. No. 1774.

CLITOCYBE ECTYPOIDES. Asheville. Photo by B. [left]; No. 3781 [right].

Our plants look very much like Bulliard's pl. 575, fig. M, and like Sowerby's pl. 363. Hussey's pl. 1, Vol. 2, has the gills much lighter than in ours. All have the caps more deeply and broadly depressed. Gillet's pl. 116 (94) is entirely too pale, as are the gills in Cooke's pl. 113 (166). Ricken's pl. 104, fig. 1, has the right color of cap, but is striate. For microscopic detail as well as a drawing in color see Hoffman, Icones Analyt. Fung., pl. 3. 1861; see also Kauffman, Agaricaceae of Michigan, pl. 159. Peck's *C. subconcava* should be compared (the spores as given by Peck are smaller.) Murrill thinks the *Agaricus cyathiformis* of Fries and of Bulliard are different and that *C. poculum* Pk. is the same as Fries's species. Our plants seem to be the darkest form of the species, particularly as regards the gills. The species is very variable, particularly as regards color. The spores agree well with the dimensions given by Kauffman and by Ricken. The only serious difficulty is the very distinct farinaceous taste which is not mentioned by others. This taste and the lavender spores suggest *Clitopilus,* but the color would escape anyone except in a heavy print. The spore color is very faint, but was noticed by five out of six observers who saw the print.

4934. In decaying leaves of mixed woods under honey-suckle vines on damp ground, December 7 and 11, 1921.

Asheville. Very common. Beardslee.
Reported by Schweinitz.

17. **Clitocybe pinophila** Pk.

PLATES 30 AND 33

Cap hygrophanous, 1.3-4.2 cm. broad, plane in center or slightly depressed or umbilicate, margin curved or nearly plane, not striate, smooth, a drab tan or buffy tan or pale whitish tan, darker when wet. Flesh thin, pliable, of pleasant taste (not farinaceous); odor none.

Gills rather close, slightly and unequally decurrent, nearly white then buffy tan, about 1.5-2.5 mm. wide.

Stem 2-3 cm. long, thick above (up to 7 mm.), tapering downward, color of cap and mealy at top, darker brown and nearly smooth downward, the very base whitened with mycelium, stuffed then hollow, toughish.

Spores (of No. 2969) elliptic, smooth, 2.5-3 x 5-7μ.

Our plants agree well enough with Peck's description and like the northern form they are confined to pine woods. The absence of a farinaceous taste is not a serious discrepancy. Peck gives the spores as nearly elliptical, 5-6.4μ long, which agrees quite well, but an authentic specimen from his herbarium (Catskill Mtns., Peck, Coll., not type, which we could not find) has spores somewhat shorter than in our plants, 2.2-3 x 3.4-4.5μ (possibly not fully mature). Kauffman's Michigan plants have spores 4 x 5-6μ, which is distinctly broader than in our southern form. The European *C. phyllophila* and *C. pithyophila*, which are quite near, are supposed to be larger and whiter. Ricken gives the spores of the former (he considers the latter a pine-loving form) as 3-4 x 4-5μ. Spores of a plant of *C. phyllophila* from Bresadola are 2.5-3.7 x 4.2-5.4μ. Schweinitz's record of *C. phyllophila* is probably based on the present species. For the white plant known as *C. pithyophila* in America see the photo by Hard, in his Mushrooms book, fig. 73, p. 100.

Beardslee finds at Asheville, on pine needles, a whiter plant that would easily pass for *C. pithyophila*, but as it has all other characters, including the spores, the same as the present species we cannot believe it specifically distinct. Beardslee's description of this whiter plant is as follows:

Cap 2-6 cm. broad, watery white when moist, becoming pure white when not soaked, glabrous, thin, plane, but a little depressed at the center, often with the margin waved or lobed. Gills white, crowded, narrow, decurrent. Stem white, stuffed, then hollow, somewhat compressed. Spores ellipsoid, 6-7 x 3-4μ.

2964. On ground, pine woods, Strowd's pasture, December 13, 1917. Spores 2.2 x 4.8-5.5μ.

2969. On ground under pines and persimmon trees, Strowd's pasture, December 6, 1917.

2957. On ground, pine woods, Strowd's pasture, December 3, 1917. A form. Spores 2.2-3 x 5.2-7μ.

Asheville. Occasional. Beardslee.

18. **Clitocybe setiseda** (Schw.) Sacc.

Clitocybe eccentrica Pk.

PLATES 24 AND 33

Cap up to 3 (rarely 6) cm. wide, deeply umbilicate, surface very

PLATE 29

CLITOCYBE CYATHIFORMIS. No. 4934.

PLATE 30

CLITOCYBE PINOPHILA. No. 2969.

minutely squamulose, scarcely more than pruinose (not noticeable except under a lens), not at all striate or fibrous, a very faint pinkish tan or soiled white. Flesh very thin, less than 0.5 mm. in marginal half, color of cap, quite strong and tough, decidedly bitter.

Gills very much crowded, thin and narrow, only 1.5 mm. wide in middle, pointed at both ends, many short, none branched, margin quite entire, decurrent, color of cap at certain angles, faintly cream colored at others.

Stem about 2 cm. long to gill tips, 1.5-2.5 mm. thick near top, somewhat larger downward, color of cap, smooth or minutely scaly-dotted like the cap except below where is is covered with long, tough, creamy hairs and strands which penetrate far into the surrounding trash; texture of stem very firm, tough and strong, with a softer central core which may become partly hollow.

Spores (of No. 817a) white, smooth, very small, oval-elliptic, about 2.7-3 x 3.8-4.2μ.

Schweinitz's plant has not been recognized since he described it from this state in 1822. It was placed by him under the subgenus *Omphalia*, but Curtis and Saccardo place it in *Clitocybe*. The description agrees so well with our plants that I see no reason why this name should not be applied to them. *Clitocybe eccentrica* is the same. A plant from Peck's herbarium, not type but authentic (Ray Brook, N. Y., Peck, coll.), is exactly like ours and has the same spores except slightly longer (2.8-3 x 4-5μ). From published data it seems impossible to separate this from *C. candicans*. Kauffman's spore measurements for the latter would serve to distinguish (4 x 5.5-6μ), but Ricken's measurements are like ours (2-3 x 4-5μ). *Omphalia scyphoides* Fr. is also hard to separate.

In most species of this group the cap has a tendency to become one-sided at times, thus appearing eccentric. Following is a translation of the original description (Schr. Nat. Ges. Leipzig 1: 88. 1822):

"White, becoming yellowish, small, cap thin, infundibuliform; gills crowded, thin, decurrent; stem with white, radiating hairs. Rare in autumn among leaves. Stem attached to leaves, hairs about one inch long, spreading in a stellate manner."

817a. On rotting bark, twigs, and leaves, woods southeast of campus, November 7, 1911.

1782. On a very rotten mossy log, Lone Pine Hill, September 14, 1915. Reported by Schweinitz.

19. **Clitocybe dealbata** Sow.

C. sudorifica Pk., toxic form.
C. morbifera Pk., toxic form.

PLATES 31 AND 33

Small plants growing gregariously in grass in lawns and pastures, not rarely cespitose in twos. Cap up to 4.5 cm. in diameter, usually smaller, smooth or sometimes slightly pruinose, especially near the margin, dull or shiny, wavy and often irregular, depressed in center (umbilicate); color a light buff or fleshy buff, sometimes with brown areas; the thin margin incurved and whitish, and slightly extended beyond the gills. Flesh very thin towards the margin, thick towards the center, about 2.5 mm. thick half way between; pale flesh color, with a distinct taste of meal, not at all bitter. The taste is just like that of *Tricholoma panaeolum* except that it is not bitter. As the plants get old they often become water-soaked and therefore much darker brown.

Gills moderately close, deepest in middle where they are 3.5-5 mm. deep, not branching, slightly notched at the stem, not decurrent, fleshy white, then fleshy tan.

Stem color of cap, 1.5-2.5 cm. long, about 3 mm. thick in center, tough and elastic, solid or hollow, smooth, pruinose at top and bottom, slightly tapering towards the base, white at base, and the white mycelium often obvious.

Spores (of No. 929) white, very small, smooth, elliptic, 2-2.5 x 3.8-5.2μ.

The color of our plants is not pure white as is described for the species. From the farinaceous taste and odor this would be var. *minor* Cooke, but that is said to grow in leaves. It is almost exactly like the form that grows in mushroom beds and described as var. *deformata* by Peck.

Two toxic forms have been described by Peck, *C. dealbata sudorifica* (N. Y. St. Mus. Bull. **150**: 43. 1911. Later described as a species in Bull. **157**: 67, pl. 7, figs. 1-6. 1912) and *C. morbifera* (Bull. Torr. Bot. Club **25**: 321. 1898). These do not seem to be distinguishable morphologically in Murrill's opinion (Mycologia **7**: 260. 1915), although Kauffman treats them as distinct. We have examined the types of both and find them alike and like our plants, and the spores are the same in all three cases (*C. sudorifica*, 2.2-3 x 4-5.2μ; *C. morbifera*,

CLITOCYBE DEALBATA. No. 929.

PLATE 32

CLITOCYBE RIVULOSA. No. 907.

2.5-3 x 3.7-4.8μ). For the toxic effects of these two forms see the original descriptions. Peck considers the latter as more serious in its effects than the former, which, in the cases reported by him, caused only a profuse perspiration in man, but the death of rabbits and guinea pigs; later, however, Roberts (Mycologia 13: 42. 1921) found its effects to be somewhat more serious, causing profuse perspiration, interference with vision, diarrhoea and other unpleasant symptoms.

For good illustrations see Peck (l. c., as *C. sudorifica*); Sowerby, Engl. Fungi, pl. 123, 1798; Cooke, Ills. Brit. Fungi, pl. 104 (142) (larger than American plant), pl. 173 (as var. *minor*, like American form); Gillet, Champ. Fr., pl. 117.

929. Gregarious in grass in northwest side of Arboretum, October 18, 1913. There is another group of these plants in the northeast side of the Arboretum, near the smallest live oak tree. Both of these groups appear every fall.
977. In hillside pasture, west side of Glen Burnie Farm, November 11, 1913.
1466. Pasture, east side of Glen Burnie Farm, November 2, 1914.

Asheville. Common, often in lawns under trees. Beardslee.

20. **Clitocybe rivulosa** (Pers.) Fr.

PLATES 32 AND 33

Cap up to 5.5 cm. wide, usually 3.5-4 cm., irregularly lobed, elevated and depressed; covered with a thin, whitish or light tan superficial layer that is marked by many rivulose lines and collapsed areas that show the cartilage colored flesh below; margin inturned always. milk-white when young. Flesh barely mealy in taste, not bitter, cartilage color, rather brittle, only about 2 mm. thick.

Gills light fleshy-cartilage color, somewhat crowded, not decurrent, about 3 mm. wide in center.

Stem only 1-1.5 cm. long, about 4.5-5 mm. thick, color and surface just like the cap; firm and solid.

Spores (of No. 907) white, smooth, elliptic, very small, 2.6 x 4.2μ.

The characters are well shown in photo of No. 907. The rivulose markings of the cap are remarkably like those of *Clitopilus novaboracensis*.

Rare, and heretofore reported in the United States only from

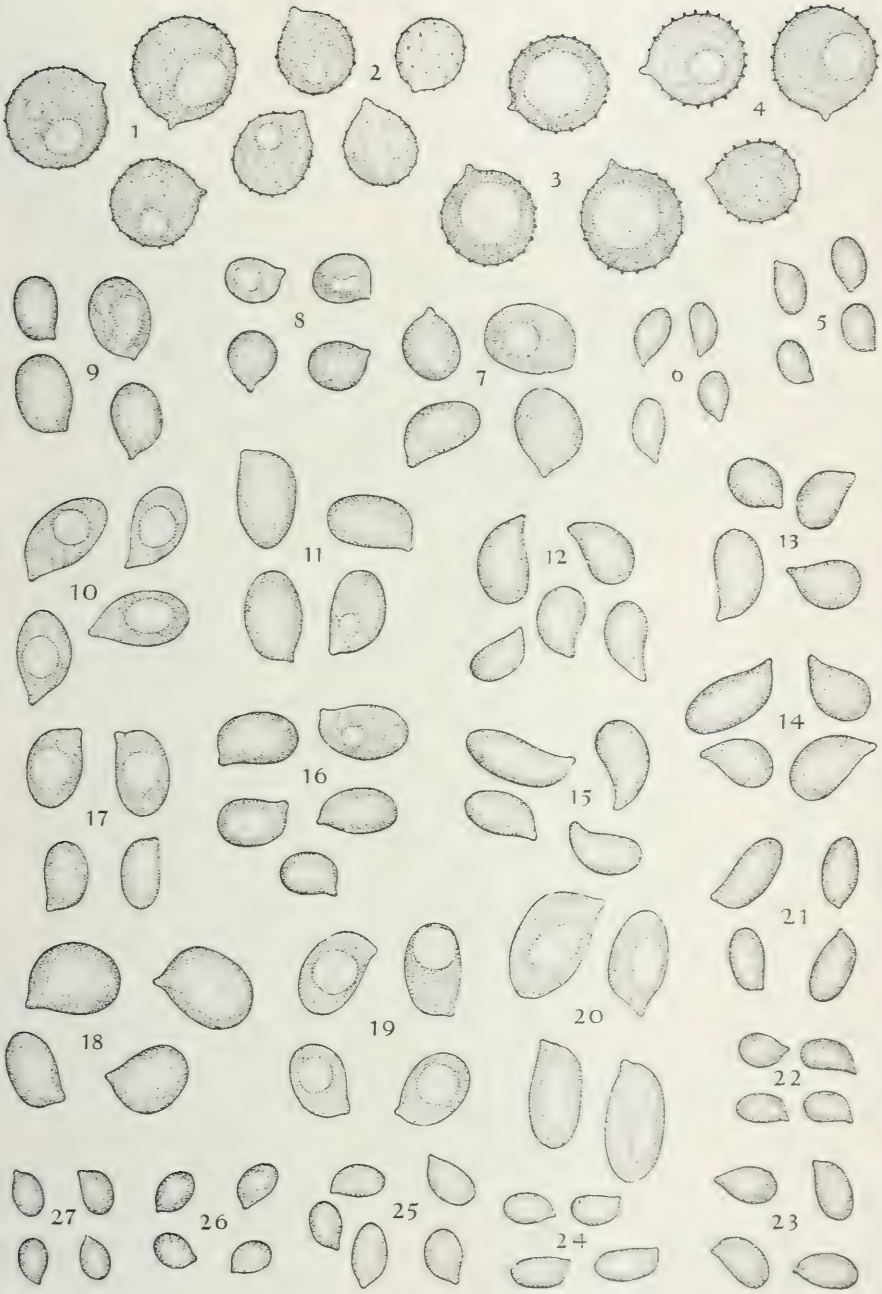
New York. In Chapel Hill they are known only in one place, where they occur gregariously every fall in rainy weather. They have been observed for three years, and are remarkably constant. This is apparently only another of the numerous forms of *C. dealbata,* which is indistinguishable except for the absence of rivulations. A plant of *C. rivulosa* from Bresadola is like ours and has the same spores (2.5-3.2 x 4-5μ) which are like those of *C. dealbata.*

907. Nine plants on edge of sidewalk west of Mrs. Kluttz's, October 11, 1913.
1269. From the same spot as No. 907, and like them in every way, September 26, 1914. Spores 2.5-3 x 4-4.8μ.

EXPLANATION OF PLATE 33

Laccaria ochropurpurea. No. 4675, fig. 1.
Laccaria laccata. No. 2960, fig. 2.
Laccaria amethystea. No. 5119, fig. 3.
Laccaria tortilis. No. 3344, fig. 4.
Clitocybe candida. No. 3546, fig. 5.
Clitocybe sp. No. 3210, fig. 6.
Clitocybe tabescens. No. 1373, fig. 7.
Clitocybe illudens. No. 183, fig. 8.
Clitocybe tumulosa. No. 2006, fig. 9.
Clitocybe subnigricans. No. 3165, fig. 10; type, fig. 11.
Clitocybe infundibuliformis. No. 2512, fig. 12.
Clitocybe adirondackensis, Bolton, N. Y., fig. 13.
Clitocybe sinopicoides. No. 3264, fig 14; type, fig. 15.
Clitocybe media. No. 2992, fig. 16.
Clitocybe odora var. anisaria. No. 4669, fig. 17.
Clitocybe anisarius. Type, fig. 18.
Clitocybe ectypoides. No. 1421, fig. 19.
Clitocybe cyathiformis. No. 4934, fig. 20.
Clitocybe pinophila. No. 2969, fig. 21.
Clitocybe setiseda. No. 817a, fig. 22.
Clitocybe eccentrica. Ray Brook, N. Y., fig. 23.
Clitocybe dealbata. No. 929, fig. 24.
Clitocybe sudorifica. Type, fig. 25.
Clitocybe morbifera. Type, fig. 26.
Clitocybe rivulosa. No. 1269, fig. 27.
All figures x 1620.

PLATE 33



THE FRUITING STAGE OF THE TUCKAHOE, PACHYMA COCOS

PLATES 34-37

By FREDERICK A. WOLF

The names tuckahoe, Indian bread or Indian potato appear to be quite generally known in the Coastal Plains section of the Carolinas as a designation for certain tuber-like structures which grow under ground. These structures are frequently unearthed by the plow especially when timbered lands are brought under cultivation. During the past spring, fifteen specimens were collected near Raleigh, N. C., in a situation where the land had been cleared and broken in preparation for a tobacco plant bed. Subsequently four other specimens were unearthed by the writer and several of his colleagues in the same locality.

My acquaintance with tuckahoe extends over a period of several years since occasional specimens, similar in appearance and accompanied by inquiries as to their nature, have been received at the botanical laboratories of this Station. An examination showed that a tuckahoe is obviously the sclerotial or resting stage of some fungus and as such is composed of a vegetative mass of fungous tissue. This fact gave no clue to the identity and systematic position of the fungus since various fungi are known to produce sclerotia. An examination of published reports on large sclerotia furthermore showed that not only the affinities of the tuckahoe, *Pachyma Cocos*, which has been collected by a number of botanists, but also the origin and formation of these subterranean fungous masses have remained for years an unsolved botanical problem. It was the writer's good fortune, however, during May, 1922, to observe the fruiting stage of this fungus. The present purpose is, therefore, to assemble the information in hand as a contribution to our knowledge of this unusually interesting form.

HISTORICAL

The name tuckahoe is of Indian origin and is apparently generic among them for all round or roundish edible roots. Gore (7) quotes the statement of Trumbull, an ethnologist, that the word is derived

from ptucqui or ptuckquen which signifies that which is made round or rounded as a loaf or cake. The name, varied by the dialects of the several tribes, applied to all esculent bulbous roots. These statements are confirmed by such historians as Smith (16), Beverley (3), Campbell, (4) and Kalm (9), who record such tribal names as tawkee, petukqui, pittikwow, 'tuquauh, petukuineg, puttuckqunnege, tockawhoughe, tawko, tuckah, and tawkin. Campbell says, "The tockawhoughe was in summer the principal article of diet among the natives. It grows in the marshes like a flag and resembles somewhat a potato in size and flavor. Raw, it is no better than poison so that the Indians are accustomed to roast it and eat it mixed with sorrel and corn meal. There is another root found in Virginia called tuckahoe and confounded with the flag-like root described above and erroneously supposed by many to grow without stem or leaf. It appears to be of the convolvulvus species[1] and is entirely unlike the root eaten by the Jamestown settlers." No less an authority than the Swedish botanist Kalm, whose travels in America shortly before the Revolutionary War are recounted in two volumes published in 1772, states that the word tawko referred to the Virginia wake robin, *Arum virginicum,* and tawkee to golden club, *Orontium aquaticum.* While the Indians no doubt included under the name tuckahoe the tubers and roots of a number of flowering plants as well as *Pachyma Cocos,* botanists have come to apply this designation exclusively to tuberous fungous masses.

The first botanical description of this tuckahoe was made by Clayton (5) in 1762 in his Flora Virginica, published by Grovinius. He was under the impression that the plant was one of the puffballs and accordingly sent specimens to Grovinius under the name *Lycoperdon solidum.* Next it is supposed by some to have been described by Walter (18) in 1788 in his Flora Caroliniana under the name *Lycoperdon cervinum.* Later, it was well described by Schweinitz (15) in 1822 as *Sclerotium Cocos.* The next year Fries (6) published it as *Pachyma Cocos,* using Schweinitz's description. The observations of MacBride (11) of South Carolina on this fungus were published in 1817 and he gave to it the name *Sclerotium giganteum.*

Later a number of other descriptive accounts were published, as will be indicated subsequently, the most comprehensive of which is

[1] This is very probably the wild potato vine, *Ipomoea pandurata.*

that of Gore (7). This account includes also the results of chemical analyses of the tuckahoe which, in confirmation of the earlier work of Torrey (17), shows that it is largely composed of pectic compounds. Torrey, however, employed the name "sclerotin" which was subsequently found to be identical with the jelly-forming constituents of fruits and tubers to which Braconnot[2] applied the name "pectous substances."[3]

DISTRIBUTION

The tuckahoe is reported to occur from New Jersey southward to the Gulf of Mexico, westward to Texas, and as far north as Kansas, in light loamy or sandy soil. Whether or not the data on distribution of tuckahoe in the accounts of Banning (2), Ravenel (13), Lockwood, (10) Gore, (7), Schrenck (14) and in a recent bulletin from the Missouri Botanical Garden (1) apply to *Pachmya Cocos* alone or include closely related species cannot now be determined. It is my belief, as will be discussed later, that *Pachmya Cocos* is parasitic and is associated only with the roots of pines. However, Lockwood (10) records finding tuckahoe among the roots of willow oak, *Quercus phellos,* in New Jersey. Further, specimens in the herbarium of Bresadola under the name "*Pachma Cocos* Fr. = *Mylitta pinetorum* Horaninow," show sclerotia which are very different from the form under discussion since they are very heavy and in section look like mottled amber.[4] Manifestly, in the absence of widespread knowledge of the identity of *Pachyma Cocos,* and of definite information of its host relationship together with confusion of names in herbarium collections, satisfactory information on distribution is not available.

DESCRIPTION OF SCLEROTIA

The tuber-like structures to which Fries (6) gave the name *Pachmya Cocos* were described by him as "oblong to elliptical in shape with hard scaly bark and with a brown and woody appearance, about the size of a man's head, exactly resembling a cocoanut;

[2] Ann. Chim. phys. **25**: 358-373. 1824.

[3] A transcript from Berkeley and Curtis' manuscript which accompanies their specimens of tuckahoe was given me by Dr. W. C. Coker. These notes include chemical studies by Prof. Ellet of South Carolina College who states that, "Twenty years ago I examined a specimen of it from Virginia. I have repeatedly worked with Carolina specimens of the substance and find them all identical in their nature. It consists entirely of pectic acid or rather the pectin of Braconnot."

[4] From notes made during the summer of 1921 by Dr. W. C. Coker.

bark thick and fibrous in general appearance like a pine root. Within the substance is uniformly whitish to flesh-colored with an odor like a mushroom. They are flesh-colored when they attain their growth, and are considered by the natives as possessing medicinal properties. They are found in Carolina especially among pine forests.''

The sclerotia which I have examined show considerable variation in size and shape as shown in plate 34. The largest specimen taken was an oval body 27 inches by 19 inches in circumference and its weight was 3161 grams or approximately 7 pounds. Another was slender and elongated and measured 41 inches in length. When first taken from the earth these masses are of such a consistency as to be easily cut with a knife but on drying they become extremely hard and horn-like and the interior becomes variously cracked and fissured. This fissuring is not perceptible from the exterior, however.

The cortex of the sclerotium possesses the roughed furrowed appearance and color of pine roots. This appearance is simulated best in specimens in which flakes of bark constitute a portion of the sclerotial cortex. When examined microscopically, this cortex is seen to consist of densely compacted fungous cells making a quite well-defined layer 100-150μ in thickness (fig. 7). The interior is whitish or tinged with pink when fresh and becomes grayish when dry. The cells which compose this portion are extremely variable in size and shape as shown in fig. 2.

ORIGIN OF SCLEROTIA

As has been recorded by the several botanists who early described tuckahoe, the habitat of these sclerotia is invariably among the roots of pine trees, *Pinus taeda* and *Pinus rigida*. It would appear improbable that such an association is purely accidental. That they are parasitic, however, seems very probable in the light of the following facts:

1. All of the sclerotia which I have found are in part pine root tissues, but there is, however, neither hypertrophy or hyperplasia of these tissues. In respect to the inclusion of host tissue *Pachyma Cocos* differs from all other known large sclerotia.

In some cases the xylem portions of the pine root extend entirely through small sclerotia and the root is free from bark inside the tuber. If the sclerotium merely surrounded the root, or attached

PLATE 34

A group of tuckahoes, *Pachyma Cocos*. The largest had a weight of seven pounds and the longest a length of 41 inches.

itself to it, the bark should be intact. Such a case has been observed also by Gore (7) and is illustrated in fig. 1 accompanying his account.

2. Sclerotia attached to the roots have been unearthed near the base of living trees.

3. There is no evidence of mycelium or rhizomorphs in the soil surrounding the sclerotia.

4. Sclerotia have been found with portions of roots not only at the end directed toward the tree, but also distal to it. If one follows the course of these roots into the sclerotia, all stages can be found from what appears microscopically to be normal woody tissue to a splitting apart and transformation of the xylem strands, which are few in number toward the outside, but numerous and slender toward the center of the sclerotium (figs. 3 & 4). In large sclerotia all traces of the woody portions of the roots have disappeared at a distance of about one and one-half inches from the end. In forming such sclerotia it seems reasonable to suppose that as they enlarged there was both a stretching apart of the woody tissue of the root and at the same time a transformation of substance appropriated from the root tissues.

5. The roots at some distance from the body of the sclerotium have to the unaided eye, apparently normal bark and wood tissues. Both portions, however, on microscopic examination are found to be invaded and the mycelium completely fills all intercellular and intracellular spaces (fig. 8).

Several investigators have held that the tuckahoe is to be regarded as an altered or transformed state of the root. Gore (7) concludes that such is the case in his discussion of their origin in which he states that "Specimens in all stages of development are in my possession from the root with only a film of the substance between the bark and the woody part of the root up to pieces six inches in diameter." MacBride (11) states that the growth originates between the bark and wood of living trees, that it gradually enlarges, detaches the bark and transforms the root tissues into its own substance. Another observer quoted by Gore (7) in a letter to him states that "this growth had taken place from the roots of pines as was evident from some having just commenced growing, the pine root extending through and reaching out on each side. Others had

developed to considerable size showing no appearance of any root in them or any bark of the pine on the outside as was the case with the smaller ones. I think the whole root for two inches or more is changed into this substance from the fact that some of the roots extend entirely through it, some of them being smaller inside and larger outside.''

The observations of Ravenel (13) alone cast doubt on the parasitic origin of the tuckahoe. He records the finding of five or six specimens varying in size from a hen's egg to more than twice as large, attached to an old pine rail. Since all other observers agree in the occurrence of tuckahoes singly and not in groups, there is a possibility of mistaken identity by Ravenel.

FORMATION AND STRUCTURE OF THE SPOROPHORE

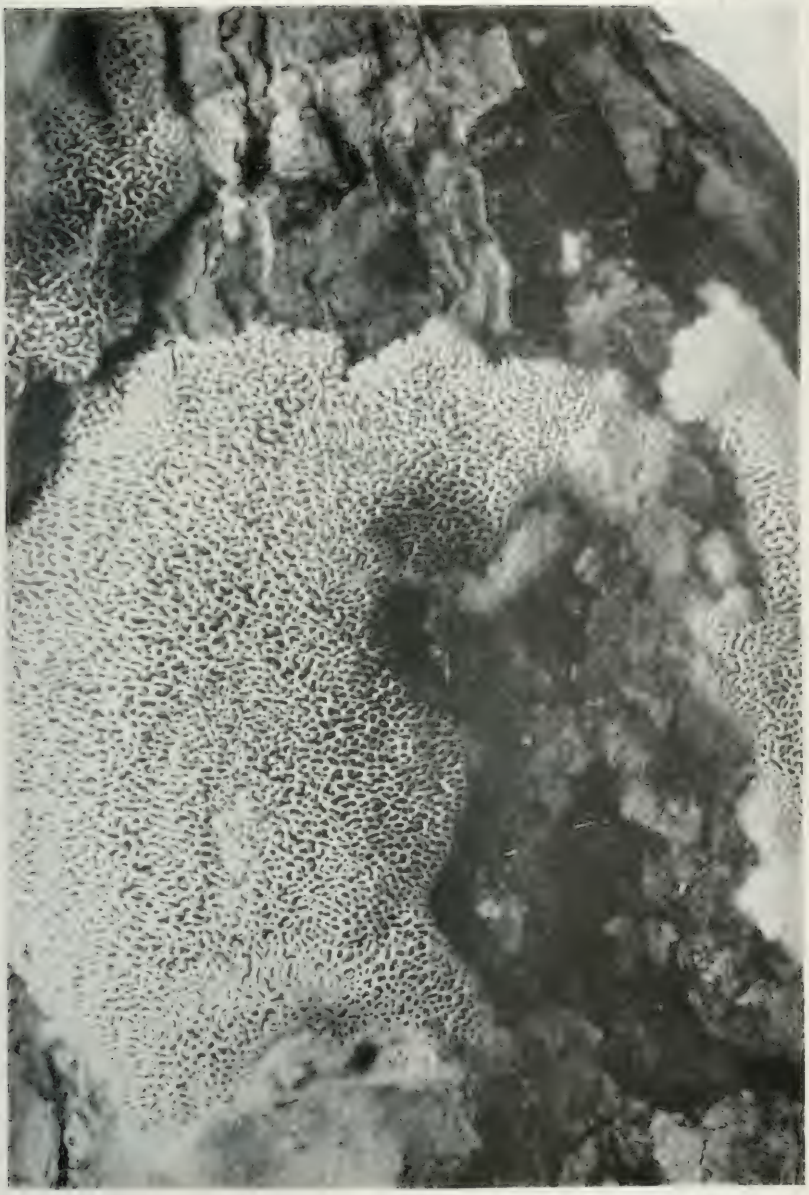
In efforts to bring about the production of fruit bodies several sclerotia which had been subjected to drying in the laboratory for a few days after collection, were placed in water to soak for about 24 hours. One was then left to lie on a laboratory table, one in a moist chamber in the laboratory, two were placed in an ice chest, one was placed in a moist chamber in a photographic dark room and three were buried out of doors in the sand. In three days, a dense white fungoid crust had formed in the case of the first one on the side in contact with the table. As I did not suspect that this crust was an immature resupinate hymenophore, since I was looking for a stalked fruit body to make its appearance, I scraped off most of it in making examination and left it lying with the crust upward. Several days later, I was surprised to find that a similar crust had formed on the opposite side. This was undisturbed and in the course of a week had matured into the hymenial layer. The one in the moist chamber had meanwhile developed a fruit body similar in appearance. The two tuckahoes in the ice chest showed no signs of growth during two weeks there. They were then placed in a moist chamber in the laboratory where within a week both fruited. One formed four fruiting structures and is the one shown in plates 35 and 36.

In the case of the sclerotium in the dark room, a profuse loose mycelial envelope which completely surrounded it had formed in two weeks. When after this time it was subjected to the diffuse light

PLATE 35

Fruit body developed in a test tube from bit of tissue from center of a sclerotium [left].
Several resupinate fruit bodies on one sclerotium [right].

PLATE 36



An enlargement of a portion of the fruit body shown in pl. 35, illustrating character of the pore surface.

of the laboratory several diminutive fruit bodies formed on its surface within a week.

The sclerotia which were buried were examined after two weeks and were found to have surrounded themselves with a loose weft of mycelium (fig. 1) which was whitish at first and became at length tawny. Two weeks later these sclerotia were largely decayed.

Several unsuccessful attempts were later made to bring into fruiting specimens which had dried out from exposure in the laboratory. These experiments, which have resulted in the development of sporophores on five tuckahoes,[5] indicate that fruiting is conditional upon at least three factors, (1) fresh specimens, (2) saturation with water. and (3) the presence of light.

In efforts to artificially culture this organism, a bit of tissue from near the center of a large sclerotium was transferred with aseptic precautions on May 2 to a potato plug. A loose white mycelium developed and on May 23rd a poroid sporophore somewhat abnormal in appearance but with mature normal spores entirely similar in size, shape and appearance to those in nature, had formed.[5]

The sporophores are resupinate, plate 35, and although pure white at first they become with age slightly tinged with brown. The subiculum is thin. The pores are large and angular to irregularly sinuous and 2-3 mm. deep, plate 36. The hymenium is at first rather tough and cartilaginous but becomes papery on drying. There is no sterile margin nor are cystidia present. The basidia are blunt, club-shaped, 20-25μ in length and 6-8μ in width and are crowned with four rather slender sterigmata, fig. 9. The basidiospores are white in mass, asymetrically cylindrical, smooth, and 7-8 x 3.5μ, Fig. 10.

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[5] After receiving this paper for publication, I suggested to Dr. Wolf that he make still further cultures so as to place the proof of relationship of the *Poria* to the tuckahoe beyond all doubt. He accordingly made six other cultures on potato plugs sterilized in glass tubes and inoculated with tissue taken from the center of three large tuckahoes. The latter were collected during the last week in April and had been left to lie in the laboratory until June 22nd, the date on which the cultures were made. By July 17th each of the six cultures had formed fruiting bodies of the *Poria* type and one of these is shown in plate 35. Dr. Wolf has also produced another fruiting body on the surface of a tuckahoe since writing this paper. A sclerotium was soaked and buried in sand for three weeks, during which time it enveloped itself with a loose, white weft. It was then dug up and put into a moist chamber. Within ten days it had formed on its surface the most perfect fruiting body that he has obtained This makes a total of six tuckahoes that have produced sporophores on their surface. The plant had been buried to test the possibility of production of a stalked sporophore. The result confirmed the previous conclusion that light is a necessary stimulus to production of a fruit body. Just as this paper was going to press there was published by Elliott an article on "Some Characters of the Southern Tuckahoe" (Mycologia **14**: 222. 1922). His specimens were not attached to pine but supposedly to sumac roots in two cases. Efforts to secure a fruiting stage were not successful, and the identity of his plant with Wolf's species must remain in doubt.—W. C. COKER.

The fruiting of *Pachyma Cocos* is manifestly of the type characteristic of the genus *Poria* which is recognized to include a heterogeneous group of forms but it is provisionally placed in this genus.

When comparison is made with the descriptions in literature of fungi arising from large sclerotia none of them are found to bear any resemblance to our specimens. *Grifola Tuckahoe* Güssow (8), for example, has coal black sclerotia with a blackish interior and its fructifications are fleshy, stipitate, ochre to yellowish brown structures. *Polyporus tuberaster* (Jacq.) Fries as first illustrated by Micheli (12) shows this species to possess an irregular, globular, sclerotium enclosing stones and earth, from which arises a stipitate polypore with angular pores. *Polyporus Sapurema* Möller from Brazil has an enormous sclerotium from which a large fleshy stipitate fruit body is developed. *Lentinus tuber regium* Rump. is a large, stipitate, gill-bearing form. In fact, all hitherto known large sclerotia whose fruiting stages have been found have large sporophores whereas our specimens bear small fruit bodies. Further, no other species of *Poria* is known to have a sclerotial stage. It is for these reasons that C. G. Lloyd to whom specimens were sent for determination is of the opinion that it is very improbable that there could be any relationship between tuckahoe and *Poria.*

The question of a species name is much more difficult since to determine whether or not this form is different from previously described species would involve a thorough-going study of all known resupinate forms. Since, however, *Pachyma Cocos* is believed to be parasitic and consequently its fruiting stage in all probability occurs only on the surface of the sclerotia, it is entirely unlikely that it has been observed or collected previously. The combination *Poria Cocos,* is therefore proposed in order to connect our fungus with the long known sclerotial stage name, with the following brief diagnosis.

Poria Cocos (Schw.) comb. nov.

Sclerotium giganteum Macbride. Trans. N. Y. Phil. Soc. 1817.
Sclerotium cocos Schw. Syn. Fung. Car. Sup., p. 56. 1822.
Pachyma cocos (Schw.) Fries. Syst. Mycol. 2: p. 242-243, 1823.*

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* Other synonyms given by Gore are:
P. solidum Oken. Lehrbuch d. Naturgesch. 2 ter Thiel. Botanik 2 ter Abtheil, 1 te Halfte, 1815.
P. pinetorum Horaninow, p. 2-23, 1856.
P. coniferarum Horaninow. (See continuation on p. 135).

Sporophoris resupinatis, albidis deinde pallide ferrugineis, membranaceis—crustaceis; tubulis 2-3 mm. long, cartilaginis, siccatis chartaceis; ore crassi, irregulari vel labyrinthiformi; margine non sterili; cystidiis nullis; basidiis clavatis, 20-25 x 6-8μ; sporis hyalinis inaequilateralibus, oblongis, levibus, 7-8 x 3.5-4μ.

Hab. ad sclerotia in vivis radicibus Pini. Sclerotium magnum, oblongo-subrotundum, arrhizum; cortex crassus, fibroso-squamosus, durus, colore radicum Pinorum; intus cellis radicorum Pini atque materia carnoso-suberosa repletum, odore fungoso-farinacea. In terra praesertim in pinetis sabulosis.

Specimens have been deposited in the herbarium at the University of North Carolina, Chapel Hill, N. C., at the Lloyd Library, Cincinnati, Ohio, and at the Missouri Botanical Gardens, St. Louis, Mo.

Special thanks are due to Dr. W. C. Coker, for his courtesy and help in connection with the preparation of this report and to Mr. C. G. Lloyd for his opinion as to the identity of the fungus.

SUMMARY

This study of the southern tuckahoe, *Pachyma Cocos,* includes an account of its history, structure and origin together with the development and morphology of its fruiting stage.

The name tuckahoe is of Indian origin and was applied by them to all edible roots and tubers. It has come to be used by botanists, however, to include only certain subterranean fungous growths or sclerotia.

The tuckahoe has been known to botanists for about 175 years but its fruiting stage has not hitherto been described. Pine root tissues are always included within this tuckahoe and it is apparently parasitic upon the roots of pine.

Several conditions which include (1) fresh sclerotia, (2) their saturation with water and (3) exposure in light govern the production of sporophores. Mature sporophores of the *Poria* type have been secured on the surface of six tuckahoes. A period of about a week's duration is necessary for their complete development. The

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Lycoperdon solidum Clayton. Flora Virginica, p. 176. 1762.
L. sclerotium Nuttal. Systematic and Physiological Botany, p. 200. 1820.
L. cervinum Walter. Flora Caroliniana, p. 262. 1788.
Tuckhaus rugosus Rafinesque. Med. Flora of N. America **2**: 255. 1830.
In such of these as we have seen, the description is too imperfect to refer with any certainty to our plant.

fruiting stage has also been developed in cultures from tissue taken from near the center of large sclerotia.

This *Poria* is herein given the name *Poria Cocos* to relate it to its tuckahoe stage.

COLLEGE STATION,
RALEIGH, N. C.

EXPLANATION OF PLATE 37

Fig. 1. Hypha from mycelial envelope of sclerotium as it appears when sclerotia are buried or put into the dark room.
Fig. 2. Variation among the cells which compose the interior of the sclerotium.
Fig. 3. A diagrammatic section of a sclerotium with three groups of woody tissue and one of bark remaining. Proportional sizes are shown.
Fig. 4. Diagram of a section of an apparently normal root and of a sclerotium. The sections are about one and one-half inches distant from each other. The woody elements have become separated into seven groups. Relative sizes are preserved.
Fig. 5. A diagram of a sclerotium showing relative sizes in cross section of the woody elements. The sections are about an inch distant from each other.
Fig. 6. All of the xylem elements have been destroyed in this section but much of the bark remains although it is densely filled with fungous hyphae.
Fig. 7. Section of the compact sclerotial wall together with the less dense subjacent tissue.
Fig. 8. Xylem cells from apparently normal tissue.
Fig. 9. Basidia of *Poria Cocos*.
Fig. 10. Basidiospores.
Fig. 11. Tissue from a rhizomorph which formed from a sclerotium which was unearthed and then partially buried in leaf mold for two months.
Figs. 1, 2, 7, 8, 9, and 11 are drawn to the same scale.

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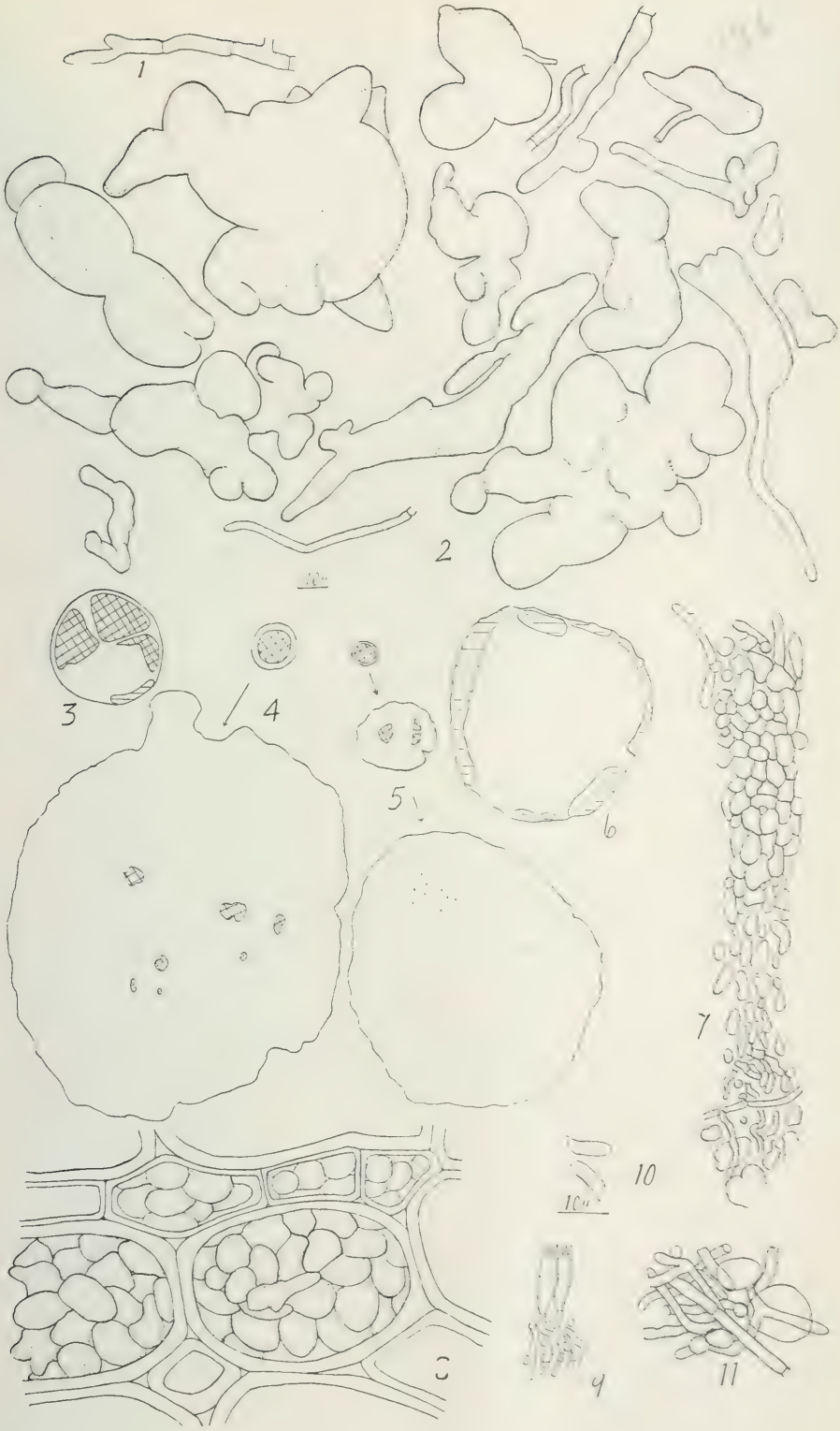
PLATE 37



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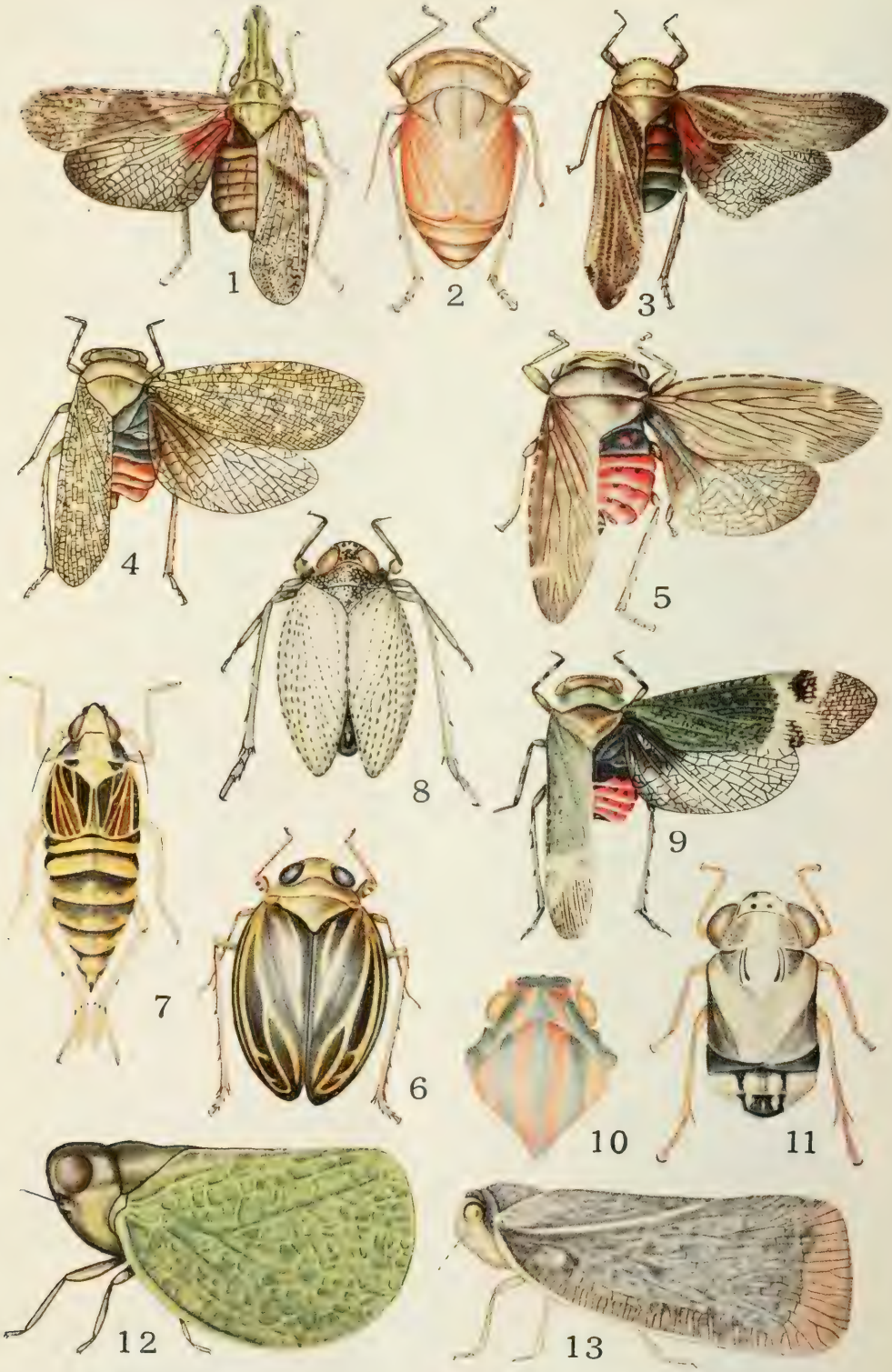

Z. P. Metcalf del.

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A KEY TO THE FULGORIDÆ OF EASTERN NORTH AMERICA WITH DESCRIPTIONS OF NEW SPECIES

By Z. P. Metcalf

Introduction

The Family *Fulgoridæ* is perhaps the most neglected family of homopterous insects. This is due in no small measure to the fact that in comparison with other families of the order they are relatively of little economic importance in our region. This is merely relative, however, and in a final summing up it must be borne in mind that a family of relatively small importance when compared with *Coccidæ* or *Aphididæ* may be of outstanding importance when compared with other families in other orders. Much more study must be devoted to this family, however, before we can even begin to estimate its real economic importance.

Taxonomically the Family *Fulgoridæ* is of great interest and perhaps in no family of insects in any modern scheme of classification do we have as many and as diverse forms as in this one. There is no doubt that the *Fulgoridæ* are really of superfamily rank, but the author feels that violent revisions in schemes of classification have no place in a study of a restricted fauna such as this. From the viewpoint of bizarre forms and structures few insect groups can even approximate the members of this family. Unfortunately from the standpoint of great popular interest the forms are too small to create much excitement. But with all of these limitations the chief drawback to a real interest in this group is the fact that there is no manual of the genera and species available. Descriptions are scattered far and wide. A recent census shows that the descriptions of the two hundred and fifty-eight described species in our region are scattered in no less than fifty-nine separate publications with usually no corre-

lation of new species with old or with no keys for their determination and very few illustrations. Then too, many of the original descriptions were made by the older entomologists before the middle of the nineteenth century and have never been brought down to date. It was with these points in mind that the present paper has been prepared in the hope that it would bridge a gap and would stimulate real interest in this family in the future.

DISTRIBUTION

The *Fulgoridæ* of Eastern North America have not been collected sufficiently for us to know very much about their distribution as is evidenced by the fact that of the three hundred and one known species eighty are known from a single state only, or two closely contiguous states. Of the remainder ninety-seven seem to have a general distribution; forty-four are generally southern in their distribution; twenty-nine are western species that invade our territory; ten are apparently West Indian forms more or less abundant in Cuba that have invaded Florida; three are European forms which have become established; and nine are Mexican forms that have crossed the Mexican border into Texas and the other border states.

As used in this paper the term Eastern North America is used to include all the territory lying east of the foot hills of the Rocky Mountains. This large area seems to be rather homogeneous as far as its fulgorid fauna is concerned, but as pointed out above there are naturally certain intrusions especially in Florida and Texas. Other West Indian, Mexican and western forms will undoubtedly be found within our territory but only species with definite records within our borders have been included below. Certain of the older species which have been recorded from North America only have been included for the guidance of future students.

TAXONOMY

HEAD REGIONS. The regions of the head of the *Fulgoridæ* used in taxonomy are the vertex, frons, genæ and clypeus. The frons, vertex and genæ are frequently prolonged into a long cephalic process. The vertex shows a number of good specific characters in most genera. The comparative length and breadth, the shape and the arrangements of the carinæ are usually quite specific and have been much used in the past. Sometimes the vertex is narrow and shades

insensibly into the frons. Sometimes it rounds into the frons but is more distinct. In still other cases it is sharply set off from the frons and may be separated for its entire breadth from the frons by a more or less distinct carinæ (*Issinæ, Megamelanus*) or sulcus (*Poblicia*). The vertex is sometimes prolonged along the dorsal side of the cephalic process (*Dictyophara, Scolops*). Sometimes the vertex is furnished with a more or less distinct median carina and another very common condition is to have two lateral carinæ converging towards the frons (*Cixius,* many *Delphacinæ*). In this condition the vertex is divided into three regions, the two lateral compartments between the lateral carinæ and the converging carinæ, and the central compartment posterior to the converging carinæ. Sometimes the central compartment is divided by a median y-shaped carina into three compartments, the frontal compartment and the posterior compartments.

The frons is usually separated from the genæ by sharp carinæ and from the clypeus by a distinct sulcus. Its separation from the vertex may be distinct and furnished by a carina or sulcus as mentioned above or it may be impossible to distinguish the frons from the vertex, in taxonomy the entire dorsal surface is usually called the vertex although this may include a portion of what is the frons morphologically. The comparative length and breadth of the frons is often a very useful character, as is its comparative width at the base, along the vertex and at the apex, along the clypeus.

The characters of the genæ have not been much used but there are frequently good generic characters present especially in the shape and size of the antennal socket and antennal collar.

The clypeus frequently furnishes reliable characters both in comparative size and shape and in the arrangement of the carinæ. In the subfamilies *Fulgorinæ* and *Dictyopharinæ* and some others the clypeus is laterally sharply carinate but in other groups it is ecarinate laterally. The depth of its insertion into the frons is also a useful character at times. The clypeus frequently shades imperceptibly into the labrum-epipharynx which may or may not be evidently divided into its separate components.

Ocelli are frequently present and usually these consist of a lateral pair placed between the compound eyes and the lateral frontal carinæ. In the *Cixiinæ* there is usually a very distinct frontal ocellus at the apex of the frons. Sometimes this frontal ocellus is represented by a scar only.

APPENDAGES. The following appendages, compound eyes, antennæ and mouth parts especially the labrum-epipharynx and labium are usually conspicuous. The compound eyes are sub-hemispherical in shape and usually crescentric in outline with a ventral sinus for the reception of the antennæ but occasionally, as in *Bothriocera,* the sinus and antennæ are anterior in position.

The antennæ consist of two segments with a terminal flagellum. The comparative lengths of the two segments of the antennæ are frequently useful as is the shape of these segments. The first segment is usually shorter than the second and is frequently set in a distinct socket and more or less surrounded by a collar-like projection of the genæ, the antennal collar. Usually the first segment is more or less terete or frequently it is widened distally and more or less club-shaped. In a few cases the first joint is much flattened (*Bostœra*). The second joint is usually club-shaped, sometimes flattened and more or less studded with sensory organs. The number and arrangement of these sensory organs furnish excellent characters as pointed out by Hansen long ago, but their examination requires a rather high power and for that reason they have not been much used. The flagellum is usually longer than the two segments of the antennæ combined. It consists of an enlarged spherical basilar portion, the basal segment and a distal portion, the bristle. The bristle of the flagellum is gradually attenuated. In *Otiocerus* the antennæ are provided with two or three vermiculate appendages of unknown function.

The mouth parts are of the usual haustellate homopterous type. The epipharynx is small and sharply pointed and lies in the groove of the labium. It is not always distinctly separated from the labrum. The labium is long or short and consists of four segments. The basal and sub-basal segments are closely applied to the gular surface of the head and are not visible from the frontal view. The apical and subapical are usually unequal in length, the apical being short and the subapical long. The length of the labium is frequently a good generic character but is seldom of any value as a specific character.

THORACIC REGIONS. The typical regions of the thorax are somewhat modified in the *Fulgoridæ*. The pro- and mesonotum are conspicuous but the metanotum is hidden by the wings when at rest. The propleura are covered by the lateral extensions of the pronotum, the breast plates, but the meso- and metapleurs are quite distinct. The sternites are small.

The pronotum is a saddle-shaped piece with the breast plates extending ventrad and covering the propleura. The pronotum is long or short sometimes being reduced to a mere collar (*Catonia*) and sometimes longer than the mesonotum. It is usually medianly carinate and more or less notched posteriorly, although it is truncate in most *Issinæ*. There are frequently intermediate and lateral carinæ whose positions and direction have been much used as generic characters among the *Delphacinæ*. The breast plates are usually separated from the dorsal field of the pronotum by distinct carinæ.

The mesonotum is generally longer than the pronotum, broadly triangular and is as a rule provided with three distinct carinæ, sometimes five (*Oliarus*). In all of our genera there are distinct tegulæ at the base of the fore wings. These are broadly crescentric in shape with one horn directed dorsad and the other laterad. The tegulæ are frequently medianly carinate and their shape and size furnish good diagnostic characters.

THORACIC APPENDAGES. The thoracic appendages are the typical three pairs of legs and two pairs of wings although the metathoracic (hind) wings are sometimes wanting (most brachypterous forms). The legs have the usual segments of an insect leg, with well developed trochantines and three jointed tarsi. In the prothoracic (fore) legs the coxæ are generally long sometimes nearly as long as the femora. The femora and tibiæ are terete with the former thick and the latter slender. They are nearly equal in length. Sometimes (*Phylloscelis* and *Phyllodinus*) the femora and tibiæ are much dilated. Spines are usually absent on the fore legs and the pulvillus and claws are weakly developed. The mesothoracic (middle) legs are but little used taxonomically. They are somewhat intermediate in character between the fore and hind legs. In the metathoracic (hind) legs the coxæ are usually nearly globular in shape but sometimes they are more elongate. The femoræ are clavate and not especially elongate. The tibiæ are slender and much elongate. Normally they have one or more heavy spines along the posterior lateral margin, although these spines are sometimes absent (*Myndus, Oecleus*). The number of these spines are not specifically constant as has been assumed by some writers as the number frequently varies on the two members on the same specimen. The number of these tibial spines and their approximate position should be recorded in all generic diagnoses, however, as they are very useful. The hind tibiæ frequently end in a circlet of spines

whose number and arrangement seems to be rather constant. The two basal segments of the hind tarsi are usually provided with well defined spines ventrally on their apical margins. The claws are usually weak and simple but the pulvilli are frequently of considerable size. The members of the subfamily *Delphacinæ* are provided with a special organ, the calcar, which is an organ of great taxonomic importance in this group. It assumes four primary shapes: spiniform, in which it is slender and attenuated to a rather fine point; cultrate, in which it has one edge thick and the other edge thin like a thick bladed knife, the thin edge may or may not be provided with marginal teeth; foliaceous, where the calcar is reduced to a thin leaf-like structure; and lastly tectiform, where the calcar is angled in cross section, in some cases (*Stenocranus*) the two edges of the tectiform calcar are brought close together and the space between is filled with a sponge-like mass. In both the foliaceous and tectiform calcars the edge may or may not be provided with minute teeth.

THE WINGS. Not very much attention has been paid to the taxonomic characters in the wings of the *Fulgoridæ*. This is perhaps due to three reasons: (1) The fore wings of *Fulgoridæ* occur quite commonly in three forms; a very short wing with reduced venation covering the basal segments of the abdomen only, brachypterous; a wing of moderate length covering most of the abdomen and with fairly well developed venation, kœlopterous; and lastly a wing usually longer than the abdomen frequently much longer with fully developed venation, macropterous; (2) the branching of the longitudinal veins are not constant either for the genus or species; (3) the position of the cross veins is very variable and the number is not constant. Yet in spite of these objections the wings furnish good characters and I feel sure that no satisfactory classification of the higher groups of this family will ever be made without taking into consideration the wing characters.

Just what are the factors that produce brachypterous, kœlopterous or macropterous wings is one of the many unsolved questions in biology today. The reduced wings are found in certain groups only and so far as I know are never found in the following subfamilies: *Fulgorinæ, Flatinæ, Acanoloninæ, Achilinæ, Derbinæ, Cixiinæ.* Brachypterous and kœlopterous wings are fairly common in the subfamily *Dictyopharinæ,* occur about as commonly as macropterous wings in the *Delphacinæ,* and are all but the rule in the subfamily

Issinæ. That this is not determined by environment would seem to be settled by the fact that brachypterous and macropterous forms, or kœlopterous and macropterous forms of the same species occur on the same host plants at the same time. That the factors are hereditary would seem in accord with all known facts but would require experimental proof before it can be established.

In spite of the fact that the longitudinal veins are not always constant either within the genus or species they are constant enough to furnish good characters. On the basis of wing venation the *Fulgoridæ* of Eastern North America fall into eight groups. Group one includes the subfamily *Fulgorinæ* and is distinguished by the following points: subcosta and radius are not united save for a short distance at the base, radius and medius are united for a considerable distance, cubitus is provided with several accessory veins, the second and third anals are united into a common stem, the surface of the fore wing is reticulated by many cross veins and the hind wing has the anal area reticulate. Group two includes the subfamily *Flatinæ*, it may be distinguished as follows: costa is distant from the margin of the wing and united with it by a series of transverse veinlets; the other veins are distinct and have many accessory veins, second and third anal distinct. The third group includes the subfamily *Acanaloninæ*. This group has the costal vein distinct from the margin but not connected by transverse veinlets, the other veins are distinct and connected by reticulating veinlets, cubitus is unbranched. Group four includes the subfamilies *Achilinæ*, *Derbinæ* and *Cixiinæ*. The principal character in this group is that subcosta and radius are united for a considerable distance from the base. Group five includes the subfamily *Dictyopharinæ*. The members of this subfamily in our fauna have subcosta and radius completely united and with medius and cubitus distinctly two branched before the apical reticulate area. Group six includes the subfamily *Delphacinæ* and is perhaps simply an evolution of group four. Subcosta and radius are united as in that group but the single stem of radius after its separation from subcosta is bent anally and merges for a short distance with medius one plus two only to separate again and appear as a distinct vein like a branch of medius. Group seven includes the *Issinæ* whose wings are generally so reduced either brachypterous or kœlopterous that little can be said about their real character. For the most part the veins are straight and extend from the base to the apex without branching but are con-

nected by many transverse veinlets. Group eight includes our *Tropiduchinæ* which have a venation quite similar to our *Dictyopharinæ*, but costa is distant from the margin of the wing sometimes united by transverse veinlets, and the apical portion of the corium is separated from the basilar portion by a distinct transverse vein, thus paralleling the development of the *Heteroptera*.

THE ABDOMEN. Outside of the genitalia the characters of the abdomen have not been much used. The general shape of the abdomen, whether compressed or depressed is sometimes useful and I have no doubt that other good specific and generic characters await discovery. The abdomen in *Fulgoridæ* consist of eight definite segments with the ninth, tenth and eleventh segments much modified by the genitalia. Typically each segment consists of the usual tergite, sternite and pleurite. The pleurites are modified in that they usually have a broad lateral portion and a broad ventral portion. The first and second segments are modified by having their tergites ending in a posteriorly directed process from the metapleura. The pleurites are wanting and the sternites are mostly covered by the metasternum, the coxa and trochanters of the hind legs. The spiracles of these segments are situated dorsally well within the lateral margins and the second pair is usually much larger than the first pair. Segments three to six are usually typical with their spiracles on the lateral faces of the pleurites. Segments seven and eight are usually modified by the genitalia but have a pair of small spiracles on the lateral faces of the pleurites.

THE GENITALIA. The genitalia are useful in some groups especially in the *Delphacinæ* where the male genitalia are the court of last appeal for specific determinations in many genera. In a few other groups they are frequently useful but in many groups they seem to be entirely useless. In the *Delphacinæ* the female genitalia are very similar to the female genitalia in other *Homoptera* and consist of a pair of swollen pygofers on either side of the ovipositors. In the males the ninth segment is modified into the tubular pygofer which opens posteriorly through a more or less circular genital aperture which includes the anal segment and the anal style dorsally. Ventrad the aperture is frequently incised to form the ventral sinus, and dorsad there is an incision, the dorsal sinus (anal emargination), which encloses the anal segment. The angles where the sinuses merge with the genital aperture are sometimes prolonged and form the dorsal (anal) and ventral angles. In a few cases the ventral wall of the

genital aperture is prolonged into variously shaped lobes or plates, which may be known as the genital plates. In a few cases there is a single median tooth on the ventral margin, the genital tooth. Looking directly into the genital aperture one can usually see the diaphragm which almost completely divides the genital chamber into an outer and inner chamber. The dorsal margin of the diaphragm is sometimes straight transverse and is sometimes variously armed or toothed, genital armature, these teeth are frequently prolonged and hook-like, genital hooks. The outer genital chamber contains two style-like plates, the genital styles, which are of various sizes and shapes. The following terms are used in describing them: outer and inner margins; apex with inner and outer angles. The ædægus lies in the inner genital chamber and projects posteriorly through the genital orifice. The tenth abdominal segment is modified into the anal segment which is armed ventrally with one or two hook-like processes, the anal processes. The eleventh segment constitutes the anal style.

Various modifications of the genitalia exist in the other subfamilies but so far as I am aware no one has attempted to homologize the genital structures of the different subfamilies of the *Fulgoridæ*.

CLASSIFICATION

The classification adopted is substantially that of Van Duzee's Catalog of the *Hemiptera* of America North of Mexico (1917). Wherever additional synonomy has been used it is clearly indicated under the genera or species concerned. Otherwise the student is referred to this excellent catalog for matters of nomenclature. As stated elsewhere the writer is far from satisfied with the present arrangement of subfamilies but as our chief interest in this paper is the identification of genera and species a thorough revision of the higher divisions need not concern us greatly.

The key given below is based as far as possible upon two contrasting characters. Having used it repeatedly during the past three years, on material from all parts of the country, no one is more familiar with its weaknesses than the writer. Nevertheless it is an attempt to stabilize our knowledge of the classification of the *Fulgoridæ* and to make easier the path of the beginner. The characters used throughout are what appear to the writer to be the most obvious ones available. These characters have been taken entirely from forms in

our territory and do not necessarily have any significance when applied to extralimital forms. As far as possible I have made an attempt to include all our described forms. A few forms as listed below have not been included for the reasons stated. A few forms have been included on characters which seem to be reliable, although I have seen no specimens. In many genera recourse has been had to color characters, a rather doubtful procedure, while in other genera it has been necessary to resort to genital characters from the one sex or the other, which is apt to prove disappointing if the sex one is trying to identify is the opposite sex to the one used in the key. At the present time the only hope in all such cases is to collect enough material and then by careful comparisons work out both sexes. For economy of time and space the keys to the subfamilies, genera and species are all grouped together, thus avoiding the necessity of searching through several pages in locating any given form.

The following changes in the nomenclature adopted in the Van Duzee Catalog are proposed:

Elidiptera Spinola to Epiptera Metcalf.
Cyclokara vanduzei Ball to Patara vanduzei Ball.
The genus Lamenia Stal in our territory to Herpis Stal as has been suggested by Muir;
The genus Cenchrea Westwood in our territory to Phaciocephalus Kirkaldy;
Stenocranus saccharivorus Westwood to Saccharosydne Kirkaldy;
Stenocranus longicornis Dozier to Megamelus Fieber;
Stenocranus palætus Van Duzee to Megamelus Fieber;
Pissonotus piceus Spooner to Phyllodinus Van Duzee;
Pissonotus crawfordi n. n. for Dicranotropis marginatus Crawford nec Pissonotus marginatus Van Duzee;
Pissonotus foveatus Spooner to Pissonotus quadripustulatus Van Duzee;
Pissonotus variegatus Spooner to Pissonotus quadripustulatus Van Duzee;
Phyllodinus kœbelei Osborn to Phyllodinus flabellatus Ball;
Stobæra quadripustulata Van Duzee to Pissonotus Van Duzee;
Stenocranus breviceps Dozier to Liburnia slossoni Ball;
Liburnia arvensis Fitch to Liburnia pellucida Fabricius;
Megamelus constrictus Crawford to Liburnia Stal.

The following species have not been included in the present review for the reasons stated:

Liburnia culta Van Duzee known from the female sex and I have been unable to place it;
Liburnia furcata Provancher, the male has not been described and I have been unable to place it;

Liburnia seminigra Stal, the male has not been described and I have not been able to place it;

Liburnia unicolor Walker, the type is an immature specimen according to Mr. W. E. China.

Dicranotropis luteivitta Walker, the male genitalia have not been described;

The following species have not been seen by the writer:

Calyptoproctus marmoratus Spinola described from North America
Myndus lunatus Van Duzee
Monopsis tabida Spinola
Aphelonema decorata Van Duzee
Thionia transversalis Melichar described from North America
Ormenis pauperata Melichar
Ormenis relicta Fabricius
Ormenis proxima Walker
Otiocerus francilloni Kirby
Otiocerus reaumurii Kirby
Megamelanus rufivittatus Ball
Pissonotus binotatus Spooner
Pissonotus divaricatus Spooner
Phyllodinus piceus Spooner
Stobæra affinis Van Duzee
Liburnia dolera Spooner

The following species have not been reported previously from America North of Mexico:

Poblicia constellata Walker, Mexican
Acanalonia virescens Stal, Mexican
Cyarda acuminipennis Spinola, West Indian
Cyarda walkeri n. n. for Cyarda conformis Melichar nec. Walker.
Flatoides insularis Melichar, West Indian
Flatoides tortrix Guerin, West Indian
Bakerella maculata Crawford, Mexican

The following new genera are proposed:

Ciocixius for Cixius dorsivittatus Van Duzee
Traxus, orthotype Traxus fulvus n. sp.
Euklastus, orthotype Euklastus harti n. sp.
Neocenchrea for Cenchrea heidemanni Ball.

The following new species are described:

Crepusia glauca
Dictyophara recurva
Scolops parvulus
Epiptera brittoni
Catonia carolina
Catonia luella
Catonia pini
Catonia lunata
Bothriocera drakei
Oliarus montanus
Oliarus texanus
Oliarus vitreus
Oliarus vittatus
Microledrida fulva
Cixius apicalis
Oecleus productus
Myndus truncatus
Bruchomorpha minima
Bruchomorpha decorata
Bruchomorpha bicolor
Bruchomorpha vittata
Bruchomorpha rugosa
Aphelonema rosa
Traxus fulvus
Thionia quinquata
Acanalonia fasciata
Flatoides maculosus
Flatoides concisus
Euklastus harti
Herpis incisa
Herpis australis
Stenocranus arundineus
Megamelanus terminalis
Megamelanus dorsalis
Megamelanus lautus
Megamelus distinctus
Megamelus æstus
Megamelus inflatus
Megamelus uncus
Megamelus anticostus
Pissonotus speciosus
Pissonotus fulvus
Pissonotus nigridorsum
Liburnia triloba
Liburnia gerhardi
Liburnia alexanderi
Liburnia fulvidorsum
Liburnia unda
Liburnia shermani
Liburnia staminata
Liburnia waldeni
Criomorphus conspicuus

KEY TO THE SUBFAMILIES, GENERA AND SPECIES OF THE FULGORIDÆ OF EASTERN NORTH AMERICA

1. Posterior tibiæ with a calcar **557** ..... SUBFAMILY DELPHACINÆ 202
   Posterior tibiæ without a calcar **529** 2
2. Fore wings macropterous, clavus granulate or reticulate **501** 3
   Fore wings macropterous or brachypterous, clavus of macropterous wings not granulate or reticulate **518** 45
3. Sides of the clypeus sharply carinate; anal area of hind wings reticulate **504** ..... SUBFAMILY FULGORINÆ 34
   Sides of the clypeus not carinate; anal area of hind wings not reticulate 4
4. Costal area with transverse veins; hind tibiæ with one to three spines **498** SUBFAMILY FLATINÆ 13
   Costal area without transverse veins; hind tibiæ without spines **497** SUBFAMILY ACANALONIINÆ (Genus *Acanalonia*) 5

ACANALONIA

5. Vertex conically produced **124** ..... *Acanalonia conica* Say
   Vertex not conically produced, at most triangular before **133** 6
6. Size small, less than 5 mm. in length **118** ..... *A. pumila* Van Duzee
   Size larger, more than 7 mm. in length 7

* Numbers in blackface refer to figures on the plates.

7. Color green or rosaceous, usually with two brown stripes on the lateral margins of the vertex and thorax which extend along the sutural margins to the apex of the clavus 12 8

Color green, without brown stripes 9

8. Venation rather simple; last ventral segment of the female not produced 558 *A. fasciata* Metcalf

Venation strongly reticulate; last ventral segment produced, notched at the tip 559 ..... *A. bivittata* Say

9. Vertex flat, not rounded before 130 ..... *A. virescens* Stal

Vertex not flat, strongly rounded before 133 10

10. Mesonotum without median carina; fore wings short and broad, not marked with fuscous points on the apical margin 132 11

Mesonotum with an evident median carina; fore wings longer, marked with fuscous points on the apical margin 133 12

11. Fore wings shaded with fuscous along the claval suture; second branch of medius with three branches arising at about the same point; vertex truncate 131 ..... *A. concinnula* Fowler

Fore wings not shaded along the claval suture; second branch of medius branching into two veins, the posterior one again branched; vertex broadly rounded 132 ..... *A. immaculata* Kirkaldy

12. Length 10-11 mm.; costal margin of the wing broadly rounded *A. latifrons* Walker

Length 14-15 mm.; costal border of the fore wings nearly straight posteriorly ..... *A. servillei* Spinola

SUBFAMILY FLATINÆ

13. Wings narrowed apically 39 14

Wings not narrowed apically 13 17

14. Wings three or four times as long as broad, with the apical margin obliquely truncate 40 ..... Genus *Cyarda Walker* 15

Wings but little longer than broad, produced into an acute point 41 *Rhynchopteryx caudate* Van Duzee

CYARDA

15. Vertex narrow, usually not more than twice as broad as long 136 *Cyarda melichari* Van Duzee

Vertex broader, usually more than three times as broad as long 138 16

16. Vertex with a distinct transverse carina basally; size small, 8 mm. 138 *C. walkeri* Metcalf

Vertex without transverse carinæ; size large, 11 mm. 139 *C. acuminipennis* Spinola

17. Vertex short, nearly linear 10 ..... Genus *Ormenis* Stal 18

Vertex triangular, produced 145 ..... Genus *Flatoides* Guerin 26

ORMENIS

18. Color light..... 19
Color dark with evident pruinosity when fresh 13....*Ormenis pruinosa* Say

19. With one sub-apical line on the fore wings 498..... 20
With two sub-apical lines on the fore wings 499..... 22

20. Head and thorax green, marked with red 10.....*O. rufifascia* Walker
Head and thorax not marked with red..... 21

21. Sub-apical line widely separated from the apical border
O. venusta Melichar
Sub-apical line near the apical border.....*O. pauperata* Melichar

22. Size small, 5 mm.....*O. proxima* Walker
Size larger, 8-10 mm..... 23

23. Frons with median carina well elevated; mesonotum yellowish or brownisk testaceous, sharply contrasted with green wings 141...*O. chloris* Melichar
Frons with median carina indistinct; mesonotum not sharply contrasted with the wings 144..... 24

24. Wings pale with brown spots.....*O. contaminata* Uhler
Wings without brown spots..... 25

25. Both sub-apical lines united with the costal nerve 499
O. septentrionalis Spinola
The last sub-apical line not reaching the costal border 500
O. relicta Fabricius

FLATOIDES

26. Hind tibiæ with three spines before the apex; fore wings light buff, heavily spotted with large black spots 17.....*Flatoides maculosus* Metcalf
Hind tibiæ with two spines before the apex; fore wings variously colored 27

27. Color blackish fuscous, unmarked 16.....*F. fuscus* Van Duzee
Color lighter, more or less strongly marked with darker 15..... 28

28. Vertex nearly twice as long as broad 147..... 29
Vertex not twice as long as broad 151..... 30

29. Color ochraceous green, with a transverse fuscous band at the apex of the clavus and numerous fuscous flecks.....*F. tortrix* Guerin
Color ochraceous yellow with a fuscous stripe along the claval suture and then diagonally to the costal margin.....*F. insularis* Melichar

30. Vertex acute at the apex; anterior margin of the pronotum not notched 149 31
Vertex obtuse at the apex; anterior margin of the pronotum notched 152 33

31. Vertex twice as broad as its median length 150..... 32
Vertex not twice as broad as it median length 151.....*F. acutus* Uhler

32. Color ochraceous buff with a broad transverse fuscous band at the base and at the apex of clavus.....*F. concisus* Metcalf
Color greenish without evident transverse bands .....*F. punctatus* Walker

33. Frons nearly smooth; vertex not produced 152.....*F. signatus* Melichar
Frons with two prominent rolls near the base; vertex produced 154, 155 *F. scabrosus* Melichar

SUBFAMILY FULGORINÆ

34. Head strongly produced 156..... 35
Head not strongly produced 163..... 37

35. Cephalic process expanded apically; lateral carinæ of the vertex crenulate 156.....*Scolopsella reticulata* Ball
Cephalic process narrowed apically; lateral carinæ of vertex not crenulate 159.....Genus *Amycle* Stal 36

AMYCLE

36. Cephalic process narrow, elongate 159.....*Amycle vernalis* Manee
Cephalic process broader 160.....*A. saxatilis* Van Duzee

37. Ninth abdominal segment elongate, quinquecarinate *Calyptoproctus marmoratus* Spinola
Ninth abdominal segment not elongate, not quinquecarinate..... 38

38. Posterior border of pronotum with a transverse carina 163 *Crepusia glauca* Metcalf
Posterior border of pronotum without a transverse carina 165..... 39

39. Vertex short with a distinct sulcus between vertex and frons 172 Genus *Poblicia* Stal 42
Vertex longer, produced anteriorly 165.....Genus *Cyrpoptus* Stal 40

CYRPOPTUS

40. Medius and cubitus of the fore wings forked at about the same distance from the base; fore wings opaque 501.....*Cyrpoptus belfragei* Stal
Medius forked much nearer the base than cubitus; apex of the fore wings semitransparent 502 41

41. Apex of the fore wings with a diagonal transparent vitta; base not clouded with fuscous; wings strongly flaring.....*C. reineckei* Van Duzee
Apex of the fore wings without a diagonal transparent vitta; base clouded with fuscous; wings not strongly flaring.....*C. nubeculosus* Stal

POBLICIA

42. Fore wings tricolored; base greenish; apex fuscous with a sub-apical transverse vitta transparent 9.....*Poblicia constellata* Walker
Fore wings not tricolored, no sub-apical transparent vitta..... 43

43. Color pale ochraceous 4.....*P. misella* Stal
Color fuscous or blackish 5..... 44

44. Color fuscous, veins and veinlets pale.....*P. fuliginosa* Oliver
Color blackish, veins and veinlets black.....*P. thanatophana* Kirkaldy

45. Macropterous wings with subcostal vein branching to form a distinct post nodal cell or post nodal cells; no brachypterous forms 518..... 104
Macropterous wings with subcostal vein not branching to form a distinct post nodal cell; brachypterous forms common 509..... 46

46. With a distinct cross vein from costal margin to apex of clavus dividing the fore wings into a distinct corium and membrane with many cross veins 505.....SUBFAMILY TROPIDUCHINÆ 47
With no distinct cross vein from costal margin to apex of clavus 508 49

SUBFAMILY TROPIDUCHINÆ

47. Frons with a median carina 180..... 48
Frons without a median carina 178.....*Pelitropis rotulata* Van Duzee

48. Costal cross veins present; vertex as long as the mesonotum 506 *Neurotmeta sponsa* Guerin
Costal cross veins absent; vertex shorter than the mesonotum 507 *Monopsis tabida* Spinola

49. Lateral margins of the pronotum equalling its median length; head narrower than the mesonotum 201.....SUBFAMILY DICTYOPHARINÆ 50
Lateral margins of the pronotum shorter than its median length; head usually as broad as the mesonotum 215.....SUBFAMILY ISSINÆ 68

SUBFAMILY DICTYOPHARINÆ

50. Vertex produced in front of the eyes; anterior femora simple 184.... 52
Vertex transverse; anterior femora foliaceous 182, 530 Genus *Phyllescelis* Germar 51

PHYLLOSCELIS

51. Fore wings pale, veins brown, dotted with white 8.....*P. pallescens* Germar
Fore wings black, veins uniform black or broadly pale yellow 6 *P. atra* Germar

52. Fore wings pale, transparent green, much longer than the abdomen; vertex not suddenly constricted in front of the eyes; cephalic process triangular 204.....Genus *Dictyophara* Germar 64
Fore wings coreaceous, equal to or slightly longer than the abdomen; vertex suddenly constricted in front of the eyes; cephalic process very slender, nearly parallel-sided 184.....Genus *Scolops* Schaum 53

SCOLOPS

53. Fore wings densely and uniformly reticulated apically 52..... 54
Fore wings with only a few irregular cross veins apically 53..... 55

54. Reticulations of the fore wings small, the veins margined with darker; cephalic process rather slender 184.....*Scolops sulcipes* Say
Reticulations of the fore wings large, not margined; cephalic process stouter 185.....*S. osborni* Ball

55. Cephalic process with the lateral margins nearly straight lines sometimes converging apically 188 56
Cephalic process suddenly narrowed in front of the eyes, the lateral margins nearly parallel to the apex 192 58

56. Cephalic process slender; size small, less than 5 mm. 186 *S. parvulus* Metcalf
Cephalic process stout 187 57

57. Cephalic process short; the margins of the frons somewhat expanded toward the apex of the cephalic process giving it an inflated appearance 187 ..... *S. hesperius* Uhler
Cephalic process long, tapering anteriorly, not inflated 188 *S. grossus* Uhler

58. Costal vein mostly white, the costal cell white 53 59
Costal vein alternately dark and pale, the costal cell not white 60

59. Cephalic process shorter than clavus; veins of the fore wings nearly uniform 190 ..... *S. angustatus* Uhler
Cephalic process longer; veins of the fore wings distinctly alternate with dark and light 192 ..... *S. perdix* Uhler

60. Color green ..... *S. viridis* Ball
Color not green 61

61. Cephalic process short 194 62
Cephalic process long 196 63

62. Cephalic process stout, at least four times as long as the diameter of the eye 194 ..... *S. desiccatus* Uhler
Cephalic process slender, not more than twice as long as the diameter of the eye 195 ..... *S. robustus* Ball

63. Cephalic process very slender, parallel sided 196 ..... *S. spurcus* Uhler
Cephalic process stouter, somewhat tapering 197 ..... *S. vanduzei* Ball

DICTYOPHARA

64. Many of the cross veins of the fore wings meeting each other, thus forming a few regular transverse veins 509 ..... *Dictyophara dioxys* Walker
Cross veins many, irregularly placed, not forming transverse veins 510 65

65. Vertex at least twice as long as its width between the eyes 199 66
Vertex scarcely longer than its width between the eyes 205 67

66. Cephalic process slender, intermediate carinæ of the frons nearly parallel, plates longer than the ovipositor 199 ..... *D. microrhina* Walker
Cephalic process stout, nearly parallel sided; intermediate carinæ of the frons not parallel; ovipositors slightly longer than the plates 201 *D. recurva* Metcalf

67. Lateral carinæ of the frons lined with black basally; female plates short 562 ..... *D. florens* Stal
Lateral carinæ of the frons concolorous; female plates long 563 *D. lingula* Van Duzee

SUBFAMILY ISSINÆ

68. Fore wings short, usually shorter than the abdomen and not covering the lateral margins 37 69
Fore wings longer than the abdomen, broader, covering the lateral margins 62 90

69. Fore and middle tibia expanded 531 ..... Genus *Fitchiella* Van Duzee 71
Fore and middle tibia not expanded 70

70. Clypeal suture not evident, head triangularly produced, face more or less horizontal 216 ..... Genus *Bruchomorpha* Newman 73
Clypeal suture evident, head not triangularly produced, face vertical 236 Genus *Aphelonema* Uhler 84

FITCHIELLA

71. Nasal process expanded apically, knob like 207 .. *Fitchiella robertsoni* Fitch
Nasal process not expanded apically 210 72

72. Nasal process viewed dorsally, obtuse 209 ..... *F. fitchi* Melichar
Nasal process viewed dorsally, acute 210 ..... *F. melichari* Ball

BRUCHOMORPHA

73. Body and wings black, often with a pale dorsal vitta 51 74
Body and wings mostly pale 57 81

74. Body and wings black without pale median vitta; legs uniformly black 75
Body with a pale median vitta; legs in part at least pale 76

75. Size large, robust; the lateral carinæ of the mesonotum strongly elevated *Bruchomorpha tristis* Stal
Size small, slender; the lateral carinæ of the mesonotum faint *B. minima* Metcalf

76. Nasal process protuberent, concave ventrally 218 77
Nasal process not protuberent, not concave ventrally 221 79

77. Dorsal vitta evident extending from the apex of the head to the apex of the abdomen 51 ..... *B. dorsata* Fitch
Dorsal vitta only faintly indicated on the head 78

78. Nasal process viewed from above centrally compressed; lateral carinæ sinuate 215 ..... *B. oculata* Newman
Nasal process not compressed; lateral carinæ not sinuate 217 *B. nasuta* Stal

79. Nasal process upturned at the apex; dorsal vitta broad, extending to the apex of the brachypterous wings 219 ..... *B. suturalis* Melichar
Nasal process not upturned at the apex 221 80

80. Dorsal vitta evident, extending to the apex of the mesonotum 55 *B. vittata* Metcalf
Dorsal vitta not extending to apex of mesonotum ..... *B. pallidipes* Stal

81. Wings strongly rugose 56 82
Wings not strongly rugose 83

82. Nasal process produced, concave ventrally, nearly unicolorous 222 *B. rugosa* Metcalf
Nasal process not produced, not concave ventrally 223 *B. decorata* Metcalf

83. Nasal process slightly protuberent, not concave ventrally, an evident stripe on each side of the apex of the vertex across the eyes to the apex of the abdomen 30 224 ..... *B. bicolor* Metcalf
Nasal process not at all protuberent, unicolorous 225 ..... *B. jocosa* Stal.

APHELONEMA

84. Vertex short, transverse 228 85
Vertex more elongate, nearly as long as pronotum, six-sided 236 88

85. General color pale ochraceous yellow or blackish fuscous 86
General color bright red 2 ..... *Aphelonema rosa* Metcalf

86. Frons elongate, clypeus black 229 ..... *A. obscura* Van Duzee
Frons transverse, clypeus not black 231 87

87. General color of the body pale ochraceous buff ..... *A. simplex* Uhler
General color of the body darker ..... *A. decorata* Van Duzee

88. Frons almost parallel-sided; intermediate carinæ not strongly arched 233 *A. bivittata* Ball
Frons nearly circular; intermediate carinæ strongly arched 235 89

89. Fore wings rugose 58 ..... *A. rugosa* Ball
Fore wings not rugose 59 ..... *A. histrionica* Stal

90. Fore wings reticulate, venation not evident 60 91
Fore wings with the longitudinal veins evident 65 92

91. Vertex triangularly produced anteriorly 60 ... *Misodema reticulata* Melichar
Vertex obtusely produced anteriorly; body hairy 61 *Dictyonissus griphus* Uhler

92. General surface of the wings rugulose; vertex broadly emarginate anteriorly 62 ..... *Traxus fulvus* Metcalf
General surface of the wings not much roughened; vertex not broadly emarginate anteriorly 64 93

93. Cubitus and medius branching 514 94
Cubitus of the fore wing unbranched 515 96

94. Hind tibia with two spines 533 ..... *Issus servillei* Spinola
Hind tibia with four or five spines 534 95

95. Vertex transverse, rounded anteriorly, wings broadly expanded at the base, form oval 64 ..... *Picumna ovatipennis* Walker
Vertex elongate, triangularly produced anteriorly, fore wings not expanded at the base, form elongate 65 ..... *Issomorphus maculatus* Melichar

96. Fore wings short, not twice as long as broad; hind wings small 66 Genus *Hysteropterum* Amyot & Serville 97
Fore wings longer, twice as long as broad; hind wings broad with a distinct incision between first and second anal vein 67 Genus *Thionia* Stal 98

HYSTEROPTERUM

97. Color dark brown; the fore wings with numerous round points; anterior margin of the vertex broadly sinuate between the eyes 246
Hysteropterum punctiferum Walker
Color ochraceous orange, the wings clouded with brown; anterior margin of the vertex nearly straight between the eyes, indented medianly 247
H. auroreum Uhler

THIONIA

98. Vertex broader than long 250 99
Vertex as long or longer than broad 256 100

99. Basal margins of the frons nearly straight between the eyes; fore wings unicolorous with dark veins 249 ..... *Thionia simplex* Germar
Basal margins of the frons broadly concave between the eyes; fore wings variegated 251 ..... *T. elliptica* Germar

100. Frons slightly arched with a bright yellow transverse band
T. transversalis Melichar
Frons not arched, without a transverse band 101

101. Vertex acutely produced anteriorly; cells of fore wings with minute dark points 252 ..... *T. producta* Van Duzee
Vertex rounded or only obtusely angulate anteriorly; fore wings variegated 256 102

102. Vertex rounded anteriorly; fore wings with an ocellated spot near the apex 254 ..... *T. ocellata* Melichar
Vertex angularly produced anteriorly; fore wings variegated 256 103

103. Vertex strongly five-angled, the lateral margins flaring anteriorly 255
T. quinquata Metcalf
Vertex obtusely produced, not five-angled, lateral margins parallel 256
T. bullata Say

104. Fore wings overlapping at the apex 72 ..... SUBFAMILY ACHILINÆ 105
Fore wings not overlapping at the apex 124

105. Pronotum short, collar-like; vertex not much produced, with median carina 266 ..... Genus *Catonia* Uhler 113
Pronotum not collar-like; vertex produced, with median sulcus 258
Genus *Epiptera* Metcalf 106

EPIPTERA

106. General color blackish, nearly uniform 112
General color brownish variegated with grayish 107

107. Frons black with a broad band of white across the apex 49 111
Frons not black, not banded with white 47 108

108. Clypeus distinctly darker than the frons 47 109
Clypeus not distinctly darker than the frons 48 110

109. Vertex longer than its basal width; size smaller, 7 mm. 258 *Epiptera floridæ* Walker
Vertex not longer than its basal width; size larger, 8-10 mm. 259 *E. septentrionalis* Provancher

110. Vertex broader than long; frons irrorate 48.....*E. variegata* Van Duzee
Vertex as long as broad or longer; frons not irrorate, pale with a distinctly darker brown band basally 261.....*E. slossoni* Van Duzee

111. Clypeus brown; vertex obtusely angulate anteriorly 262.....*E. pallida* Say
Clypeus black; vertex broadly rounded anteriorly 263...*E. brittoni* Metcalf

112. Vertex elongate, twice as long as broad 264.....*E. colorata* Van Duzee
Vertex as long as broad 265.....*E. opaca* Say

CATONIA

113. Veins of the fore wings impunctate 73..... 114
Veins of the fore wings distinctly punctate 14..... 116

114. Fore wings uniform brown in color, a few of the cross veins sometimes marked with paler, size larger about 6 mm..... 115
Fore wings blackish uniformly spotted with small pale spots, size smaller about 3 mm.....*Catonia luella* Metcalf

115. Frons uniformly black; clypeus paler, strongly contrasted 70 *C. dimidata* Van Duzee
Frons transversely banded with pale 69.....*C. impunctata* Fitch

116. Fore wings with incomplete transverse veinlets in the cells *C. grisea* Van Duzee
Fore wings without transverse veinlets in the cells..... 117

117. Face unbanded..... 118
Face conspicuously banded 70..... 119

118. Frons with a short white bar at the middle and at the apex, colors darker, size larger, about 6 mm.....*C. carolina* Metcalf
Frons without the white bars, color mostly tawny, size smaller, about 5 mm. *C. pumila* Van Duzee

119. Middle light band narrow, basal and apical bands brownish..... 120
Middle light band broad..... 121

120. Wings variegated; lateral margins of the frons distinctly punctate *C. pini* Metcalf
Wings unicolorous except the punctate veins.....*C. bicinctura* Van Duzee

121. Basal and apical bands brown, the latter with a distinct pale transverse mark along the clypeal border.....*C. lunata* Metcalf
Basal and apical bands black..... 122

122. Frons much narrowed between the eyes, broadened apically; size larger 7 mm.....*C. nava* Say
Frons not much narrowed between the eyes; not much broadened apically; size smaller, 5 mm. or less..... 123

123. Color strongly contrasted, mesonotum variegated.....*C. cinctifrons* Fitch
Color not strongly contrasted, mesonotum unicolorous....*C. picta* Van Duzee

124. Carinæ distinct on the mesonotum; frontal ocellus usually evident 274
SUBFAMILY CIXIINÆ 125
Carinæ indistinct on the mesonotum; frontal ocellus wanting
SUBFAMILY DERBINÆ 172

SUBFAMILY CIXIINÆ

125. Posterior tibiæ armed with one to three spines before the apex 538.... 126
Posterior tibiæ without spines before the apex 539..... 149

126. Posterior margin of the vertex broadly rounded, mesonotum tricarinate 290 139
Posterior margin of the vertex angulate, parallel to the posterior margin of the angulate pronotum; mesonotum usually quinquecarinate 274
Genus *Oliarus* Stal 127

OLIARUS

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128. Fore wings uniform smoky brown, stigma and narrow costal margin pale; size larger, 8 mm.....*Oliarus cinnamomeus* Provancher
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129. Median tooth of the male pygofer simple, acute 569..... 132
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130. Vertex about as broad as median length; male styles not broadly expanded apically 566.....*O. montanus* Metcalf
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131. Wing veins uniformly punctate, fuscous markings not confined to the veins and cross veins, female with a distinct fuscous longitudinal vitta at the apex of the fore wings.....*O. placitus* Van Duzee
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132. Fore wings distinctly and uniformly punctate..... 134
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133. Size smaller, 4-5 mm.; fore wings nearly uniform in color, or infuscated apically 569.....*O. franciscanus* Stal.
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134. Frons with a broad white mark on either side next the base of the clypeus *O. aridus* Ball
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135. Frons not greatly narrowed between the eyes; median tooth of the male pygofer nearly as long as the pygofer; clypeus usually paler than the frons 571 ..... *O. quinquelineatus* Say
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136. Size smaller, less than 5 mm. 137
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137. Genital styles of the male longer than the ventral sinus; anal segment hood-like 572 ..... *O. texanus* Metcalf
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138. General color blackish, polished; male plates very slender basally, the apices strongly recurved and ridged so as to appear coiled 574 *O. vitreus* Metcalf
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139. Frons as broad as long or broader 279 140
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140. Vertex short, transverse, about four times as broad as long 278 *Monorachis sordulentus* Uhler
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MICROLEDRIDA

141. Color light testaceous yellow; male genital styles not produced into a long reflexed process at the apex 576 ..... *Microledrida flava* Metcalf
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142. Posterior margin of the pronotum broadly rounded; fore wings nearly vertical 282 ..... *Ciocixius dorsivittatus* Van Duzee
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143. Wings with the basal half infuscated, apical half milky hyaline, more or less marked with fuscous; median tooth of male pygofer longer than its basal width 78, 578 ..... *Cixius apicalis* Metcalf
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147. Vertex broadly triangular 288.....*C. misellus* Van Duzee
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148. Anal processes of the male very long; female with base of fore wings strongly infuscated 582.....*C. basalis* Van Duzee
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149. Antennæ inserted anteriorly to the eyes; eyes with an anterior sinus 294 Genus *Bothriocera* Burmeister 150
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153. With a row of distinct fuscous points in the cells near the apex 82 *B. tinealis* Burmeister
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154. Vertex paler than the mesonotum; hyaline spots on the fore wings irregular in outline 83.....*B. bicornis* Fabricius
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155. Vertex narrow, trough-like; lateral carinæ well elevated 297..... 156
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156. Vertex narrowed anteriorly 295.....*Oeclidius nanus* Van Duzee
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157. Male pygofer with the median tooth finger-like or tongue-like 588..... 158
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159. Laterial margins of the vertex nearly touching posteriorly, strongly widened anteriorly; anal segment of the male strongly produced and deflexed beyond the pygofer 588 ..... *O. productus* Metcalf
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163. Color uniform ochraceous orange, eyes darker ..... *Myndus fulvus* Osborn
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165. Frons marked with fuscous bands or spots 166
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166. Frons with a pair of black spots between the carinæ at the base, larger, 5 mm.
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167. Costal border of fore wings broadly whitish ..... *M. enotatus* Van Duzee
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168. Vertex narrow, elongate; color greenish 309 ..... *M. viridis* Ball
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169. Fore wings vittate with brown apically; genital styles of the male broadened apically 599 ..... *M. pictifrons* Stal
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170. Genital styles obliquely truncate apically, the inner angles strongly produced 600 ..... *M. truncatus* Metcalf
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171. Sides of the vertex converging to the apex; veins of the fore wings brown, not concolorous 313 ..... *M. sordidipennis* Stal
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178. Apex of the cephalic process with a black line laterally ..... *O. wolfii* Kirby
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179. Fore wings with a large black spot on the sutural margin and four smaller ones in a square ..... *O. signoretii* Fitch
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181. General color of the wings dark 33 ..... *O. stollii* Kirby
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182. Wings with a conspicuous band 28 183
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183. Head with a lateral sanguineous stripe; band on the wings sanguineous *O. coquebertii* Kirby
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184. Vertex nearly an equilateral triangle; apical veins of the wing strongly recurved 334 ..... *Euklastus harti* Metcalf
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185. Costa narrow; fore wings with several transverse costal veinlets, not crowded together to give the appearance of a stigma 87 ... Genus *Anotia* Kirby 187
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AMALOPOTA

186. Fore wings milky white, longitudinally banded with fuscous 25 *Amalopota fitchi* Van Duzee
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187. First three segments of the abdomen with a mid-dorsal black stripe *Anotia burnetii* Fitch
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188. Apical border of the fore wings with round black spots in the cells 87 *A. bonnetii* Kirby
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195. Medius and cubitus of the fore wings each with two branches, not connected by cross veins 523.....*Neocenchrea heidemanni* Ball
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196. Lateral carinæ of the vertex strongly elevated; general color ochraceous tawny.....*Phaciocephalus fulvus* Van Duzee
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198. Genital styles of the male with an apical tooth 618..... 199
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199. Inner margin of the genital styles straight 618.....*H. vulgaris* Fitch
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203. Calcar spiniform, without lateral teeth 542..... 208
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STOBÆRA

204. Sides of the frons not parallel 369.....*Stobæra pallida* Osborn
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205. Frons distinctly lighter in the middle, base and apex darker..... 206
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206. Head narrower than pronotum; anal process trilobed ventrally; genital styles with the inner angles strongly produced 623.....*S. concinna* Stal
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207. Vertex distinctly shorter than broad; frons nearly concolorous; larger, 4 mm.....*S. affinis* Van Duzee
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208. Antennæ foliaceous, half as long as the body; scutellum tricarinate; frons with a single median carina 96.....*Copicerus irroratus* Swartz
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212. Frons, pronotum and abdomen with prominent pits Genus *Laccocera* Van Duzee 213
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LACCOCERA

213. Vertex broader than long; colors black and buffy 384
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214. Anterior and middle femora foliaceous 546
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215. Head as broad as pronotum; brachypterous wings with veins white, apical margin concolorous 102.....*Phyllodinus nervatus* Van Duzee
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216. Frons with transverse white bands..... 217
Frons unicolorous.....*P. nitens* Van Duzee

217. Mesonotum white..... 218
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218. Frons with indistinct carina between median and lateral carinæ
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219. Frons with two median carinæ 392..... 220
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220. Lateral carinæ of the pronotum reaching the hind margin; head narrower than the mesonotum 389.....*Macrotomella carinata* Van Duzee
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221. Median carina of the frons running to the posterior margin of the vertex without oblique carinæ to the lateral margins 393
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222. Lateral carinæ of the pronotum straight or convergingly curved, usually reaching the hind margin of the pronotum 398..... 223
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223. Frons narrow, sides nearly parallel; head narrower, produced 400..... 224
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224. Vertex inflated in front of the eyes and then narrowed to the apex 395
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STENOCRANUS

225. Second antennal segment four times as long as the first; female pygofers cylindrical 494 ..... *Stenocranus similis* Crawford
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226. General color bright ochraceous orange, not darker in the lateral compartments of the frons ..... *S. arundineus* Metcalf
General color darker, sometimes distinctly darker in the lateral compartments of the frons 227

227. Frons light brown in the lateral compartments ..... *S. felti* Van Duzee
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228. Genital styles broad and contiguous at the base; anal process short, not reaching the ventral margin of the genital aperture 642 *S. vittatus* Stal
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229. Median carina of the frons forked below the apex of the vertex, head not much narrowed between the eyes 437 251
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230. When viewed laterally the apex of the head is acute with a faint transverse carina 426 ..... Genus *Megamelanus* Ball 246
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231. Frons widest above the middle, not or scarcely narrowed between the eyes; vertex scarcely produced in front of the eyes 421 Genus *Kelisia* Fieber 244
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232. Head nearly as wide as the pronotum; face oval in outline; slender species 419 ..... Genus *Prokelisia Osborn* 243
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MEGAMELUS

233. Genital plates flat 646 234
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234. Anal processes wanting 646 235
Anal processes present 651 239

235. Pygofer of the male strongly inflated 646 236
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236. Genital styles shorter than the genital plates, calcars very large, as long as the basal segment of the tarsus 645 ..... *Megamelus palætus* Van Duzee
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237. Genital hooks long, reaching the anal segment 647 *M. longicornis* Dozier
Genital hooks wanting 649 238

238. With a pale median dorsal vitta, genital plates ligulate, obtuse 648 *M. notulus* Germar
Without a pale mid-dorsal vitta, genital plates broadly triangular, acute 649 ..... *M. distinctus* Metcalf

239. Anal processes four, hook-like 650 ..... *M. æstus* Metcalf
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240. Genital hooks strongly reflexed, hook-like, genital styles obtuse at the apex, not reflexed 651 ..... *M. uncus* Metcalf
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241. Color dark, almost uniform black or piceous 242
Color light, marked with darker 7 ..... *M. angulatus* Osborn

242. Calcar very large, as long as the first segment of the tarsus *M. davisi* Van Duzee
Calcar smaller, not as long as the first segment of the tarsus *M. piceus* Van Duzee

PROKELISIA

243. Frons very broad at the apex, three times as broad as at base 416 *Prokelisia marginata* Van Duzee
Frons about twice as broad as at base 419 ..... *P. setigera* Osborn

KELISIA

244. Fore wings vittate with brown, sutural margins pale 109 *Kelisia axialis* Van Duzee
Fore wings not vittate 245

245. Vertex distinctly longer than broad, with a pale median vitta 423 *K. crocea* Van Duzee
Vertex barely as long as broad, without a pale median vitta 424 *K. parvula* Ball

MEGAMELANUS

246. Vertex very long, its length beyond the eyes equal to or greater than the long diameter of the eyes 425 247
Vertex not as long before the eye as the long diameter of the eye 434 250

247. Frons nearly parallel sided and much elongate 426 *Megamelanus terminalis* Metcalf
Frons broader below, somewhat narrowed between the eyes 430 248

248. Fore wings with a distinct white stigmatal and anal spots 38 *M. lautus* Metcalf
Fore wings without distinct stigmatal and anal spots 249

249. Wings pale, with fuscous spots apically 122 ..... *M. elongatus* Ball
Wings uniform black 110 ..... *M. dorsalis* Metcalf

250. Color pale green, with a pair of dark red stripes from the apex of the vertex to the apex of the abdomen.....*M. rufivittatus* Ball
Color pale ochraceous yellow, eyes black.....*M. spartini* Osborn

251. Median carina of the frons forked near the middle, the two prongs of the fork widely separated; macropterous forms chiefly 111, 437
Peregrinus maidis Ashmead
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PISSONOTUS

252. Clypeus black..... 253
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253. Pale buffy in color, with distinct pustules on the seventh abdominal segment 115.....*Pissonotus quadripustulatus* Van Duzee
Color darker, without pustules 116..... 254

254. With the apex of the brachypterous wings marked with paler, veins concolorous 117..... 256
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255. Apex of the frons broadly white, frons marked with white bars
P. aphidioides Van Duzee
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256. Abdomen black, with a broad median vitta brown 117
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257. Color almost uniform black, wings sometimes a little paler..... 258
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258. Apical markings of the wings in the form of a distinct band..... 259
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P. ater Van Duzee

259. Anterior and intermediate tibiæ black or nearly so
P. marginatus Van Duzee
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260. Anal processes long, nearly reaching the ventral margin; genital plates tubular, surrounding the genital styles basally 673
P. pallipes Van Duzee
Anal processes short, the dorsal angles of the pygofers strongly produced 674.....*P. crawfordi* Metcalf

261. Head concolorous or paler than the pronotum and elytra..... 262
Head and pronotum black or nearly so, sharply contrasted with the paler mesonotum, wings and abdomen.....*P. guttatus* Spooner

262. Anal processes of the male long, reaching the ventral margin of the genital aperture 676 ..... *P. basalis* Van Duzee
Anal processes of the male short, not reaching the ventral margin of the genital aperture 677 ..... *P. delicatus* Van Duzee

263. Head, pro- and mesonotum black 264
General color pale ochraceous tawny, eyes black ..... *P. fulvus* Metcalf

264. Wings black, opaque ..... *P. nigridorsum* Metcalf
Wings semitransparent, not black ..... *P. speciosus* Metcalf

LIBURNIA

265. Carinæ obscure on the apex of head; vertex broadly rounded in front, not produced 451 266
Carinæ distinct on the apex of head; vertex narrow, produced 455 273

266. General color of head and thorax light yellow or brown 267
General color of head and thorax dark brown or black 272

267. Genital styles acute at the apex 681 268
Genital styles broad at apex 683 270

268. Anal tube without anal processes; frontal carinæ bordered with darker; genital styles claw-like 681 ..... *Liburnia lutulenta* Van Duzee
Anal tube with one ventral process; frontal carinæ not paler than frons 683 269

269. Genital styles lanceolate, broadly divergent; anal processes long, almost reaching the base of the styles 682 ..... *L. obscurella* Boheman
Genital styles notched internally near the apex; anal processes short 683 *L. analis* Crawford

270. Mesonotum pale between the lateral carinæ black laterally; genital styles broad, short, square at the apex roundly divergent 684 *L. campestris* Van Duzee
Mesonotum not darker laterally 271

271. Styles contiguous basally, the apices broadened but divergent 685 *L. rotundata* Crawford
Styles not contiguous basally, their apices mushroom shaped 686 *L. shermani* Metcalf

272. Frons less than twice as long as broad, lateral margins rounded; styles short, lanceolate 687 ..... *L. occlusa* Van Duzee
Frons twice as long as broad, lateral margins nearly parallel; styles long, acuminate 688 ..... *L. nigridorsum* Crawford

273. Genital styles acute at apex 689 274
Genital styles acute or bifurcate at apex 702 286

274. Carinæ of the frons pale not concolorous 275
Carinæ of the frons concolorous or nearly so 282

275. General color of head and thorax yellow to light brown 276
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276. Macropterous wings vittate with fuscous 112.....*L. slossoni* Ball
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277. Frons conspicuously narrowed between the eyes; styles broad, suddenly narrowed at the apex 690.....*L. foveata* Van Duzee
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278. Genital styles of the male elongate, diverging from each other at an angle of about thirty degrees 691.....*L. constricta* Crawford
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279. Legs lineate with darker; genital styles long 693..... 280
Legs not lineate with darker..... 281

280. Styles slender, wings infuscated 693.....*L. gillettei* Van Duzee
Styles broad, wings not infuscated, ciliate 694.....*L. lineatipes* Van Duzee

281. Genital aperture large; styles horizontal, sinuate and flexed at the tip 695 *L. pellucida* Fabricius
Genital aperture small, nearly circular; styles smaller, divergent not horizontal 696.....*L. consimilis* Van Duzee

282. General color of head and thorax brown or black; frons narrow, black 283
General color of head and thorax yellow to light brown; wings black *L. kilmani* Van Duzee

283. Styles widely diverging 699..... 284
Styles more or less curved, nearly parallel 698.....*L. waldeni* Metcalf

284. Styles with basal angles produced 699.....*L. basivitta* Van Duzee
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285. Styles not widely diverging, color black.....*L. andromeda* Van Duzee
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286. Styles bifurcate or trifurcate at the apex 702..... 287
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287. Dorsal angles of the male pygofer strongly produced 701..... 288
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288. Macropterous wings vittate with fuscous; vertex, pro- and mesonotum with a broad pale vitta 113.....*L. albolineosa* Fowler
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289. Styles terete, not much flattened apically, narrowly arched 702 *L. triloba* Metcalf
Styles flattened apically, broadly arched 703.....*L. gerhardi* Metcalf

290. Head and thorax yellow, brachypterous wings black, strongly contrasted 31 291
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291. Styles together lyre-shaped, apices reflexed; frons black, carinæ pale 704 *L. alexanderi* Metcalf
Styles obtuse at the apex, diverging 705.....*L. fulvidorsum* Metcalf

292. Color creamy white to light brown..... 293
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293. Calcar very large, as long as the basal segments of the tarsus..... 294
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294. Genital styles gradually narrowed to near the apex then suddenly expanded, stamen-like; anal processes broad triangularly 706
L. staminata Metcalf
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295. Styles broadened at the apex, truncate; pronotum unusually long 708 296
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296. Pygofer of the male elongate; genital aperture very broad, oval; genital styles strongly diverging 708.....*L. detecta* Van Duzee
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297. Styles ligulate, following the contour of the genital aperture 710
L. tuckeri Van Duzee
Styles broad, rounded at the apex; reaching the anal tube; genital aperture with the dorsal angles strongly produced 711
L. lateralis Van Duzee

298. Macropterous wings fuscous with a large stigmatal spot pale 114
L. teapæ Fowler
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299. Antennæ short, not reaching clypeal margin; styles broad and truncate 713
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300. Male pygofer deeply notched dorsally and produced caudally around the anal segment 714.....*L. laminalis* Van Duzee
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301. Color black; pronotum white posteriorly; styles with a tooth on their inner margins 715.....*L. puella* Van Duzee
Color brown; pronotum not white..... 302

302. Styles broadly diverging, following the contour of the genital aperture
L. dolera Spooner
Styles concentric, slightly indented apically.....*L. weedi* Van Duzee

Crepusia glauca n. sp.

Figs. 43, 163, 164, 166

This species may be recognized by the general ochraceous buff color which is strongly sprinkled with black.

Head narrow. Vertex about three times as broad as long. Frons with the base narrow, apex somewhat broadened. Clypeus with the

central area flat, distinct indication of the clypeal grooves. Antennal collar conspicuous, second joint globular. Pronotum truncate anteriorly; median carinæ strongly elevated, transverse carinæ distinct. Fore wings semitransparent; hind wings transparent.

COLOR: General color ochraceous buff, marked with numerous black points which become confluent in various areas making irregular black blotches. Frons heavily marked; tibiæ thrice banded with blackish fuscous. Fore wings with the clavus irregularly marked with black; basal area of the corium more or less marked with black, numerous irregular blotches along the costal margin and an irregular vitta from the claval suture to apical angle; bases of hind wings ochraceous, rest of the wing transparent; veins blackish. Abdomen ochraceous orange dorsally, with the lateral field of each segment heavily marked with black; ventrally, the abdomen is pale ochraceous with the pleural pieces and a broad triangular blotch on the outer margin of each segment black.

Length, apex of head to apex of abdomen 10.4 mm.; to tip of wing 13.1 mm.; wing expanse 35.4 mm.

Holotype ♂. Brownsville, Texas.

Allotype ♀. Nogales, Arizona.

Paratypes 1 ♂. Dragoon, Arizona. 10 ♂ Nogales, Arizona.

Dictyophara recurva n. sp.

Figs. 201, 202, 203, 561

This species may be distinguished from *Dictyophara microrhina* Walker, to which it is closely related, by the more robust cephalic process which is parallel-sided and not tapering as in *D. microrhina* and the genital characters are different.

Vertex more than three times as long as broad, nearly parallel sided and not much narrowed toward the apex; median carina extending from base to apex; genæ with a median carina from the eye, almost to the apex; frons rather broad; clypeal expansion very slight; intermediate carinæ more widely separated than in *D. microrhina;* fore wings very finely reticulate; female pygofers much longer and more slender than in *D. microrhina,* not so deeply curved and not as much constricted at the base; ovipositors slightly exceeding the pygofers with small teeth; subanal plate parallel-sided, reflexed border narrow; male plates rather long, blunt at the tip, slightly exceeded by the anal plate.

COLOR: Grass green; fore and middle tibiæ and apical segment of the labium suffused with scarlet red; tip of the labium and of the tarsal claws only, black.

Length, apex of vertex to apex of abdomen 11.00-12.00 mm.; tip of wing 14.00-15.00 mm.; wing expanse 24-25 mm.

Holotype ♀. Southern Pines, North Carolina. A. H. Manee.
Allotype ♂. Southern Pines, North Carolina. A. H. Manee.

Scolops parvulus n. sp.

Fig. 186

This species may be recognized by its small size and by the stout gradually tapering cephalic process.

Disk of the vertex broad, well rounded, being much broader than in any other species known to me; cephalic process broad, stout, intermediate in shape between the processes of sulcipes and grossus; general form broad and oval, wing veins sharp and distinct.

COLOR: General color fuscous, with the eyes, lateral areas of the pronotum, tips of the wings, the tibiæ and the tarsi blackish.

Length, eyes to tip of the abdomen 3.50 mm.; cephalic process 2.40 mm.

Holotype ♂. Southern Pines, N. C., June 14, 1918. A. H. Manee.

Paratype ♀. Southern Pines, N. C., June 14, 1918. A. H. Manee.

Epiptera brittoni n. sp.

Fig. 263

This species may be recognized by its dark brown color, narrow produced vertex which is transversely rounded before.

Vertex elongate, narrow, the lateral margins a little arched and the anterior margin broadly transversely rounded; frons narrow, the lateral margins strongly elevated; clypeus strongly carinate; pronotum obtusely produced between the eyes; mesonotal carinæ nearly obsolete.

COLOR: General color dark brown somewhat intermediate between the black species like opaca and the brown species like variegata; vertex, pro- and mesonotum irregularly marked with ochraceous tawny; base of the frons black; apex pale ochraceous buff; clypeus

black, the lighter band continued indefinitely across the genæ, the narrow ventral margin of the breast plates, pro- and mesopleura; the breast plates deep dorsally; legs and abdomen dark brown, the segments of the latter narrowly bordered with paler.

Length, apex of head to apex of abdomen 6.50-7.00 mm.; tips of wings 8.00-9.00 mm.

Holotype ♂. Black Mountain, N. C., Sept. 12, 1912.

Allotype ♀. West Point, N. Y., Sept. 15, 1912. In the collection of W. T. Davis.

Paratypes 1 ♂. Portland, Conn., Aug. 15, 1913. B. H. Walden.

I take pleasure in dedicating this pretty little species to Dr. W. E. Britton, State Entomologist of Connecticut, who has sent me many interesting *Fulgoridæ*.

Catonia carolina n. sp.

This species may be recognized by its rather large size, dark color with the frons unbanded but marked with two short ivory white transverse bars.

Vertex produced, obtusely angulate anteriorly; the median carina faint, the lateral margins strongly elevated; the frons narrow between the eyes; lateral margins nearly straight to near the apex where they are slightly narrowed to the broad clypeus; pronotum short, carinæ well elevated; mesonotal carinæ distinct; veins of the fore wings strongly punctate.

COLOR: General color blackish fuscous; the carinæ of the vertex, pro- and mesonotum paler; frons brownish fuscous, laterally alternate with black and white spots; a short transverse bar at the middle and another at the apex ivory white; ocellated spots on the mesonotum reduced to small pale spots; wings blackish fuscous, more or less variegated with whitish; veins in the wings irregular; longitudinal and cross veins at the apex narrowly white; venter and legs brownish fuscous; abdomen mostly blackish fuscous.

Length, apex of head to apex of abdomen 4.60 mm.; to the apex of the wings 5.90 mm.

Holotype ♀. Swannanoa, N. C., Aug. 8, 1919. H. Osborn and Z. P. Metcalf.

Allotype ♂. Vienna, Va., Aug. 1918.

Paratypes 4 ♀. Plummer's Island, Maryland. O. Heidemann. In the collection of Cornell University. 1 ♂ Vienna, Va., Aug. 1918.

Catonia luella n. sp.

This species may be recognized by its small size, blackish color, veins of the wings impunctate, the cells with numerous small round pale spots.

Vertex narrow, rounded before, the carinæ strongly elevated; frons broad, not distinctly narrowed between the eyes; clypeus broad, shallowly inserted in the frons; pronotum rather elongate, the carinæ strongly elevated, the links of the lateral chain distinct; mesonotum tricarinate; the lateral carinæ but slightly divergent; fore wings with the veins impunctate.

COLOR: General color blackish fuscous; frons nearly unicolorous; the lateral carinæ a little paler; eyes black; mesonotum blackish fuscous, with two indistinct ocellated spots on the anterior margin, two on the posterior margin; fore wings blackish fuscous, the veins blackish, some of the cross veins at the apex narrowly pale; all of the cells with numerous pale round spots; venter and legs blackish, the latter more or less marked with pale.

Length, apex of head to apex of abdomen 3.00 mm.; to the apex of the wings 3.70 mm.

Holotype ♂. Upper Natacumbe Key, Florida. March. In the collection of the Museum of Comparative Zoology.

Allotype ♀. Paradise Key, Florida.

Paratypes 1 ♂, 4 ♀. Paradise Key, Florida. February.

Catonia pini n. sp.

This species may be recognized by its large size, uniform mesonotum, strongly variegated wings, the frons brownish with a narrow pale transverse band.

Vertex produced, obtusely rounded anteriorly; frons narrow at the base, widened apically, the lateral margins a little arcuate; median carina faint, lateral margins strongly elevated; wings strongly punctate.

COLOR: General color pale, more or less variegated with brownish and blackish fuscous; vertex, pro- and mesonotum uniformly ochraceous brown; frons ochraceous brown, the lateral margins alternate with black and ivory white, the narrow transverse band ivory white, basal third of the clypeus ivory white, the apex brownish; wings largely pale ochraceous yellow, irregularly variegated with brownish and blackish fuscous; venter and legs mostly ochraceous brown.

Length, apex of head to apex of abdomen 4.70 mm.; to the tips of wings 6.20 mm.

Holotype ♂. Southern Pines, N. C., August 10, 1917. A. H. Manee.

Allotype ♀. Southern Pines, N. C., late August, 1917. A. H. Manee.

Paratypes 2 ♂ ♂. Southern Pines, N. C., June, 1909. Z. P. Metcalf.

Catonia lunata n. sp.

This species may be recognized by its small size, blackish color and broad strongly produced vertex with the frons brown with a broad transverse pale band in the middle and a shorter pale bar at the apex.

Vertex strongly produced but little narrowed anteriorly; frons broad, not much narrowed at the base or at the apex; wings strongly punctate.

COLOR: General color blackish; vertex pale yellow, with two elongate dashes next the inner margins of the eyes and two near the median carina anteriorly; frons brown, the lateral margins alternate with black and ivory white, the transverse band broad ivory white, a small ivory white bar along the clypeal margin; clypeus mostly pale; pronotum with the carinæ broadly pale, leaving small blackish spots in the compartments; mesonotum blackish, with the carinæ pale and a few small tawny spots; fore wings blackish fuscous variegated with ivory white; venter largely tawny yellow, legs brownish fuscous; abdomen blackish.

Length, apex of head to apex of vertex 4.00 mm.; to the apex of the wings 4.30 mm.

Holotype ♀. Swannanoa, N. C., August 29, 1919. H. Osborn and Z. P. Metcalf.

Allotype ♂. Paradise Keys, Florida.

Paratypes 1 ♀. Paradise Keys, Florida. February. In the collection of the Museum of Comparative Zoology. 1 ♀, Tyngsboro, Mass. 1 ♀, Bay Shore, Long Island. In the collection of Mr. C. E. Olsen.

Bothriocera drakei n. sp.

Figs. 81, 585

This species may be recognized by its pale yellowish testaceous color with the fore wings heavily and irregularly spotted with fuscous, the apex of the wings being strongly infuscated.

Vertex strongly produced; lateral margins of the frons strongly produced; clypeus very long. Pronotum not deeply notched posteriorly. Mesonotum tricarinate. Male pygofer narrow, ventral tooth rather long, genital styles short, narrow at the base, broad and rounded at the apex.

COLOR: General color pale yellowish testaceous; the mesonotum brownish fuscous; fore wings pale whitish testaceous, heavily marked with fuscous, two small fuscous spots at the base, a fuscous band anterior to the stigma, narrowly separated from the stigmatal band; apical portion of the wings crossed by two irregular bands beyond the stigma, the apical border of the wing broadly infuscated; legs testaceous yellow, except the tips of the tarsi which are black; abdomen ochraceous orange; pygofer of the male testaceous yellow.

Length, apex of head to apex of abdomen 2.45 mm.; to the tips of the wings 4.00 mm.

Holotype ♂. Gainesville, Florida. July 4, 1918. C. J. Drake.
Allotype ♀. Gainesville, Florida. July 7, 1918. C. J. Drake.

This species may be merely a darker color variety of *Bothriocera undata* Fabricius but the male genitalia seem to be quite distinct and as stated before it would require a much larger collection of these insects to be sure of their specific distinctions.

Oliarus montanus n. sp.

Figs. 269, 566

This species may be recognized by its broad vertex, finely punctate wing veins and distinct male genitalia.

Vertex broad, narrowed anteriorly, deeply notched posteriorly; frons longer than broad; the clypeus shorter than the frons, much more deeply inserted. Pronotum rather long, the posterior margin triangularly emarginate, the sides nearly straight. Mesonotum with five carinæ distinct, the intermediate carinæ broadly arched. Male pygofer short, broad, the ventral sinus broad, median tooth broadly expanded apically, the apical border but little reflexed, genital styles

slender, broadly curved, the apical portion but little widened; the inner margins short, not contiguous, the outer angles but little produced; the anal segment hood-like, rounded on the apex, which is strongly deflexed, almost touching the apex of the median tooth.

COLOR: General color blackish fuscous, the wings strongly infuscated, veins darker, finely punctate; frons blackish fuscous, the carinæ but little paler; clypeus rufo-fuscous; carinæ distinctly paler; venter and femora fuscous, with tibia testaceous brown, with fuscous rings; abdomen black, the segments narrowly bordered with pale yellow, male genital pieces brown.

Length, apex of head to apex of abdomen 5.00 mm.; to the tip of the wings 7.20 mm.

Holotype ♂. Black Mountains, N. C.

Allotype ♀. Herndon, Virginia.

Paratype 1 ♂. Craggy Mountains, N. C., and 1 ♂, Makanda,

Oliarus vitreus n. sp.

Fig. 574

This species may be recognized by its large size, glossy blackish color and distinct male genitalia.

Vertex narrow, triangularly narrowed anteriorly; frons narrow between the eyes, broader below; pronotum deeply notched posteriorly; mesonotum with five distinct carinæ; fore wings uniformly punctate; male pygofer with a long median tooth, genital styles slender with a distinct elevated ridge, their apices much reflexed appearing coiled.

COLOR: General color dark, glossy; head, thorax and abdomen black, clypeus not distinctly paler than the frons; legs uniform dark tawny; fore wings glossy much infuscated and marked with blackish, there is usually a broad distinct transverse band from the middle of the costal margin diagonally across the wings to near the apex of the clavus, this band nearly paralleling the lateral borders of the mesonotum.

Length, male, apex of head to apex of abdomen 6.00 mm.; tips of wings 8.00 mm.; female, apex of head to apex of abdomen 7.00 mm.; tips of wings 9.00 mm.

Holotype ♂. Southern Pines, N. C. May 29, A. H. Manee.

Allotype ♀. Southern Pines, N. C. May 29, A. H. Manee.

Paratype 1 ♀. Southern Pines, N. C. June 4, A. H. Manee.

Oliarus texanus n. sp.

Figs. 275, 572

This species may be recognized by its small size, broad form, narrow vertex which is deeply notched posteriorly and distinct male genitalia.

Vertex narrow, triangular before, posterior border deeply emarginate; frons very narrow at the base, broad at the apex, the side margins nearly straight; clypeus shorter than the frons. Mesonotum distinctly five carinae; pygofer of the male rather slender, the ventral tooth broad at the base, suddenly constricted apically; the genital styles broadly excavated at the base, nearly touching in the middle line apically, the apical portion reflexed and produced into an acute tooth laterally, the anal segment broad, hood like, almost enclosing the tips of the genital styles.

COLOR: General color blackish fuscous; the eyes brown, vertex and disk of the mesonotum, the clypeus of the female brownish fuscous; wings a little smoky with veins fuscous apically; all the veins strongly punctate; legs testaceous yellow, the coxæ and femora blackish fuscous.

Length, male, apex of head to apex of abdomen 2.60 mm.; to the tips of the wings 3.85 mm. Female, apex of head to apex of abdomen 4.20 mm.; to the apex of the wings 4.90 mm.

Holotype ♂. Brownsville, Texas. November 21, 1911.

Allotype ♀. Brownsville, Texas. November 21, 1911.

Paratypes. Brownsville, Texas. November 19, one ♂, December 9, one ♂ and November 23, one ♀.

Oliarus vittatus n. sp.

Figs. 74, 276, 573

This species may be recognized by its small size, narrow vertex with the genital styles of the male about as long as the ventral sinus.

Vertex narrow, elongate, the sides nearly parallel; frons much narrowed between the eyes, about half as wide at the base as at the apex; mesonotum quinquecarinate; the intermediate carinæ rather faint; wings strongly and uniformly punctate; male pygofer with median tooth simple; triangular, the ventral sinus deep; the genital styles rather broad at the base, constricted near the apex, the inner and outer angles about equally produced.

COLOR: General color tawny; the eyes and the lateral margins of the mesonotum blackish; frons and venter largely fuscous; the legs pale yellow. The female that I associate with this species has the claval area of the wings fuscous and a broad vitta at the apex fuscous.

Length, apex of head to apex of abdomen 3.50 mm.; to tips of the wings 5.80 mm.

Holotype ♂. Brownsville, Texas. November 19, 1911. In the collection of the Illinois State Laboratory of Natural History.

Allotype ♀. Brownsville, Texas. December 8, 1911.

Cixius apicalis n. sp.

Figs. 78, 284, 285, 578

This species may be recognized by the fact that the wings are broadly fuscous to near the apex of the clavus with the apex milky subhyaline, thickly spotted with fuscous and by the distinct genitalia.

Vertex crescent-shaped transverse, broadly rounded before, not reaching the frons; frons longer than the clypeus, strongly narrowed between the eyes; lateral carinæ of the mesonotum strongly diverging; pygofer of the male short, ventral tooth elongate, acute, genital styles narrow at the base, widely separated, meeting apically, their apices broadly expanded and reflexed, reaching the anal segment; anal segment narrow, not produced.

COLOR: General color of the body blackish fuscous; carinæ of the frons and posterior margin of the pronotum yellowish testaceous; fore wings blackish fuscous on the basal half with clavus darker, almost black on the costal margin, paler and brownish internally; the apical portion of the wings milky subhyaline, more or less spotted with fuscous; there are three distinct fuscous spots on the costal margain; the middle one continued as an interrupted fuscous band towards the apex of the clavus, the longitudinal veins with some triangular fuscous spots on the apical margin; basilar angles narrowly pale yellow; legs testaceous yellow; the fore femora fuscous; abdomen fuscous; the apex of the genitalia testaceous yellow.

Length, apex of head to apex of abdomen 3.50 mm.; to tips of wings 5.25 mm.

Holotype ♂. New Haven, Conn. June 25, 1921. B. H. Walden.

Allotype ♀. Ithaca, N. Y. June 8, 1895.

I believe that this is the species that has been identified in the past as *Cixius albocinctus* Germar, the Paleartic species given as a variety of *Cixius pilosus* by Oshanin; but it seems to be distinct from specimens in my collection identified as *Cixius albocinctus* Germar and *Cixius pilosus* by Lethierry.

Ciocixius New Genus.

Orthotype *Cixius dorsivittatus* Van Duzee.

This genus may be recognized by the broad vertex and by the nearly perpendicular wings which are broadened apically and strongly compressed.

Head nearly as broad as the pronotum; vertex squarely produced for more than half its length in front of the eyes; lateral compartments of the genæ evident dorsally; frons nearly vertical, median carina distinct, lateral margins strongly reflexed, regularly arcuate from base to apex; pronotum short, collar-like, the anterior and posterior margins nearly concentric; disk of the mesonotum tricarinate, strongly elevated, the lateral compartments nearly vertical; fore wings vertical, strongly broadened apically; subcosta and radius united at the base for a short distance only, cubitus forked at about the same level as the union of the claval veins; posterior tibia armed with two small spines, one on the basal half and the other near the middle.

Microledrida flava n. sp.

Figs. 76, 280, 281, 576

This species may be recognized by its pale yellow color, practically unmarked wings and distinct male genitalia.

Vertex broad, not produced for more than one-third of its length in front of the eyes; median carina strongly elevated throughout; frons broad, not more than one and one-half times as broad as long; median carina distinct; pronotum not half as long as the vertex; mesonotum nearly twice as long as the vertex; median tooth of the male pygofer short and obtuse; genital styles not widely separated, their inner angles meeting on the median line; outer angles only slightly produced, obtuse.

COLOR: General color pale testaceous yellow, eyes brown; clypeus shading to ochraceous orange; wings milky subhyaline; the punctures

testaceous yellow with an indistinct fuscous spot at the apex of subcosta, otherwise wings are unmarked; legs pale ochraceous yellow, spines and claws tipped with black; abdomen pale ochraceous yellow.

Length, apex of head to apex of abdomen 2.50 mm.; to the tips of the wings 3.25 mm.

Holotype 1 ♂. Brownsville, Texas. November 21, 1911. In the collection of the Illinois State Laboratory Natural History.

Oecleus productus n. sp.

Figs. 298, 588

This species may be recognized by its small size, general pale yellow color with the anal segments of the male strongly produced.

Vertex much narrowed posteriorly, lateral margins almost touching, much produced in front of the eyes; frons rather broad at the apex, suddenly constricted at about the middle of the eyes; median carina distinct; pronotum short, the posterior border strongly reflexed, rather deeply notched; mesonotum quinquecarinate; median tooth of the male pygofer short but tongue-like; genital styles rather short; the anal segments strongly produced, narrowed apically.

COLOR: General color pale ochraceous orange or ochraceous yellow; frons and clypeus black between the carinæ; genæ black, the eyes and antennæ paler; vertex black and the carinæ paler; pronotum mostly pale but a little clouded with blackish; mesonotum ochraceous orange, somewhat clouded between the carinæ; wings yellowish; veins on the base concolorous, fuscous at the apex; abdomen blackish, the segments narrowly bordered with yellow apically.

Length, apex of head to apex of abdomen 2.50 mm.; to the apex of wings 4.20 mm.

Holotype ♂. Dongola, Illinois. August 23, 1916.

Paratypes 2 ♂. Metropolis, Illinois. August 19 and 20, 1916. 1 ♂, Phoenix, Ariz., June 8, 1902.

Myndus truncatus n. sp.

Figs. 312, 600

This species may be recognized by its twice banded frons and truncate genital styles.

Vertex long, narrow, the lateral margins converging to the middle of the eyes then nearly parallel to the front; frons very short and

broad below; pronotum short, deeply sinuate; mesonotum long, lateral carinæ strongly diverging; median tooth elongate, obtuse; genital styles long, meeting on the median line for about half their length, their apices slightly broadened, obliquely truncate.

COLOR: General color ochraceous yellow; apex of the vertex marked with blackish fuscous; frons and clypeus ochraceous buff, the former with a broad basal band and a narrow apical band of black; mesonotum ochraceous orange, the intermediate compartments clouded with blackish fuscous; wings milky subhyaline, the veins heavily brown, the apical margin narrowly fuscous.

Length, apex of head to apex of abdomen 4.20 mm.; to the tips of the wings 5.25 mm.

Holotype ♂. Elizabeth, Ill. July 6, 1917. In the collection Illinois State Laboratory of Natural History.

Bruchomorpha vittata n. sp.

Figs. 55, 220

This species may be recognized by its elongate narrow front, short nearly truncate nasal process.

Vertex rather broad, the lateral margins converging to the intermediate carinæ, the anterior margin nearly straight; frons rather elongate, narrow; the intermediate carinæ slightly arched, the nasal process short, but little produced, nearly truncate anteriorly. Pronotum broadly rounded anteriorly, deeply almost triangularly emarginate posteriorly. Mesonotum ecarinate, the disk broadly arched, the scutellar portion flat, produced. Macropterous wings narrow, elongate.

COLOR: General color dull blackish fuscous; eyes grayish brown; median frontal stripe evident, extending to the posterior border of the pronotum. Mesonotum and abdomen paler, median stripe narrower. Macropterous wings smoky hyaline; legs pale yellowish testaceous; all the femora and fore tibiæ washed with brownish fuscous.

Length, macropterous form, apex of head to apex of abdomen 3 mm.; apex of wings 4.20 mm.

Holotype ♀. Brownsville, Texas. November 21, 1911. In the collection of the Illinois State Laboratory Natural History.

Paratypes 2 ♀ ♀. Brownsville, Texas. November 21, 1911.

Bruchomorpha rugosa n. sp.

Figs. 56, 222

This species may be recognized by its general pale testaceous color with the brachypterous wings strongly rugose, the nasal process narrowly produced.

Vertex almost triangular, strongly produced anteriorly; frons narrow, elongate, the intermediate carina broadly arched enclosing a nearly oval area, nasal process distinctly produced, not deeply sinuate ventrally. Pronotum elongate, broadly arched anteriorly, nearly straight posteriorly. Mesonotum rather short, tricarinate, the lateral carinæ converging with two impressed points on the posterior half of the disk; wings coarsely rugose; legs stout.

COLOR: General color testaceous yellow, more or less marked with black; intermediate carinæ of the frons narrowly bordered by black internally; lateral compartments of the frons black; the apex of the nasal process broadly black; genæ chiefly black; abdomen with a series of six short dashes on each side of the segments; legs testaceous yellow; heavily marked with black; fore and middle femora twice-ringed with black; all the tibiæ broadly black apically; tarsi blackish fuscous.

Length, apex of head to apex of abdomen 3 mm.

Holotype ♀. Brownsville, Texas, September.

Paratype 1 ♀. Nogales, Arizona, September 24.

This special somewhat suggests *Aphelonema rugosa* Ball but it is an evident *Bruchomorpha* with strongly produced front and short vertex.

Bruchomorpha bicolor n. sp.

Figs. 30, 224

This species may be recognized by its shortly produced nasal process, elongate frons, general pale yellow color with two broad black stripes extending from the apex of the nasal process across the eyes to the apex of the abdomen.

Vertex short, the anterior margin broad, nearly straight; frons elongate, the intermediate carina broadly arched basally then converging straight to the apex of the frons; nasal process elongate, bluntly triangular, the ventral margin not sinuate. Pronotum broadly

rounding anteriorly, broadly sinuate posteriorly, about half as long as the mesonotum; disk of the mesonotum broad, the lateral carinæ evident, the intermediate carina faint; male genital styles broad at the base, gradually narrowed apically, the apex produced, short triangular teeth directed anteriorly.

COLOR: General color pale dull yellow, a broad blackish fuscous stripe on each side of the body extending from the apex of the nasal process across the compound eyes, the disk of the wings and then converging to the apex of the abdomen; meta-pleura black, a narrow black stripe on the lateral ventral margins of the abdomen, spines and claws of the legs black; genitalia black.

Length of male, 2 mm.; of the female 3 mm.

Holotype ♂. Brownsville, Texas, November 21, 1911.

Allotype ♀. Brownsville, Texas, November 21, 1911.

Paratypes 5 ♀ ♀. Brownsville, Texas, November 21, 1911.

Bruchomorpha minima n. sp.

Fig. 213

This species may be recognized by its uniform black color, small size and narrow frons.

Vertex narrow, the anterior border broadly sinuate, median carina of the vertex strongly elevated; median carina of the frons strongly elevated, the intermediate carine strongly arched basally, gradually converging anteriorly; nasal process not produced, broadly rounded anteriorly; anterior border of the pronotum broadly rounded, the posterior border narrowly and shallowly sinuate. Mesonotum but little longer than pronotum, none of the carinæ strongly elevated; wings coarsely rugose.

COLOR: General color almost uniform shining black; the posterior tarsi a little rusty.

Length, apex of head to apex of abdomen 1.90 mm.

Holotype ♂. Southern Pines, North Carolina. Late June, A. H. Manee.

Paratypes 2 ♂ ♂. Southern Pines, N. C. Late June, A. H. Manee.

This is the smallest species known to me. It is very close to *B. tristis* Stal but seems to be distinct.

Bruchomorpha decorata n. sp.

Figs. 57, 223

This species may be recognized by its very short nasal process, nearly vertical frons and strongly contrasted colors.

Vertex short, strongly sinuate on the anterior margins, nasal process not produced, broadly rounded anteriorly; frons more nearly vertical than in any other species of the genus; frons broad about one and one-half times as long as broad; the intermediate carina broadly arched; pronotum produced anteriorly, posterior margin broadly sinuate with a distinct median notch. Mesonotum short and broad, about twice as long as the pronotum; tricarinate, the lateral carinæ strongly elevated; wing coarsely reticulate; male genitalia broad at the base, gradually narrowed to the acute apices, the inner margins nearly parallel, the apices a little curved anteriorly.

COLOR: General color ochraceous orange, heavily and irregularly marked with black; frons ochraceous orange, the lateral compartments irregularly marked with black; genæ black. Pronotum ochraceous orange, with a row of heavy black spots anteriorly. Mesonotum varying from ochraceous orange with a few black spots to black with a few ochraceous orange spots; wings with the veins mostly pale, the cells irregularly clouded with fuscous or black; legs blackish fuscous or brownish fuscous; dorsal portion of the abdomen ochraceous buff or ochraceous orange varied with blackish; venter of the abdomen black.

Length of the male 2.25 mm.; of the female 2.75 mm.

Holotype ♂. Brownsville, Texas, November 21, 1911.

Allotype ♀. Brownsville, Texas, November 21, 1911.

Paratype 1 ♀. Brownsville, Texas, November 21, 1911.

Aphelonema rosa n. sp.

Figs. 2, 226, 227

This species may be recognized by its small size, narrow vertex, general reddish color and short obtuse genital styles of the male.

Vertex short, about six times as broad as long; frons short and broad, the intermediate carinæ strongly arched, pustules inconspicuous; clypeus with an evident median carina. Pronotum with the anterior margin strongly curved laterally, the posterior margin almost

straight, median carinæ evident, the disk without pustules. Mesonotum short, the disk broad; lateral compartments pustulate. Brachypterous wings truncate posteriorly, nearly reaching the third segment; genital styles of the male broad, rather obtuse, the inner margins nearly contiguous for the entire length; the apices acute, directed anteriorly.

COLOR: General color pale dull red, the legs, vertex, dorsal part of the frons, the pro- and mesonotum salmon orange; eyes black.

Length, apex of head to apex of abdomen 2.25 mm.

Holotype 1 ♂. Cape Charles, Virginia, September 1, 1920. D. M. DeLong.

Paratype 3 ♂. Cape Charles, Virginia, September 1, 1920. D. M. DeLong.

Paratype 1 ♂. Pascagoula, Miss., August 6, 1921. H. L. D.

Traxus New Genus.

Orthotype *Traxus fulvus* n. sp.

This genus is close to *Hysteropterum* Amyot and Serville but it may be recognized by its general rugose appearance, triangularly incised vertex, narrowly parallel-sided concave frons.

Vertex short, about four times as broad as its median length; anterior margin deeply incised, the lateral margins nearly one and one-half times as long as the median length; frons narrow, tricarinate, nearly parallel-sided, the margins finely crenulate; clypeus small, reflexed; antennæ short, second segment globular; pronotum about twice as long as the vertex, strongly produced anteriorly; mesonotum about as long as the pronotum, tricarinate; the lateral carinæ strongly elevated and tuberculate; fore wings rugulose and reticulate, the corium broadly expanded and the clavus elevated; no submarginal veins; posterior tibiæ with strong spine at the middle, and another near the apex.

Traxus fulvus n. sp.

Figs. 62, 238, 239, 532, 474

This species may be recognized by its general ochraceous orange color with the clypeus and coxæ black.

Frons concave deeply emarginate dorsally, the carinæ very irregular the lateral margins nearly parallel crenulate, suddenly constricted

to the small clypeus; pronotum with an evident median carina and two impressed points either side; mesonotum tricarinate, the median carina faint, the lateral carinæ elevated into elongate tubercules; wings rather narrow, the apical margins obliquely rounded.

COLOR: General color dull ochraceous orange sometimes clouded with blackish; eyes black, the lateral margins of the frons alternate black and white; clypeus, coxæ, fore and middle femora black, irrorate with paler; wings concolorous, the veins a little paler.

Length, male, apex of head to apex of abdomen 4 mm.; female, 5.50 mm.

Holotype ♂. Brownsville, Texas, August 8, 1906. A. B. Wolcott.

Allotype ♀. Brownsville, Texas, November 26, 1910. In the collection of Illinois State Laboratory Natural History.

Paratypes 1 ♀. November 24, 1911. 1 ♀, November 21, 1911. 1 ♀, November 26, 1919. All collected at Brownsville, Texas.

Thionia quinquata n. sp.

Fig. 255

This species may be recognized by its narrow five angled vertex and nearly uniform brown color which is almost uniformly covered with small dark points.

Vertex narrow, a little longer than broad, the lateral margins diverging, the anterior margin strongly produced; frons narrow tricarinate, the lateral margins a little arched; pronotum strongly produced between the eyes; mesonotum long with an evident transverse carinæ; fore wings with the longitudinal and transverse veins evident.

COLOR: General color ochraceous brown with the whole surface of the body including the wings and legs uniformly sprinkled with small black points, veins of the wings and claws black.

Length to tips of the wings 8.00 mm.

Holotype ♀. Raleigh, N. C. Early September. C. S. Brimley.

Acanalonia fasciata n. sp.

Figs. 127, 558

This species bears a general resemblance to *Acanalonia bivittata* Say but it may be recognized by its small size, pale legs and frons, and different genitalia.

Head broad, slightly broader than the prothorax; vertex broad, tricarinate; lateral margins strongly diverging; posterior margin broadly curved; anterior margin curving gradually into the frons. Frons very broad, nearly twice as broad as long. Pronotum elongate; anterior margin produced; posterior margin broadly triangularly notched. Mesonotum elongate without carina. Fore wings elongate, about twice longer than broad, longitudinal veins distinct; reticulating veins rather indistinct on the basal half. Last ventral segment of the female broadly excavated without median tooth.

COLOR: General color testaceous (green in life?) with the broad brownish fascia extending from the compound eyes across the lateral field of the pro- and mesonotum and gradually attenuated along the sutural margins of the elytra. Frons, clypeus and all of the legs testaceous. Last ventral segment of the female broadly excavated to almost its anterior border.

Length, apex of head to apex of abdomen 5.25 mm.; to apex of wing 7.35 mm.; length of wing 5.07 mm.; greatest width of wing 2.62 mm.

This species might readily be mistaken for a depauperate form of *Acanalonia bivittata* but the coloring is somewhat different and the genitalia totally unlike.

Holotype ♀. Brownsville, Texas.

Allotype ♂. Nogales, Arizona.

Paratypes 1 ♀, 1 ♂. Nogales, Arizona. September.

Flatoides maculosus n. sp.

Figs. 17, 145

This species may be recognized by its short, broad vertex, pale ochraceous buff or olive ochraceous buff color, heavily spotted with fuscous and by the very distinct genitalia.

Head broad; vertex nearly twice broader than long angularly produced anteriorly; frons somewhat elongate, conically produced basally; clypeus about one and one-half times as long as broad; clypeal grooves evident; antennæ with second segments about one and one-half times as long as first segment, both segments somewhat flattened. Pronotum broad, short, nearly four times as broad as long. Mesonotum strongly produced anteriorly; costal margins of the wing faintly crenulate; costal membrane about twice as broad as the costal

cell; the transverse veins slightly reticulate; humeral angles not much produced; hind tibia with three spines; the basilar one small; female genitalia with last and penultimate segments deeply almost squarely excavated; pygofers large, broadly curved on the inner margins; marginal teeth very fine and numerous; anal segment broad, triangular, barely exceeding the pygofers; last ventral segment of the male broader than long, roundly excavated apically; pygofers narrow, about two and one-half times as long as broad, longer than the last ventral segment, broadly separated at the base, approximate subapically, their apices bluntly rounded.

COLOR: General color in the female pale ochraceous buff, heavily flecked with blackish fuscous; in the male the general color is more olive; head unmarked except for two blackish dashes in front of the eyes and three black spots on the second joint of the antennæ. Pronotum with two impressed points near the anterior border and a blackish cloud behind the eye. Mesonotum with three blackish spots along each posterior border, the central one very large and a pair of spots medianly near the anterior border; wings heavily marked with irregular blackish fuscous spots. There is usually a row of very irregular spots along the costal border which become small triangular spots around the apical margin. The corium is marked with numerous large and small spots and the last subapical line is irregularly bordered with fuscous externally; the clavus has a large spot near the base and a row of short dashes along the sutural margin.

Length, female, apex of head to apex of abdomen 7.50 mm.; to apex of wing 10.40 mm.; male, apex of head to apex of abdomen 6.30 mm.; to apex of wing 9.20 mm.

This species might be confused with pale specimen of *Flatoides punctatus* Walker but they are much more heavily spotted and their genitalia are entirely different.

Holotype ♀. Paradise Key, Florida. In the collection of the U. S. National Museum.

Allotype ♂. Marco, Florida.

Flatoides concisus n. sp.

Fig. 150

This species may be recognized by its small size, pale color and short transverse vertex.

Head broad, nearly as broad as the disk of the pronotum; vertex short, about one and one-half times as broad as long; anterior margin nearly right angled; frons longer than broad, bluntly produced basally; clypeus broad, flat, clypeal grooves indistinct, antennæ with second joint nearly three times as long as first, truncate apically. Pronotum short, produced anteriorly to the anterior margins of the eyes, triangularly notched posteriorly. Mesonotum small, flat, wings elongate narrow, costal membrane about twice as wide as the costal cell, costal margin straight; two subapical lines rather irregular; hind tibia with two spines on the apical third; last ventral segment of the female triangularly notched; penultimate deeply notched with the side margins converging slightly; pygofers short, broader than long, the apical margins broadly rounded with heavy teeth; anal segment short, transverse, exceeded by the pygofers.

COLOR: General color pale ochraceous buff, heavily sprinkled with a whitish powder, a few blackish fuscous markings; vertex fuscous with the median lines and lateral margins paler; frons and clypeus ochraceous buff; pronotum with two impressed points and a blackish cloud behind the eyes. Mesonotum brownish fuscous clouded with blackish anteriorly; fore wings ochraceous buff, veins nearly concolorous. There is a broad irregular blackish fuscous band from the costal margin across the humeri to the middle of the clavus, another one at the apex of the clavus extends on to the corium, another diagonal band at the apex of the costal membrane and a few irregular fuscous clouds in the cells of the membrane, apical spots very faint; venter and legs ochraceous buff, excepting the mesopleura, genital pieces, spines and claws of the legs which are marked with fuscous.

Length, apex of head to apex of abdomen 6.60 mm.; to tip of wing 9.10 mm.

Holotype ♀. Florida.

This is a very small pale species which is closely related to *Flatoides acutus* Uhler. The genitalia seem to be sufficiently distinct and the color is entirely distinct.

Neocenchrea New Genus.

Orthotype *Cenchrea heidemanni* Ball.

This genus is closely related to *Cenchrea* but the vertex is narrower, more produced; the frons is narrower, the side margins more elevated; the wings are elongate with distinct venation.

Head narrow; vertex about twice as long as broad, strongly produced anteriorly; triangularly excavated on the posterior margin, lateral margins strongly elevated and pustulate; anterior margin separated from the frons by a distinct carina; frons narrow, about four times as long as broad on the clypeal margin, the lateral margins nearly parallel above, gradually widened to the border of the clypeus below; the lateral margins strongly elevated; median carina wanting; clypeus strongly inflated broadly inserted into the frons, wider than the frons; lateral border faintly margined; median carina distinct; antennæ short; antennal collar strongly elevated; second segment of the antennæ about four times as long as the first; eyes large, ventral sinus broad and deep; prothorax short, broadly notched posteriorly; the posterior borders strongly elevated; median carina blunt; intermediate carina blunt; lateral carina not as strongly elevated as the ventral margin; antennal chamber very deep. Mesonotum nearly as long as broad, strongly inflated anteriorly, tricarinate; all the carinæ faint; wings long and narrow, nearly five times as long as broad; radius separated from subcosta at about the middle of its length; medius two branched, each of these branches forked at a short distance from the apex; cubitus deeply forked; forking nearly the same level as the claval veins; claval veins two, the posterior one coarsely pustulate; legs slender; posterior tibia unarmed; posterior tarsi nearly half as long as the tibia.

Euklastus New Genus.

Fig. 339

Orthotype *Euklastus harti* n. sp.

This genus may be recognized by the peculiar venation of the wings, by the narrow frons and elongate antennæ.

Head narrow, the eyes large, vertex very small, deeply incised posteriorly; produced anteriorly and continued as the narrow rounded frons; frons very narrow produced; clypeus broader slightly inflated, antennæ elongate, first joint very small, second joint flattened, elongate; pronotum short, deeply notched posteriorly, the anterior margin a little produced, median carina evident; mesonotum large, ecarinate; fore wings long, subcosta and radius united to near the apex of the wing; medius with four branches, clavus narrow, open, the common stem of claval veins extending to first cubitus, hind wings small, costal margin with an appendix, venation reduced; legs slender, hind tibiæ without spines.

Euklastus harti n. sp.

Figs. 23, 334, 335, 336, 520, 479

This species may be recognized by its small vertex, pale colors with the wings heavily but sparsely spotted with fuscous.

Vertex consisting chiefly of the carinate lateral borders, posterior margin deeply triangularly emarginate, broadly rounded anteriorly to the frons; frons narrow, keel-like, produced; eyes large, deeply sinuate, the anterior horn strongly produced ventrally; antennal collar strongly elevated; first segment of the antennæ minute, second segment flattened about six times as long as broad, narrow basally, widened apically, the apex obliquely truncate and notched for the bristle; pronotum deeply notched posteriorly, the sides flaring; fore wings elongate, spatulate.

COLOR: General color pale tawny yellow, eyes black, fore wings milky subhyaline, veins yellow with a few spots of tawny, and a few rosy red spots at the apex of the costal cell on the costal cross veins, the tawny spots are arranged as follows, a small one at the base, a narrow one about one-third the length of the wing from the base extends from the costal margin to the cubital veins, two small transverse ones beyond this in the costal cell, a narrow cloud on the radio-medial cross veins, a broad cloud on the cell subcosta one, a large spot on the first and second medius, the veins at the apex of the wing with small spots and the small quadrangular cells of the costal margin clouded with tawny; legs and abdomen pale tawny yellow.

Length, apex of head to apex of abdomen 2.10 mm.; to tips of fore wings 6.30 mm.

Holotype ♂. Alto Pass, Illinois. C. A. Hart, August 13, 1891.

This delicate little species is named in honor of the late Mr. C. A. Hart who labored so industriously collecting and arranging the Illinois *Fulgoridæ*.

Herpis incisa n. sp.

Figs. 619, 486

This is a small blackish species with distinct male plate.

Vertex twice broader than long. Frons broad, short, scarcely two and one-half times as long as broad, only slightly narrowed between the eyes; lateral margins slightly elevated with faint central carinæ.

Clypeus elongate, longer than the frons with distinct lateral and central carinæ. Compound eyes with ventral sinus rather deep. Pronotum narrow, deeply and broadly notched posteriorly; breast plates rather small; three mesonotal carinæ rather sharp; subcostal cell about twice as long as broad. Male plates with the inner margins with a distinct notch on basal half, apical tooth very blunt and short.

COLOR: General color blackish fuscous; beak and legs ochraceous buff with the tip of the former and the tarsi spotted with blackish. Fore wings blackish fuscous, veins darker, covered in fresh specimens with dark bluish powder. Hind wings smoky, subhyaline; veins blackish.

Length, apex of head to apex of abdomen 1.75 mm.; to apex of wings 3.15 mm.; width of pronotum .98 mm.; wings expanse 8.40 mm.

Holotype ♂. New Haven, Conn., July 2, 1920. B. H. Walden.

Allotype ♀. North Branford, Conn., July 2, 1920. B. H. Walden. On *Salix*.

Herpis australis n. sp.

Fig. 620

This is a medium large, blackish fuscous species with light yellow venter and legs; and distinct genitalia.

Vertex nearly twice as wide as long, rounded anteriorly, separated from the frons by a very faint carina; frons nearly three times as long as broad, side margins strongly reflexed but little narrowed between the eyes; clypeus long, nearly as long as the frons; subantennal plate strongly elevated. Pronotum short, deeply excavated, posteriorly. Mesonotum long, weakly tricarinate on the anterior border; wings long and narrow; venation typical. Male plates large, separated about the width of their bases basally, the inner margins converging and nearly meeting in the middle of their length then widely converging apically ending in long sharp recurved spines. This species bears a general resemblance to our northern *Herpis vulgaris* Fitch but it averages somewhat smaller and the genital plates are entirely distinct.

COLOR: General color blackish or brownish fuscous; venter and legs pale yellow, more or less covered with blueish powder; head mostly brownish testaceous; lateral margins of the clypeus and frons bordered by a broad blackish stripe; eyes blackish; genæ and lateral margins of the clypeus blackish fuscous; pronotum yellowish testa-

ceous. Mesonotum blackish; fore wings deep brownish fuscous at the base gradually paler apically, densely covered with brownish powder, veins darker; venter and legs pale yellowish; tips of the tarsi and claws blackish; abdomen brownish fuscous densely covered with brownish powder.

Length, apex of head to apex of abdomen 2.45 mm.; to apex of wing 4.20 mm.; length of wing 3.85 mm.; greatest width of wing 1.40 mm.; width across the tegulæ 1.05 mm.

Holotype ♂. Brownsville, Texas, November 11. In the collection of the Illinois Laboratory of Natural History.

Allotype ♀. Brownsville, Texas, November 24.

Paratypes 2 ♂ ♂. Brownsville, Texas, December.

Stenocranus arundineus n. sp.

Figs. 399, 400, 640, 641, 552

This species may be recognized by its general light orange yellow color without conspicuous black markings except the black eyes and its broad short vertex.

Head narrower than the pronotum; vertex broad about twice as long as broad at the base, the basal margins strongly elevated and weakly triangularly notched; the lateral carinæ meeting before the anterior margin of the compound eyes; median carina wanting; frons about five times as long as broad nearly parallel margined throughout its entire length; clypeus long about two-thirds as long as the frons; antennæ long reaching beyond the clypeal margin with segment two about three times as long as segment one; pronotum about as long as vertex; lateral carinæ strongly convergingly curved; posterior margin weakly excavated between the lateral carinæ; mesonotum about two and one-half times as long as pronotum; lateral carinæ converging; calcar half as long as the basal segment, strongly appressed; male pygofer about as long as broad; genital styles broad at the base, rather suddenly constricted curving outward and then inward with sharp apices nearly touching; anal tube as long as the pygofer with two strong nearly parallel ventral processes which are quite sharply pointed; female pygofers broad and rather flat; ovipositor narrow, well elevated; anal tube short without ventral spines.

COLOR: General color light orange yellow with the frons and the antennæ and two broad stripes just inside the lateral carinæ orange;

between these stripes the pronotum and mesonotum are creamy white, these stripes are faintly indicated along the clavus with the suture margin creamy white; the eyes, the spines on the legs and the claws black.

Length, apex of vertex to apex of abdomen 3.75 mm.; width of pronotum 1.00 mm.; length of vertex .33 mm.

Holotype ♂. Swannanoa, N. C., August 9, 1918. Herbert Osborn and Z. P. Metcalf.

Allotype ♀. Swannanoa, N. C., August 9, 1918. Herbert Osborn and Z. P. Metcalf.

Paratypes 10 ♂ and 10 ♀.

Collected Swannanoa, North Carolina, August 1919 from *Arundinaria* sp.

Megamelanus terminalis n. sp.

Figs. 18, 425, 426, 555, 661

This species may be recognized by the bicolored wings of the brachypterous male, the strongly spatulate vertex and the straight lateral carinæ of the pronotum.

Head as broad as pronotum; vertex flat with the lateral carina meeting at the apex; median carina faint; lateral carinæ of the genæ very strong giving the vertex a broad spatulate appearance; frons about four times as long as broad; antennæ short; second segment about two and one-half times as long as first; pronotum projecting anteriorly to about the middle of the eyes; nearly square anteriorly; weakly sinuate posteriorly; about half as long as the vertex; lateral carinæ broadly separated straight, weakly diverging mesonotum equalling the pronotum; the lateral carinæ straight and more strongly divergent; calcar nearly as long as the basal segment of the tarsi without the apical spines, strongly and uniformly toothed; pygofer of the male rather long, the genital aperture oval; genital styles diverging for about three-fourths of the length with the apical portion incurved, sharply acuminate, meeting in the median line; anal tube with two long curved horn-like processes.

COLOR: General color of the male: head and thorax pale buffy more or less shaded with fuscous; eyes black; legs ochraceous orange faded to buff at the joints with the spines and tarsal claws black. Brachypterous wings with the basal half milky subhyaline allowing

white metanotum to show through; the apical half opaque black; abdominal segments dorsally and ventrally ochraceous orange marked with black along the lateral margins; genital pieces black. Color of the female: eyes, spines of the legs, claws and ovipositors black; lateral margins of the pronotum and the tegulæ dusky; metapleura clouded with black; keolopterous wings long, narrow, faintly yellow the veins white setigerous.

Length, apex of vertex to apex of abdomen, male, 2.25 mm.; female 3.50 mm.; length of vertex, male, .66 mm.; female .66 mm.; width of pronotum, male, .50 mm.; female .66 mm.

Holotype ♂. Carolina Beach, Wilmington, N. C., June 4, 1920.

Allotype ♀. Carolina Beach, Wilmington, N. C., June 4, 1920.

Paratypes 5 ♂. Carolina Beach, Wilmington, N. C., June 1920. Four ♂, Cape Charles, Virginia, July 31, 1920. D. M. DeLong. Ten ♀, Carolina Beach, North Carolina, June 1920. Two ♀, Cape Charles, Virginia, August 1, 1920. D. M. DeLong.

Megamelanus dorsalis n. sp.

Figs. 110, 432, 433, 664

This species may be recognized by its yellowish testaceous head and thorax, and blackish wings and distinct genitalia.

Vertex elongate, narrow, the lateral margins converging slightly to in front of the eyes and then strongly to the acute apex; frons widened apically, strongly narrowed to the apex of the vertex; frons tricarinate; clypeus broad and short, antennæ short; first segment about half as long as the second; second segment globular; eyes subglobular, triangular in outline. Pronotum about half as long as the vertex, deeply notched posteriorly, tricarinate on the disk, the intermediate carina somewhat bowed outwardly; ventral margins of the breast plates convex, strongly reflexed. Mesonotum about as long as the pronotum, tricarinate, the lateral carina strongly converging anteriorly; wings elongate, narrow, opaque. Male pygofer rather short, broader than long; aperture large, the genital styles long, narrow, widened apically; anal segment short, anal processes short incurved, nearly meeting in the intermediate line, anal style short; female pygofers long, narrow, nearly parallel-sided; last and penultimate ventral segment triangularly notched; ovipositor long, reaching to the

apex of the pygofers; anal segment short, broad, nearly four times as broad as long, anal styles heavy about twice as long as the anal segment.

COLOR: General color yellowish white and black as follows: vertex, basal margins of the frons and genæ, pro-and mesonotum yellowish white; apical seven-eights of the frons, clypeus, venter, abdomen and fore wings blackish; legs mostly blackish; fore tibia and middle tibia and tarsi except the apex of the tarsi and claws yellowish whitish; apex of the hind femora, base and apex of the tibia and the hind tarsi yellowish.

Length, apex of head to apex of abdomen 2.25 mm.; to the tip of the wing 2.60 mm.; width across the tegulæ .50.

Holotype ♂. Atlantic City, New Jersey, August 25. W. J. Gerhardt.

Allotype ♀. Atlantic City, New Jersey, August 25. W. J. Gerhardt.

Paratype ♂. Pascagoula, Miss., August 6, 1921. H. L. Dozier.

Megamelanus lautus n. sp.

Figs. 38, 427, 428, 662

This species bears a superficial resemblance to Megamelanus dorsalis but the vertex is longer, narrower, the wings are more elongate, brownish fuscous, spotted with white and the genitaliæ are different.

Vertex very long and narrow, not as much narrowed anteriorly as in the allied species; posterior margin nearly straight, median carina extending for only about half the length of the vertex; lateral carinæ strongly elevated; frons much narrowed above to the narrow vertex, strongly produced to the median carina; second segment of the antennæ about twice as long as the first, subglobular. Pronotum slightly shorter than the vertex, disk tricarinate, the lateral carinæ nearly straight and nearly parallel to the median carina. Mesonotum tricarinate; median carina abbreviated on the scutellar portion; fore wings elongate, narrow, nearly five times as long as broad, parallel margined not widened apically. Male pygofer short, broad, the aperture large, subtriangular; genital styles broad; flattening; the inner margins nearly continguous for half their length on the base then suddenly excavated, the apices obliquely truncate; the inner angles produced nearly meeting; anal processes short, blunt, incurved, nearly

meeting on the median line, anal style short, blunt, barely produced beyond the anal segment; last ventral segment of the female triangularly notched to the base; pygofers subterete, exceeding the ovipositors slightly; anal segment short and broad, posterior margin roundly excavated, anal style elongate, subconical.

COLOR: General color of the male, blackish fuscous, pale yellow and whitish; vertex, disk of the pro-and mesonotum pale yellowish white; frons, clypeus, ventral portion of the genæ, breast plates and lateral areas of the mesonotum blackish fuscous; fore wings blackish fuscous; scutellar angle, apex of the clavus, broad triangular marks on the costal and anal borders whitish; legs pale yellowish with the spines and teeth on the calcar and the claws black; abdomen largely blackish fuscous, a row of ochraceous orange spots on each segment; the penultimate and last ventral segments and the pygofer ochraceous orange, the latter more or less clouded with fuscous apically. The female that I associate with this species is almost entirely pale yellowish with the eyes clouded with brownish; the clypeus pale ochraceous buff; the spines, teeth and claws of the leg black; the wings heavily clouded with fuscous apically.

Length, male apex of head to apex of abdomen 2.50 mm.; to the tip of wing 3.15 mm.; across the tegular .50 mm.; female, apex of head to apex of abdomen 3.15 mm.; to the tip of the wing 3.85 mm.; width across the tegulæ .70 mm.

Holotype ♂. Loma, Texas, December 11, 1910. In the collection of the Illinois State Laboratory of Natural History.

Allotype ♀. Loma, Texas, December 11, 1910.

Paratype 1 ♂. Sarita, Texas, December 5, 1911.

Paratype 1 ♂. Ocean Springs, Miss., August 15, 1921. H. L. Dozier.

Megamelus distinctus n. sp.

Figs. 408, 649

This species may be recognized by its pale frons with the black clypeus and distinct genitalia.

Vertex about three times as long as broad, rounded before; frons much narrower between the eyes, nearly twice as wide below; antennæ short, first segment nearly as long as the second; pronotum short, lateral carinæ straight and reaching posterior margin; meso-

notum twice as long as the pronotum, scutellar portion broad, obtuse; calcar tectiform, marginal teeth evident; pygofer of the male broad; genital plates long, triangular; genital styles small, U-shaped; anal segments elongate, the ventral margins produced into two obtuse processes; ædægus long, slender, needle-like.

COLOR: General color testaceous gray, strongly marked with dull black; vertex whitish; posterior and frontal compartments marked with black; frons whitish, this color extended as a broad band across the genæ, the proximal end of the fore coxæ, the breast plates to the mesopleura; first segment of the antennæ and the proximal end of the second similarly colored; the distal end of the second segment black; clypeus black, this color extended as a broad band across the distal end of the coxæ to the metapleura; legs grayish testaceous, more or less clouded with brownish; disk of the pronotum blackish; narrow anterior and posterior borders and the carinæ testaceous gray; mesonotum black, the median carina and the scutellar portion gray; fore wings testaceous gray, the veins ochraceous yellow, faintly pustulate, basilar margin blackish fuscous, claval stem black fuscous to the commissural margin which is broadly blackish fuscous where the claval stem joins it, common stem of medius and cubitus blackish fuscous, this color extending along medius and cubitus for a short distance making a definite Y-shaped mark, veins at the apex brownish fuscous; abdomen black, the pleural pieces and posterior margin of the segments testaceous gray.

Length apex of head to apex of abdomen 2.10 mm.; to the tips of wings 3.15 mm.

Holotype ♂. Portland, Conn., July 25, 1920. B. H. Walden.

Megamelus æstus n. sp.

Figs. 108, 409, 650

This species may be recognized by its general blackish color with a median pale vitta evident dorsally and distinct genitalia.

Vertex narrow, strongly produced; frons much narrowed between the eyes, gradually widened apically; antennæ with the basal segment about as long as the second segment; pronotum a little shorter than the vertex, the intermediate carinæ not strongly divergent; mesonotum about as long as the pronotum, the intermediate carinæ not strongly divergent; male pygofer not strongly inflated; genital

plates flat, obtuse at the apex; genital styles short, about half as long as the genital plates; genital hooks wanting; anal processes four, horn-like.

COLOR: General color blackish fuscous, a broad median vitta pale yellow; frons, antennæ, legs and venter, except the abdomen, pale yellow.

Length, apex of head to apex of abdomen 2.50 mm.

Holotype ♂. Carolina Beach, N. C., June 7, 1920. Z. P. Metcalf.

Megamelus inflatus n. sp.

Figs. 406, 646

This species may be recognized by its almost uniform pale yellow color with the pygofer of the male strongly inflated, genital hooks united into a single obtuse process.

Vertex rather broad, strongly produced; frons narrowed between the eyes, broadened apically, the median frontal carinæ forming a distinct callosity at the apex of the head; antennæ long; first segment almost as long as the second; pronotum elongate, with a distinct impressed point either side of the median carina; intermediate carinæ strongly divergent, reaching the posterior border; mesonotum about as long as the pronotum; calcars small; less than half as long as the basal segment of the tarsus; male pygofer strongly inflated; genital plates flat, incurved at the apex with a small median tooth between; genital styles short, about half as long as the genital plates, obtuse at the apex; genital hooks united on the median line then produced into an elongate obtuse process; anal segments short, anal processes not produced.

COLOR: General color pale yellow, the frons, antennæ and eyes and the lateral margins of the abdomen a little darker.

Length, apex of head to apex of abdomen 2.10 mm.

Holotype ♂. Mill Neck, New York, June 19. N. Banks. In the collection of the Museum of Comparative Zoology.

Paratype ♂. Mill Neck, New York. June 19. N. Banks.

This distinct little species has evidently been confused in the past with *Megamelus notulus* but the male genitalia are entirely distinct.

Megamelus uncus n. sp.

Figs. 410, 411, 651

This species may be recognized by its general pale yellow color with the lateral borders of the abdomen broadly black and distinct male genitalia.

Vertex narrow, produced; frons rather broad, narrow between the eyes first segment of the antennæ about two-thirds as long as the second; pronotum shorter than the vertex; the intermediate carinæ not strongly divergent; mesonotum longer than the pronotum; calcar about half as long as the basal segment of the tarsus; male pygofer broad, the genital plates narrow, triangular; genital styles about as long as the plates; genital hooks elongate, strongly recurved; anal processes two.

COLOR: General color pale yellow; eyes black; metapleura with a large black spot; tarsus spines black; lateral border of the abdomen, the pygofer and most of the venter black.

Length, apex of head to apex of abdomen 2.40 mm.

Holotype ♂. Ellis Bay, Anticosti, Quebec, August 29. In the collection of the Museum of Comparative Zoology.

Allotype ♀. Ellis Bay, Anticosti, Quebec, August 29. In the collection of the Museum of Comparative Zoology.

This is another species that might easily be confused with *Megamelus notulus* Germar; the male genitalia, however, are very distinct.

Megamelus anticostus n. sp.

Figs. 412, 652

This species may be recognized by the evident pale dorsal vitta and distinct male genitalia.

Vertex broad, not much produced; frons broad, not narrowed between the eyes; first segment of the antennæ about half as long as the second; pronotum about as long as the vertex; the intermediate carinæ somewhat divergent; mesonotum longer than the pronotum; calcar about half as long as the basal segment of the tarsus; pygofer of the male broad, not inflated; genital plates narrow, ligulate, broadly separated; genital styles short; their apices bent at right angles; genital hooks elongate, broad and obtuse; anal segments two. spine-like.

COLOR: General color pale yellow, eyes black; the lateral margins of the pronotum and mesonotum, the costal margins of the wings faintly fuscous, the lateral margins of the abdomen blackish, leaving a broad pale median vitta.

Length, apex of head to apex of abdomen 2.50 mm.

Holotype ♂. Ellis Bay, Anticosti, Quebec, August 29.

Allotype ♀. Ellis Bay, Anticosti, Quebec, August 29.

This species might readily be confused with *Megamelus notulus* but the male genitalia are very distinct.

Pissonotus speciosus n. sp.

Figs. 32, 450, 680

This species may be recognized by its small size bright colors and distinct genitalia.

Vertex not short, produced; frons short, the median carina forked just below the apex of the head; pronotum a little longer than the vertex, sinuate posteriorly; mesonotum very small, wings reaching nearly to the pygofers; genital aperture small, ventral sinus produced; genital styles terete at the base broadly curved, the apices expanded and truncate, the inner angles produced meeting on the median line, the basal angles obtusely produced; anal processes strongly produced, obtuse and finger-like apically.

COLOR: General color black and bright ochraceous orange and black, strongly contrasted; vertex and frons black; eyes, genæ and first segment of the antennæ black; clypeus and second segment of antennæ bright ochraceous orange; pronotum black; posterior border broadly white; mesonotum black; wings transparent; scutellar portion of the mesonotum and basal segments of the abdomen bright ochraceous orange; apical segments largely black with distinct white powder, paler in the dorsal line and on the posterior borders; legs pale ochraceous buff.

Length, apex of head to apex of abdomen 1.90 mm.

Holotype ♂. Wrentham, Mass., June 27, 1920. G. W. Barber.

Paratypes 2 ♂♂. Wrentham, Mass., June 27, 1920. G. W. Barber.

Pissonotus fulvus n. sp.

Figs. 448, 678

This species may be recognized by its almost uniform ochraceous orange color with only the eyes and tips of the tarsi black.

Vertex elongate, narrow, nearly twice as long as broad; frons elongate, narrow, the median carina forked well below the apex of the head; pronotum shorter than the vertex, the lateral carinæ reaching the posterior border; mesonotum shorter than the vertex; genital aperture elongate, linear; the genital plates triangularly produced; genital styles slender, acute, parallel shorter than the hooks, genital hooks nearly straight, parallel, the apices suddenly constricted acute; anal processes short, incurved.

COLOR: Almost uniform ochraceous orange; eyes black; carinæ of frons sometimes narrowly lined with black; clypeus yellow, tarsal claws black; genital sytles and hooks and the anal process tipped with black.

Length, apex of head to apex of abdomen 2.50-3.00 mm.

Holotype ♂. Paxton, Illinois, July 30, 1916.

Allotype ♀. Paxton, Illinois, July 30, 1916.

Paratype 1 ♂. Metropolis, Illinois, August 19, 1916.

Pissonotus nigridorsum n. sp.

Figs. 449, 679

This species may be recognized by its general shining black color with the clypeus and legs bright yellow.

Vertex broad, broadly rounded anteriorly; frons broad, the median carina forking below the middle of the eyes; antennæ long first segment joint about half as long as the second; pronotum longer than the vertex, the lateral carinæ becoming obsolete before the posterior border; aperture of the pygofer broad; ventral sinus distinct; genital styles large, twisted broader and truncate apically, the inner angle produced and recurved; anal processes short, recurved, their apices concealed by the styles.

COLOR: General color shining black, clypeus and legs except the tip of the tarsi pale yellow.

Length, apex of head to apex of abdomen 2.25 mm.

Holotype ♂. Greenburg, Pa., September 18, 1904. M. Wirtner.

Liburnia shermani n. sp.

Figs. 557, 686

This species is close to *L. campestris* Van Duzee but may be recognized by the entirely distinct genitalia.

Vertex long and narrow, short; lateral carinæ indistinct over the apex of the head; frons broad below about three times as long as broad; posterior margin of the pronotum nearly straight; lateral carinæ strongly curved outward, following the posterior margin of the eyes; calcar short and narrow about half as long as the basal tarsal segment; marginal teeth very minute; male pygofer short, the genital opening notched ventrally, rounded dorsally; genital styles broad at the base, widely separated touching each other medially about one-third of the distance from the margin of the genital aperture then constricted into a narrow neck-like portion which expands apically into a broad mushroom-shaped apex; anal tube with two blunt ventral processes; female genitalia with the pygofers about four times as long as broad, slightly longer than the ovipositor.

COLOR: General color brilliant orange yellow with the following parts marked with black; eyes, genæ, meso-and metapleura and a row of lateral spots on the margins of the abdomen; the frons in the male is deep black, in the female brownish testaceous; the lateral pieces of the pronotum are white in the male and female with the broad posterior margin of the pronotum in the male whitish.

Length, apex of head to apex of abdomen 2 mm.; width of the pronotum .66 mm.

Holotype ♂. Raleigh, N. C., late July. F. Sherman.
Allotype ♀. Raleigh, N. C., late July. F. Sherman.
Paratypes 5 ♀ ♀. Raleigh, N. C., late July. F. Sherman.

Liburnia unda n. sp.

Fig. 709

This is a pale species quite similar to *Liburnia detecta* Van Duzee but may be recognized by its distinct genitalia.

Vertex broad and short; the lateral carinæ distinct over the apex of the head; frons broad, narrowed to about half its width between the eyes; pronotum as long as the vertex; the lateral carinæ divergingly curved outward; mesonotum but little longer than the pro-

notum; calcar rather narrow with the margins strongly reflexed, about two-thirds as long at the basal segment of the tarsi, teeth very fine; pygofers of the male short; the genital aperture broadly oval below the anal tube; the dorsal margin strongly reflexed and touching the anal tube dorsally; genital styles narrow, blunt, their bases contiguous about one-third of the length and then roundly diverging so that their apices are about half of their length apart.

COLOR: Color pale creamy white with the eyes, the lateral margins of the mesonotum, mesopleura, and a row of more or less confluent spots on the lateral margins of the segments of the abdomen blackish; these blackish markings fading to fuscous in the female.

Length, apex of vertex to apex of abdomen 2.50 mm.; width of pronotum .85 mm.

Holotype ♂. Carolina Beach, near Wilmington, N. C., June 6, 1920. Z. P. Metcalf.

Allotype ♀. Carolina Beach, near Wilmington, N. C., June 6, 1920. Z. P. Metcalf.

Paratypes 1 ♂. Carolina Beach, near Wilmington, N. C., June 6, 1920. Z. P. Metcalf.

Liburnia triloba n. sp.

Fig. 702

This species may be recognized by its dull ochraceous brown color, large size and distinct genitalia.

Vertex quadrate, produced anteriorly, a little longer than broad; frons narrow between the eyes, arched ventrally; antennæ long, the second segment about one and one-half times as long as the first; pronotum as long as the vertex, broadly notched posteriorly; mesonotum nearly twice as long as the pronotum, the scutellar portion very large; calcar large and foliaceous, marginal teeth stout; genital aperture elongate, ventral sinus shallow, ventral teeth small, acute, side margins a little inflated; dorsal angles slightly produced; genital styles contiguous, horizontal at the base, strongly projecting posteriorly, the apical portion bent at right angles and trilobed; the inner lobe slender with a ventral tooth, dorsal lobe elongate, marginal lobe obtuse; genital hooks slender, curving posteriorly; anal segment short, processes obtuse.

COLOR: General color testaceous yellow; frons and clypeus brown; eyes black; wings brownish yellow, veins faint on the base a little brown apically; abdomen of the male black, the margins and ventral pieces narrowly bordered with pale yellow.

Length, apex of head to apex of abdomen 2.25 mm.; to the tips of wings 3.30 mm.

Holotype ♂. New Orleans, La.

Paratypes 2 ♂ ♂. Titusville, Fla., November 8, 1911. Cornell University collection.

Liburnia alexanderi n. sp.

Fig. 704

This species may be recognized by the pale yellow color of the head, thorax and legs, the frons, wings and abdomen largely black.

Vertex narrow about twice as long as broad, more produced anteriorly; frons narrow between the eyes widened below; antennæ short, first joint nearly as long as the second; pronotum shorter than the vertex; mesonotum short, lateral carinæ strongly divergent; calcar small, acute; genital aperture large, ventral sinus shallow; genital styles together lyre-shaped, contiguous at the base, their basal angles a little produced, the apical margin broadly recurved, the inner angles a little produced.

COLOR: General color of the head and thorax and legs pale yellow; eyes black, lateral compartments of the frons and clypeus black; the carinæ pale yellow, genæ largely black; wings piceous brown to piceous black, the veins distinct; abdomen piceous brown to black, the broad posterior margins of the abdominal segments and the lateral margins pale yellow.

Length, apex of head to apex of abdomen 1.75 mm.

Holotype ♂. Swannanoa, N. C., August 25, 1919. H. Osborn and Z. P. Metcalf.

Paratypes 1 ♂. Urbana, Illinois. 1 ♂ Dongola, Illinois, August 21, 1916.

1 ♂. Tupelo, Miss., March 22, 1921. H. L. Dozier.

1 ♂. Falls Church, Va., August 24, N. Banks.

Liburnia fulvidorsum n. sp.

Figs. 31, 705

This species may be recognized by the pale yellow color of the frons, vertex, thorax and legs; wings and the abdomen largely black.

Vertex about twice as long as broad, rounded anteriorly, carinæ distinct; frons nearly parallel sided, very little broadened below; antennæ long, reaching the clypeal margin, the second segment twice as long as the first; pronotum elongate, the posterior margin triangularly notched; mesonotum short, the lateral carinæ strongly diverging; calcar foliaceous; rather broad; aperture of the pygofer very broad, triangular below, the dorsal angles strongly produced; genital styles broad, ligulate, truncate at the apex; anal segment short.

COLOR: Head excepting the black eyes pale yellow; thorax including the legs pale yellow, the metapleura with a fuscous spot; brachypterous wings black, opaque; abdomen black, the posterior segments broadly margined with yellow, the lateral margins broadly yellow.

Length, apex of head to apex of abdomen 2.10 mm.

Holotype ♂. Brownsville, Texas, December 10, 1910.

Paratypes 2 ♂♂. Brownsville, Texas, December 10, 1910.

Liburnia gerhardi n. sp.

Figs. 703, 496

This species may be recognized by its general bright ochraceous yellow color with the frons narrow and distinct genitalia.

Vertex about one and one-half times as broad as long, distinctly carinate, broadly rounded at the frons; frons narrow, elongate, the sides a little arched below the eyes; antennæ elongate, the first segment about as long as the second; pronotum about as long as the vertex, broadly sinuate posteriorly; mesonotum large, the scutellar portion occupying about half its length, lateral carinæ broadly divergent; calcar very large, foliaceous, nearly as long as the basal segment of the tarsus; genital aperture very large, ventral sinus triangular, deep, the ventral angles a little produced, dorsal angles strongly produced; genital styles contiguous at the base, the basal angles roundly produced posteriorly, the stems strongly divergent, the

apical portion broad and flat, the outer angle produced dorsad to near the dorsal angle, the inner angle reflexed, produced into a strong finger-like process; anal segments short, anal processes slender, incurved, reaching the dorsal margin of the diaphragm.

COLOR: General color bright ochraceous yellow, shining; eyes black; pleural pieces and abdomen black, the lateral margins and posterior borders of the segments narrowly yellow.

Length, apex of head to apex of abdomen 2.95 mm.; to the tips of wings 5.25 mm.

Holotype 1 ♂. Beverly Hills, Ill., August 31, 1907. W. J. Gerhard.

Allotype 1 ♀. Beverly Hills, Ill., August 31, 1907. W. J. Gerhard.

Paratype 1 ♀. Chicago, Ill., July 5, 1907.

I take pleasure in naming this species for Mr. W. J. Gerhard who very kindly loaned me his entire collection of *Fulgoridæ* for study.

Liburnia staminata n. sp.

Fig. 706

This species may be recognized by its pale color with the frons strongly constricted between eyes, the genital styles slender; the apices suddenly expanded.

Head broad; vertex narrow, strongly produced; lateral margins converging anteriorly and the carinæ strong over the apex of the head; frons broad strongly narrowed between the eyes broadest at about the level of the antennæ, converging toward the clypeus; antennæ reaching the clypeal margin, first segment nearly as long as second; pronotum longer than vertex, distinctly notched posteriorly; mesonotum transverse, the scutellar portion large; calcar very long, longer than the basal segment of the tarsus; pygofer of male long, genital aperture large, ventral sinus shallow; genital styles slender, contiguous at the base, diverging from each other at an angle of about eighty-five degrees; the apices suddenly expanded stamen-like; the dorsal margin of diaphragm produced into a short nearly quadrate median tooth; anal segment short; anal processes broadly triangular reaching the dorsal margin of the diaphragm.

COLOR: General color dull ochraceous yellow; eyes black, tips of tarsi black; wings ochraceous yellow, the veins brighter; anal segment fuscous brown.

Length, apex of head to apex of abdomen 2.80 mm.; to tips of wings 3.50 mm.

Holotype ♂. Chicago, Ill., July 25. W. J. Gerhard.

Liburnia waldeni n. sp.

Fig. 698

This species may be recognized by its uniform dull brown color and short male pygofer.

Vertex rather narrow, elongate; carinæ fairly distinct over the apex of the head; frons narrowed between the eyes, a little arched below; antennæ reaching well beyond the clypeal margin; pronotum nearly as long as the vertex, the lateral carinæ not strongly reflexed; pygofer of the male short, truncate caudally, the genital aperture large, the genital styles long, ligulate, a little arched, their apices acute meeting in the median line just below the anal segment, which is definitely incised on the ventral margin and triangularly produced on each side.

COLOR: General color dull blackish brown; antennæ and legs buffy, lateral margins of the abdomen with large pale spots, wings brownish, the veins darker.

Length, apex of head to apex of abdomen 2.10 mm.; to tips of wings 3.30 mm.

Holotype ♂. New Haven, Conn., August 8, 1920. B. H. Walden.

Criomorphus conspicuus n. sp.

Figs. 105, 391, 392, 549, 635

This species has a general resemblance to *Phyllodinus flabellatus* Ball but the tibiæ are terete, not expanded and the median frontal carina is forked on the clypeal margin.

Head wide, about as wide as the pronotum; vertex about as broad as long; median carina short, the lateral compartments elongate, reaching almost to the base of the vertex; posterior margin of the vertex nearly straight; anterior margin slightly arched; frons about twice as long as broad, lateral margins curved; median carina of the frons forked nearly to the clypeal margins, the two prongs of the fork conspicuous on the apex of the head; antennæ with first segment about half as long as second, the second segment clavate. Pronotum

nearly as long as the vertex, posterior margin nearly straight. Mesonotum small, carinæ wanting or very faint. Brachypterous wings short, reaching the second segment; abdomen short and stout. Male pygofer short, broad, about twice as broad as long; aperture broad, triangularly excavated ventrally; genital styles slender, nearly horizontal; the inner margin expanded to the middle then suddenly constricted, the styles ending in acute reflexed tips; anal segment short, the anal processes long, acutely pointed, anal styles short, barely exserted.

COLOR: General color black with the head, thorax and legs largely testaceous yellow, the posterior margin of the pronotum and the apical margin of the wings bordered with whitish; head testaceous yellow; eyes blackish; frons with the carinæ narrowly bordered with fuscous. Pronotum testaceous yellow; posterior border margined with whitish. Mesonotum testaceous yellow, the posterior borders whitish; fore wings blackish, the apical margins bordered with whitish; legs testaceous yellow; femora lineate with fuscous; claws and spines blackish; abdomen shining black with each dorsal segment with a median testaceous yellow dash on the posterior border; pygofer fuscous and anal segments bordered with yellow posteriorly.

Length, apex of head to apex of abdomen 2.60 mm.

Holotype ♀. New Haven, Conn., June 1920. B. H. Walden.

Paratypes 1 ♀. Urbana, Ill., June 1913. 1 ♀. Forest Hills, Mass., August 1919.

This is a very pretty little species and has apparently escaped attention previously.

EXPLANATION OF PLATES

PLATE 38

Fig. 1. Amycle vernalis Manee.
Fig. 2. Aphelonema rosa Metcalf.
Fig. 3. Cyrpoptus belfragei Stal.
Fig. 4. Poblicia misella Stal.
Fig. 5. Poblicia fuliginosa Olivier.
Fig. 6. Phylloscelis atra albovenosa Melichar.
Fig. 7. Megamelus angulatus Osborn.
Fig. 8. Phylloscelis pallescens Germar.
Fig. 9. Poblicia constellata Walker.
Fig. 10. Ormenis rufifascia Walker.
Fig. 11. Aphelonema bivittata Ball.
Fig. 12. Acanalonia bivittata Say.
Fig. 13. Ormenis pruinosa Say.

PLATE 39

Fig. 14. Catonia nava Say.
Fig. 15. Flatoides scabrosus Melichar.
Fig. 16. Flatoides fuscus Van Duzee.
Fig. 17. Flatoides maculosus Metcalf.
Fig. 18. Megamelanus terminalis Metcalf.
Fig. 19. Pentagramma vittatifrons Uhler.
Fig. 20. Myndus slossoni Ball.
Fig. 21. Pissonotus guttatus Spooner.
Fig. 22. Laccocera zonata Van Duzee.

PLATE 40

Fig. 23. Euklastus harti Metcalf.
Fig. 24. Amalopota uhleri Van Duzee.
Fig. 25. Amalopota fitchi Van Duzee.
Fig. 26. Patara vanduzei Ball.
Fig. 27. Otiocerus degeerii Kirby.
Fig. 28. Otiocerus coquebertii Kirby.
Fig. 29. Liburnia campestris Van Duzee.
Fig. 30. Bruchomorpha bicolor Metcalf.
Fig. 31. Liburnia fulvidorsum Metcalf.
Fig. 32. Pissonotus speciosus Metcalf.
Fig. 33. Otiocerus stollii Kirby.
Fig. 34. Otiocerus abbotii Kirby.
Fig. 35. Otiocerus wolfii Kirby.
Fig. 36. Otiocerus schellenbergii Kirby.
Fig. 37. Fitchiella robertsoni Fitch.
Fig. 38. Megamelanus lautus Metcalf.

PLATE 41

Fig. 39. Cyarda melichari Van Duzee.
Fig. 40. Cyarda acuminipennis Spinola.
Fig. 41. Rhyncopteryx caudata Van Duzee.
Fig. 42. Scolopsella reticulata Ball.
Fig. 43. Crepusia glauca Metcalf.
Fig. 44. Pelitropis rotulata Van Duzee.
Fig. 45. Neurotmeta sponsa Guerin.
Fig. 46. Phylloscelis atra Germar.
Fig. 47. Epiptera septentrionalis Provancher, face.
Fig. 48. Epiptera variegata Van Duzee, face.
Fig. 49. Epiptera opaca Say, face.
Fig. 50. Fitchiella melichari Ball.
Fig. 51. Bruchomorpha dorsata Fitch.

PLATE 42

Fig. 52. Scolops sulcipes Say.
Fig. 53. Scolops perdix Uhler.
Fig. 54. Bruchomorpha suturalis Melichar.
Fig. 55. Bruchomorpha vittata Metcalf.
Fig. 56. Bruchomorpha rugosa Metcalf.
Fig. 57. Bruchomorpha decorata Metcalf.
Fig. 58. Aphelonema rugosa Ball.
Fig. 59. Aphelonema histrionica Stal.
Fig. 60. Misodema reticulata Uhler (after Melichar).
Fig. 61. Dictyonissus griphus Uhler (after Melichar).
Fig. 62. Traxus fulvus Metcalf.

PLATE 43

Fig. 63. Issus servillei Spinola.
Fig. 64. Picumna ovatipennis Walker.
Fig. 65. Issomorphus maculatus Melichar.
Fig. 66. Hysteropterum punctiferum Walker.
Fig. 67. Thionia simplex Germar.
Fig. 68. Catonia dimidata Van Duzee, face.
Fig. 69. Catonia impunctata Fitch, face.
Fig. 70. Catonia bicinctura Van Duzee, face.
Fig. 71. Catonia cinctifrons Fitch, face.
Fig. 72. Epiptera opaca Say.
Fig. 73. Catonia impunctata Fitch.
Fig. 74. Oliarus vittatus Metcalf.
Fig. 75. Oliarus cinnamomeus Provancher.

PLATE 44

Fig. 76. Microledrida fulva Metcalf.
Fig. 77. Ciocixius dorsivittatus Van Duzee.

Fig. 78. Cixius apicalis Metcalf.
Fig. 79. Cixius basalis Van Duzee.
Fig. 80. Bothriocera undata Fabricius, fore wing.
Fig. 81. Bothriocera drakei Metcalf, fore wing.
Fig. 82. Bothriocera tinealis Burmeister, fore wing.
Fig. 83. Bothriocera westwoodi Stal, fore wing.
Fig. 84. Bothriocera bicornis Fabricius.
Fig. 85. Oeclidius nanus Van Duzee.
Fig. 86. Oecleus borealis Van Duzee.
Fig. 87. Anotia bonnetii Kirby.
Fig. 88. Anotia westwoodi Fitch.
Fig. 89. Anotia sayi Ball.
Fig. 90. Anotia kirkaldyi Ball.

PLATE 45

Fig. 91. Mysidia mississippiensis Dozier.
Fig. 92. Neocenchrea heidemanni Ball.
Fig. 93. Phaciocephalus uhleri Ball.
Fig. 94. Herpis maculata Van Duzee.
Fig. 95. Stobæra tricarinata Say.
Fig. 96. Copicerus irroratus Swartz.
Fig. 97. Bostæra nasuta Ball.
Fig. 98. Bakerella maculata Crawford.
Fig. 99. Laccocera vittipennis Van Duzee.
Fig. 100. Saccharosydne saccharivorus Westwood.
Fig. 101. Stenocranus vittatus Stal.
Fig. 102. Phyllodinus nervatus Van Duzee.
Fig. 103. Phyllodinus flabellatus Ball.

PLATE 46

Fig. 104. Macrotomella carinata Van Duzee.
Fig. 105. Criomorphus conspicuus Metcalf.
Fig. 106. Liburniella ornata Say.
Fig. 107. Megamelus palaetus Van Duzee.
Fig. 108. Megamelus æstus Metcalf.
Fig. 109. Kelisia axialis Van Duzee.
Fig. 110. Megamelanus dorsalis Metcalf.
Fig. 111. Peregrinus maidis Ashmead.
Fig. 112. Liburnia slossoni Ball.
Fig. 113. Liburnia albolineosa Fowler.
Fig. 114. Liburnia teapea Fowler.
Fig. 115. Pissonotus quadripustulatus Van Duzee.
Fig. 116. Pissonotus aphidioides Van Duzee.
Fig. 117. Pissonotus dorsalis Van Duzee.

PLATE 47

Fig. 118. Acanalonia pumila Van Duzee.
Fig. 119. Myndus enotatus Van Duzee.
Fig. 120. Dictyophara microrhina Walker.
Fig. 121. Liburnia detecta Van Duzee.
Fig. 122. Megamelanus elongatus Ball.
Fig. 123. Megamelanus spartini Osborn.

PLATE 48

Fig. 124. Acanalonia conica, dorsal view.
Fig. 125. Acanalonia conica, lateral view.
Fig. 126. Acanalonia pumila, dorsal view.
Fig. 127. Acanalonia fasciata, dorsal view.
Fig. 128. Acanalonia servillei, frontal view.
Fig. 129. Acanalonia bivittata, dorsal view.
Fig. 130. Acanalonia virescens, dorsal view.
Fig. 131. Acanalonia concinnula, dorsal view.
Fig. 132. Acanalonia immaculata, dorsal view.
Fig. 133. Acanalonia latifrons, dorsal view.
Fig. 134. Acanalonia servillei, lateral view.
Fig. 135. Acanalonia servillei, dorsal view.
Fig. 136. Cyarda melichari, dorsal view.
Fig. 137. Cyarda melichari, frontal view.
Fig. 138. Cyarda walkeri, dorsal view.
Fig. 139. Cyarda acuminipennis, dorsal view.
Fig. 140. Rhynchopteryx caudata, dorsal view.
Fig. 141. Ormenis chloris, frontal view.
Fig. 142. Ormenis rufifascia, frontal view.
Fig. 143. Ormenis venusta, frontal view.
Fig. 144. Ormensis septentrionalis, frontal view.
Fig. 145. Flatoides maculosus, dorsal view.
Fig. 146. Flatoides fuscus, dorsal view.
Fig. 147. Flatoides tortrix, dorsal view.

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Fig. 148. Flatoides insularis, dorsal view.
Fig. 149. Flatoides punctatus, dorsal view.
Fig. 150. Flatoides consisus, dorsal view.
Fig. 151. Flatoides acutus, dorsal view.
Fig. 152. Flatoides signatus, dorsal view.
Fig. 153. Flatoides signatus, frontal view.
Fig. 154. Flatoides scabrosus, dorsal view.
Fig. 155. Flatoides scabrosus, frontal view.
Fig. 156. Scolopsella reticulata, dorsal view.
Fig. 157. Scolopsella reticulata, frontal view.
Fig. 158. Scolopsella reticulata, lateral view.

Fig. 159. Amycle vernalis, dorsal view.
Fig. 160. Amycle vernalis, frontal view.
Fig. 161. Amycle vernalis, lateral view.
Fig. 162. Amycle saxatilis, dorsal view.
Fig. 163. Crepusia glauca, dorsal view.
Fig. 164. Crepusia glauca, frontal view.
Fig. 165. Cyrpoptus belfragei, dorsal view.
Fig. 166. Cyrpoptus belfragei, frontal view.
Fig. 167. Cyrpoptus belfragei, lateral view.
Fig. 168. Cyrpoptus reineckei, dorsal view.
Fig. 169. Cyrpoptus nubeculosus, dorsal view.
Fig. 170. Poblicia constellata, dorsal view.
Fig. 171. Poblicia constellata, frontal view.

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Fig. 172. Poblicia fuliginosa, dorsal view.
Fig. 173. Poblicia fuliginosa, frontal view.
Fig. 174. Poblicia fuliginosa, lateral view.
Fig. 175. Poblicia thanatophana, dorsal view.
Fig. 176. Poblicia thanatophana, frontal view.
Fig. 177. Pelitropis rotulata, dorsal view.
Fig. 178. Pelitropis rotulata, frontal view.
Fig. 179. Neurotmeta sponsa, dorsal view.
Fig. 180. Neurotmeta sponsa, frontal view.
Fig. 181. Monopsis tabida, frontal view (after Spinola)
Fig. 182. Phylloscelis atra, dorsal view.
Fig. 183. Phylloscelis atra, frontal view.
Fig. 184. Scolops sulcipes, dorsal view.
Fig. 185. Scolops osborni, dorsal view.
Fig. 186. Scolops parvulus, dorsal view.
Fig. 187. Scolops hesperius, dorsal view.
Fig. 188. Scolops grossus, dorsal view.
Fig. 189. Scolops grossus, frontal view.
Fig. 190. Scolops angustatus, dorsal view.
Fig. 191. Scolops angustatus, frontal view.
Fig. 192. Scolops perdix, dorsal view.
Fig. 193. Scolops viridis, dorsal view.
Fig. 194. Scolops desiccatus, dorsal view.
Fig. 195. Scolops robustus, dorsal view.

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Fig. 196. Scolops spurcus, dorsal view.
Fig. 197. Scolops vanduzei, dorsal view.
Fig. 198. Scolops spurcus, lateral view.
Fig. 199. Dictyophara microrhina, dorsal view.
Fig. 200. Dictyophara microrhina, frontal view.

Fig. 201. Dictyophara recurva, dorsal view.
Fig. 202. Dictyophara recurva, frontal view.
Fig. 203. Dictyophara recurva, lateral view.
Fig. 204. Dictyophara florens, dorsal view.
Fig. 205. Dictyophara lingula, dorsal view.
Fig. 206. Dictyophara lingula, frontal view.
Fig. 207. Fitchiella robertsoni, dorsal view.
Fig. 208. Dictyophara florens, frontal view.
Fig. 209. Fitchiella fitchi, dorsal view.
Fig. 210. Fitchiella melichari, dorsal view.
Fig. 211. Fitchiella melichari, lateral view.
Fig. 212. Bruchomorpha tristis, lateral view.
Fig. 213. Bruchomorpha minima, lateral view.
Fig. 214. Bruchomorpha dorsata, lateral view.
Fig. 215. Bruchomorpha oculata, dorsal view.
Fig. 216. Bruchomorpha oculata, lateral view.
Fig. 217. Bruchomorpha nasuta, dorsal view.
Fig. 218. Bruchomorpha nasuta, lateral view.
Fig. 219. Bruchomorpha suturalis, lateral view.

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Fig. 220. Bruchomorpha vittata, lateral view.
Fig. 221. Bruchomorpha pallidipes, lateral view.
Fig. 222. Bruchomorpha rugosa, lateral view.
Fig. 223. Bruchomorpha decorata, lateral view.
Fig. 224. Bruchomorpha bicolor, lateral view.
Fig. 225. Bruchomorpha jocosa, lateral view.
Fig. 226. Aphelonema rosa, dorsal view.
Fig. 227. Aphelonema rosa, frontal view.
Fig. 228. Aphelonema obscura, dorsal view.
Fig. 229. Aphelonema obscura, frontal view.
Fig. 230. Aphelonema simplex, dorsal view.
Fig. 231. Aphelonema simplex, frontal view.
Fig. 232. Aphelonema bivittata, dorsal view.
Fig. 233. Aphelonema bivittata, frontal view.
Fig. 234. Aphelonema rugosa, dorsal view.
Fig. 235. Aphelonema rugosa, frontal view.
Fig. 236. Aphelonema histrionica, dorsal view.
Fig. 237. Aphelonema histrionica, frontal view.
Fig. 238. Traxus fulvus, dorsal view.
Fig. 239. Traxus fulvus, frontal view.
Fig. 240. Issus servillei, dorsal view.
Fig. 241. Issus servillei, frontal view.
Fig. 242. Picumna ovatipennis, dorsal view.
Fig. 243. Picumna ovatipennis, frontal view.

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Fig. 244. Issomorphus maculatus, dorsal view.
Fig. 245. Issomorphus maculatus, frontal view.
Fig. 246. Hysteropterum punctiferum, dorsal view.
Fig. 247. Hysteropterum punctiferum, frontal view.
Fig. 248. Thionia simplex, dorsal view.
Fig. 249. Thionia simplex, frontal view.
Fig. 250. Thionia elliptica, dorsal view.
Fig. 251. Thionia elliptica, frontal view.
Fig. 252. Thionia producta, dorsal view.
Fig. 253. Thionia producta, frontal view.
Fig. 254. Thionia ocellata, dorsal view.
Fig. 255. Thionia quinquata, dorsal view.
Fig. 256. Thionia bullata, dorsal view.
Fig. 257. Thionia bullata, frontal view.
Fig. 258. Epiptera floridæ, dorsal view.
Fig. 259. Epiptera septentrionalis, dorsal view.
Fig. 260. Epiptera variegata, dorsal view.
Fig. 261. Epiptera slossoni, dorsal view.
Fig. 262. Epiptera pallida, dorsal view.
Fig. 263. Epiptera brittoni, dorsal view.
Fig. 264. Epiptera colorata, dorsal view.
Fig. 265. Epiptera opaca, dorsal view.
Fig. 266. Catonia grisea, dorsal view.
Fig. 267. Oliarus cinnamomeus, dorsal view.

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Fig. 268. Oliarus humilis, dorsal view.
Fig. 269. Oliarus montanus, dorsal view.
Fig. 270. Oliarus placitus, dorsal view.
Fig. 271. Oliarus difficilis, dorsal view.
Fig. 272. Oliarus franciscanus, dorsal view.
Fig. 273. Oliarus aridus, dorsal view.
Fig. 274. Oliarus quinquelineatus, dorsal view.
Fig. 275. Oliarus texanus, dorsal view.
Fig. 276. Oliarus vittatus, dorsal view.
Fig. 277. Oliarus vicarius, dorsal view.
Fig. 278. Monorachis sordulentus, dorsal view.
Fig. 279. Monorachis sordulentus, frontal view.
Fig. 280. Microledrida fulva, dorsal view.
Fig. 281. Microledrida fulva, frontal view.
Fig. 282. Ciocixius dorsivittatus, dorsal view.
Fig. 283. Ciocixius dorsivittatus, frontal view.
Fig. 284. Cixius apicalis, dorsal view.
Fig. 285. Cixius apicalis, frontal view.
Fig. 286. Cixius cultus, dorsal view.

Fig. 287. Cixius stigmatus, dorsal view.
Fig. 288. Cixius misellus, dorsal view.
Fig. 289. Cixius colœpium, dorsal view.
Fig. 290. Cixius basalis, dorsal view.
Fig. 291. Cixius pini, dorsal view.

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Fig. 292. Bothriocera bicornis, dorsal view.
Fig. 293. Bothriocera bicornis, frontal view.
Fig. 294. Bothriocera bicornis, lateral view.
Fig. 295. Oeclidius nanus, dorsal view.
Fig. 296. Oeclidius nanus, frontal view.
Fig. 297. Oecleus decens, dorsal view.
Fig. 298. Oecleus productus, dorsal view.
Fig. 299. Oecleus fulvidorsum, dorsal view.
Fig. 300. Oecleus lineatus, dorsal view.
Fig. 301. Oecleus obtusus, dorsal view.
Fig. 302. Oecleus borealis, dorsal view.
Fig. 303. Oecleus borealis, frontal view.
Fig. 304. Myndus fulvus, dorsal view.
Fig. 305. Myndus slossoni, dorsal view.
Fig. 306. Myndus radicis, dorsal view.
Fig. 307. Myndus radicis, frontal view.
Fig. 308. Myndus enotatus, dorsal view.
Fig. 309. Myndus viridis, dorsal view.
Fig. 310. Myndus pusillus, dorsal view.
Fig. 311. Myndus pictifrons, dorsal view.
Fig. 312. Myndus truncatus, dorsal view.
Fig. 313. Myndus sordidipennis, dorsal view.
Fig. 314. Myndus delicatus, dorsal view.
Fig. 315. Otiocerus degeerii, dorsal view.

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Fig. 316. Otiocerus degeerii, frontal view.
Fig. 317. Otiocerus degeerii, lateral view.
Fig. 318. Otiocerus abbotii, dorsal view.
Fig. 319. Otiocerus abbotii, lateral view.
Fig. 320. Otiocerus wolfii, dorsal view.
Fig. 321. Otiocerus wolfii, lateral view.
Fig. 322. Otiocerus amyotii, dorsal view.
Fig. 323. Otiocerus amyotii, lateral view.
Fig. 324. Otiocerus signoretii, dorsal view.
Fig. 325. Otiocerus signoretii, lateral view.
Fig. 326. Otiocerus stollii, dorsal view.
Fig. 327. Otiocerus stollii, lateral view.
Fig. 328. Otiocerus schellenbergii, dorsal view.

Fig. 329. Otiocerus schellenbergii, lateral view.
Fig. 330. Otiocerus coquebertii, dorsal view.
Fig. 331. Otiocerus coquebertii, lateral view.
Fig. 332. Otiocerus kirbyii, dorsal view.
Fig. 333. Otiocerus kirbyii, lateral view.
Fig. 334. Euklastus harti, dorsal view.
Fig. 335. Euklastus harti, frontal view.
Fig. 336. Euklastus harti, lateral view.
Fig. 337. Amalopota fitchi, dorsal view.
Fig. 338. Amalopota fitchi, lateral view.
Fig. 339. Amalopota uhleri, dorsal view.

PLATE 57

Fig. 340. Amalopota uhleri, frontal view.
Fig. 341. Amalopota uhleri, lateral view.
Fig. 342. Anotia burnetii, dorsal view.
Fig. 343. Anotia burnetii, lateral view.
Fig. 344. Anotia bonnetii, dorsal view.
Fig. 345. Anotia bonnetii, frontal view.
Fig. 346. Anotia bonnetii, lateral view.
Fig. 347. Anotia robertsoni, dorsal view.
Fig. 348. Anotia robertsoni, lateral view.
Fig. 349. Anotia westwoodi, dorsal view.
Fig. 350. Anotia westwoodi, lateral view.
Fig. 351. Anotia sayi, dorsal view.
Fig. 352. Anotia sayi, lateral view.
Fig. 353. Anotia kirkaldyi, dorsal view.
Fig. 354. Anotia kirkaldyi, lateral view.
Fig. 355. Patara vanduzei, dorsal view.
Fig. 356. Patara vanduzei, frontal view.
Fig. 357. Patara vanduzei, lateral view.
Fig. 358. Mysidia mississippiensis, dorsal view.
Fig. 359. Neocenchrea heidemanni, dorsal view.
Fig. 360. Neocenchrea heidemanni, frontal view.
Fig. 361. Phaciocephalus fulvus, dorsal view.
Fig. 362. Phaciocephalus fulvus, frontal view.
Fig. 363. Phaciocephalus uhleri, dorsal view.
Fig. 364. Phaciocephalus uhleri, frontal view.

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Fig. 365. Herpis maculata, dorsal view.
Fig. 366. Herpis vulgaris, dorsal view.
Fig. 367. Herpis vulgaris, frontal view.
Fig. 368. Stobæra pallida, dorsal view.
Fig. 369. Stobæra pallida, frontal view.
Fig. 370. Stobæra tricarinata, dorsal view.

Fig. 371. Stobæra tricarinata, frontal view.
Fig. 372. Stobæra minuta, dorsal view.
Fig. 373. Stobæra minuta, frontal view.
Fig. 374. Copiocerus irroratus, dorsal view.
Fig. 375. Copiocerus irroratus, frontal view.
Fig. 376. Pentagramma minore, dorsal view.
Fig. 377. Pentagramma minore, frontal view.
Fig. 378. Pentagramma vittatifrons, dorsal view.
Fig. 379. Pentagramma vittatifrons, frontal view.
Fig. 380. Bostæra nasuta, dorsal view.
Fig. 381. Bostæra nasuta, frontal view.
Fig. 382. Bakerella maculata, dorsal view.
Fig. 383. Bakerella maculata, frontal view.
Fig. 384. Laccocera vittipennis, dorsal view.
Fig. 385. Laccocera vittipennis, frontal view.
Fig. 386. Laccocera zonata, dorsal view.
Fig. 387. Phyllodinus nervatus, dorsal view.
Fig. 388. Phyllodinus nervatus, frontal view.

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Fig. 389. Macrotomella carinata, dorsal view.
Fig. 390. Macrotomella carinata, frontal view.
Fig. 391. Criomorphus conspicuus, dorsal view.
Fig. 392. Criomorphus conspicuus, frontal view.
Fig. 393. Liburniella ornata, dorsal view.
Fig. 394. Liburniella ornata, frontal view.
Fig. 395. Saccharosydne saccharivorus, dorsal view.
Fig. 396. Saccharosydne saccharivorus, frontal view.
Fig. 397. Saccharosydne saccharivorus, lateral view.
Fig. 398. Stenocranus similis, dorsal view.
Fig. 399. Stenocranus arundineus, dorsal view.
Fig. 400. Stenocranus arundineus, frontal view.
Fig. 401. Stenocranus felti, dorsal view.
Fig. 402. Stenocranus felti, frontal view.
Fig. 403. Stenocranus vittatus, dorsal view.
Fig. 404. Stenocranus dorsalis, dorsal view.
Fig. 405. Megamelus palaetus, dorsal view.
Fig. 406. Megamelus inflatus, dorsal view.
Fig. 407. Megamelus longicornis, dorsal view.
Fig. 408. Megamelus distinctus, dorsal view.
Fig. 409. Megamelus æstus, dorsal view.
Fig. 410. Megamelus uncus, dorsal view.
Fig. 411. Megamelus uncus, lateral view.
Fig. 412. Megamelus anticostus, dorsal view.
Fig. 413. Megamelus angulatus, dorsal view.
Fig. 414. Megamelus davisi, dorsal view.

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Fig. 415. Prokelisia marginata, dorsal view.
Fig. 416. Prokelisia marginata, frontal view.
Fig. 417. Prokelisia marginata, lateral view.
Fig. 418. Prokelisia setigera, dorsal view.
Fig. 419. Prokelisia setigera, dorsal view.
Fig. 420. Kelisia axialis, dorsal view.
Fig. 421. Kelisia axialis, frontal view.
Fig. 422. Kelisia axialis, lateral view.
Fig. 423. Kelisia crocea, dorsal view.
Fig. 424. Kelisia parvula, dorsal view.
Fig. 425. Megamelanus terminalis, dorsal view.
Fig. 426. Megamelanus terminalis, lateral view.
Fig. 427. Megamelanus lautus, dorsal view.
Fig. 428. Megamelanus lautus, lateral view.
Fig. 429. Megamelanus elongatus, dorsal view.
Fig. 430. Megamelanus elongatus, frontal view.
Fig. 431. Megamelanus elongatus, lateral view.
Fig. 432. Megamelanus dorsalis, dorsal view.
Fig. 433. Megamelanus dorsalis, lateral view.
Fig. 434. Megamelanus spartini, dorsal view.
Fig. 435. Megamelanus spartini, lateral view.
Fig. 436. Peregrinus maidis, dorsal view.
Fig. 437. Peregrinus maidis, frontal view.

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Fig. 438. Pissonotus quadripustulatus, dorsal view.
Fig. 439. Pissonotus aphidioides, dorsal view.
Fig. 440. Pissonotus brunneus, dorsal view.
Fig. 441. Pissinotus dorsalis, dorsal view.
Fig. 442. Pissonotus ater, dorsal view.
Fig. 443. Pissonotus marginatus, dorsal view.
Fig. 444. Pissonotus pallipes, dorsal view.
Fig. 445. Pissonotus guttatus, dorsal view.
Fig. 446. Pissonotus basalis, dorsal view.
Fig. 447. Pissonotus delicatus, dorsal view.
Fig. 448. Pissonotus fulvus, dorsal view.
Fig. 449. Pissonotus nigridorsum, dorsal view.
Fig. 450. Pissonotus speciosus, dorsal view.
Fig. 451. Liburnia lutulenta, dorsal view.
Fig. 452. Liburnia lutulenta, frontal view.
Fig. 453. Liburnia campestris, dorsal view.
Fig. 454. Liburnia slossoni, dorsal view.
Fig. 455. Liburnia pellucida, dorsal view.
Fig. 456. Liburnia pellucida, frontal view.
Fig. 457. Liburnia albolineosa, dorsal view.

Fig. 458. Liburnia albolineosa, frontal view.
Fig. 459. Liburnia teapea, dorsal view.
Fig. 460. Liburnia teapea, frontal view.
Fig. 461. Liburnia puella, dorsal view.

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Fig. 462. Acanalonia conica, antennæ.
Fig. 463. Flatoides tortrix, antennæ.
Fig. 464. Scolopsella reticulata, antennæ.
Fig. 465. Amycle saxatilis, antennæ.
Fig. 466. Crepusia glauca, antennæ.
Fig. 467. Cyrpoptus belfragei, antennæ.
Fig. 468. Poblicia fuliginosa, antennæ.
Fig. 469. Pelitropis rotulata, antennæ.
Fig. 470. Neurotmeta sponsa, antennæ.
Fig. 471. Phylloscelis albovenosa, antennæ.
Fig. 472. Scolops perdix, antennæ.
Fig. 473. Dictyophara microrhina, antennæ.
Fig. 474. Traxus fulvus, antennæ.
Fig. 475. Epiptera variegata, antennæ.
Fig. 476. Cixius colœpium, antennæ.
Fig. 477. Bothriocera bicornis, antennæ.
Fig. 478. Otiocerus degeerii, antennæ.
Fig. 479. Euklastus harti, antennæ.
Fig. 480. Amalopota fitchi, antennæ.
Fig. 481. Anotia westwoodi, antennæ.
Fig. 482. Anotia sayi antennæ.
Fig. 483. Patara vanduzei, antennæ.
Fig. 484. Mysidia mississippiensis, antennæ.
Fig. 485. Neocenchrea heidemanni, antennæ.
Fig. 486. Herpis incisa, antennæ.
Fig. 487. Stobæra pallida, antennæ.
Fig. 488. Copiocerus irroratus, antennæ.
Fig. 489. Pentagramma vittatifrons, antennæ.
Fig. 490. Bostæra nasuta, antennæ.
Fig. 491. Bakerella maculata, antennæ.
Fig. 492. Laccocera vittipennis, antennæ.
Fig. 493. Saccharosydne saccharivorus, antennæ.
Fig. 494. Stenocranus similis, antennæ.
Fig. 495. Stenocranus vittatus, antennæ.
Fig. 496. Liburnia gerhardi, antennæ.

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Fig. 497. Acanalonia latifrons, wing.
Fig. 498. Ormenis venusta, wing.
Fig. 499. Ormenis septentrionalis, wing.

Fig. 500. Ormenis relicta, wing.
Fig. 501. Cyrpoptus belfragei, wing.
Fig. 502. Cyrpoptus reinecki, wing.
Fig. 503. Poblicia fuliginosa, fore wing.
Fig. 504. Poblicia fuliginosa, hind wing.
Fig. 505. Pelitropis rotulata, wing.
Fig. 506. Neurotmeta sponsa, wing.
Fig. 507. Monopsis tabida, wing (after Spinola).
Fig. 508. Scolops perdix, wing.
Fig. 509. Dictyophara dioxys, wing.
Fig. 510. Dictyophara microrhina, wing.
Fig. 511. Bruchomorpha oculata, wing.
Fig. 512. Issus servillei, wing.

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Fig. 513. Picumna ovatipennis, wing.
Fig. 514. Issomorphus maculatus, wing.
Fig. 515. Thionia bullata, wing.
Fig. 516. Epiptera opaca, wing.
Fig. 517. Oecleus borealis, wing.
Fig. 518. Myndus pictifrons, wing.
Fig. 519. Otiocerus degeerii, wing.
Fig. 520. Euklastus harti, wing.
Fig. 521. Anotia bonnetii, wing.
Fig. 522. Patara vanduzei, wing.
Fig. 523. Neocenchrea heidemanni, wing.
Fig. 524. Phaciocephalus uhleri, wing.
Fig. 525. Herpis vulgaris, wing.
Fig. 526. Liburniella ornata, wing.
Fig. 527. Saccharosydne saccharivorus, wing.
Fig. 528. Stenocranus vittatus, wing.

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Fig. 529. Cyrpoptus belfragei, hind legs.
Fig. 530. Phylloscellis atra, fore legs.
Fig. 531. Fitchiella melichari, fore legs.
Fig. 532. Traxus fulvus, hind legs.
Fig. 533. Issus servillei, hind legs.
Fig. 534. Picumna ovatipennis, hind legs.
Fig. 535. Issomorphus maculatus, hind legs.
Fig. 536. Hysteropterum punctiferum, hind legs.
Fig. 537. Thionia simplex, hind legs.
Fig. 538. Oliarius quinquelineatus, hind legs.
Fig. 539. Myndus radicis, hind legs.
Fig. 540. Stobæra pallida, hind legs.
Fig. 541. Copiocerus irroratus, hind legs.

Fig. 542. Pentagramma vittatifrons, hind legs.
Fig. 543. Bostæra nasuta, hind legs.
Fig. 544. Bakerella maculata, hind legs.
Fig. 545. Laccocera vittipennis, hind legs.
Fig. 546. Phyllodinus nervatus, fore legs.
Fig. 547. Phyllodinus nervatus, hind legs.
Fig. 548. Macrotomella carinata, hind legs.
Fig. 549. Criomorphus conspicuus, hind legs.
Fig. 550. Liburniella ornata, hind legs.
Fig. 551. Saccharosydne saccharivorus, hind legs.
Fig. 552. Stenocranus arundineus, hind legs.
Fig. 553. Prokelisia setigera, hind legs.
Fig. 554. Kelisia axialis, hind legs.
Fig. 555. Megamelanus terminalis, hind legs.
Fig. 556. Pissonotus quadripustulatus, hind legs.
Fig. 557. Liburnia shermani, hind legs.

PLATE 66

Fig. 558. Acanalonia fasciata, female genitalia.
Fig. 559. Acanalonia bivittata, female genitalia.
Fig. 560. Dictyophara microrhina, female genitalia.
Fig. 561. Dictyophara, recurva, female genitalia.
Fig. 562. Dictyophara florens, female genitalia.
Fig. 563. Dictyophara lingula, female genitalia.
Fig. 564. Oliarus cinnamomeus, male genitalia.
Fig. 565. Oliarus humilis, male genitalia.
Fig. 566. Oliarus montanus, male genitalia.
Fig. 567. Oliarus placitus, male genitalia.
Fig. 568. Oliarus difficilis, male genitalia.
Fig. 569. Oliarus franciscanus, male genitalia.
Fig. 570. Oliarus aridus, male genitalia.
Fig. 571. Oliarus quinquelineatus, male genitalia.
Fig. 572. Oliarus texanus, male genitalia.
Fig. 573. Oliarus vittatus, male genitalia.
Fig. 574. Oliarus vitreus, male genitalia.
Fig. 575. Oliarus vicarius, male genitalia.
Fig. 576. Microledrida fulva, male genitalia.
Fig. 577. Microledrida asperta, male genitalia.
Fig. 578. Cixius apicalis, male genitalia.
Fig. 579. Cixius stigmatus, male genitalia.
Fig. 580. Cixius misellus, male genitalia.
Fig. 581. Cixius colœpium, male genitalia.
Fig. 582. Cixius basalis, male genitalia.
Fig. 583. Cixius pini, male genitalia.
Fig. 584. Bothriocera undata, male genitalia.
Fig. 585. Bothriocera drakei, male genitalia.

Fig. 586. Bothriocera tinealis, male genitalia.
Fig. 587. Oecleus decens, male genitalia.
Fig. 588. Oecleus productus, male genitalia.
Fig. 589. Oecleus fulvidorsum, male genitalia.

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Fig. 590. Oecleus lineatus, male genitalia.
Fig. 591. Oecleus obtusus, male genitalia.
Fig. 592. Oecleus borealis, male genitalia.
Fig. 593. Myndus fulvus, male genitalia.
Fig. 594. Myndus slossoni, male genitalia.
Fig. 595. Myndus radicis, male genitalia.
Fig. 596. Myndus enotatus, male genitalia.
Fig. 597. Myndus viridis, male genitalia.
Fig. 598. Myndus pusillus, male genitalia.
Fig. 599. Myndus pictifrons, male genitalia.
Fig. 600. Myndus truncatus, male genitalia.
Fig. 601. Myndus sordidipennis, male genitalia.
Fig. 602. Myndus delicatus, male genitalia.
Fig. 603. Otiocerus degeerii, male genitalia.
Fig. 604. Otiocerus abbotii, male genitalia.
Fig. 605. Otiocerus amyotii, male genitalia.
Fig. 606. Otiocerus coquebertii, male genitalia.
Fig. 607. Amalopota uhleri, male genitalia.
Fig. 608. Anotia burnetii, male genitalia.
Fig. 609. Anotia bonnetii, male genitalia.
Fig. 610. Anotia westwoodi, male genitalia.
Fig. 611. Anotia sayi, male genitalia.
Fig. 612. Anotia kirkaldyi, male genitalia.
Fig. 613. Neocenchrea heidemanni, male genitalia.
Fig. 614. Phaciocephalus fulvus, male genitalia.
Fig. 615. Phaciocephalus uhleri, male genitalia.
Fig. 616. Herpis maculata, male genitalia.
Fig. 617. Herpis edentula, male genitalia.
Fig. 618. Herpis vulgaris, male genitalia.
Fig. 619. Herpis incisa, male genitalia.
Fig. 620. Herpis australis, male genitalia.
Fig. 621. Herpis obscura, male genitalia.

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Fig. 622. Stobæra pallida, male genitalia.
Fig. 623. Stobæra concinna, male genitalia.
Fig. 624. Stobæra tricarinata, male genitalia.
Fig. 625. Stobæra minuta, male genitalia.
Fig. 626. Copiocerus irroratus, male genitalia.
Fig. 627. Pentagramma minore, male genitalia.

Fig. 628. Pentagramma vittatifrons, male genitalia.
Fig. 629. Bostæra nasuta, male genitalia.
Fig. 630. Bakerella maculata, male genitalia.
Fig. 631. Laccocera vittipennis, male genitalia.
Fig. 632. Laccocera zonata, male genitalia.
Fig. 633. Phyllodinus nervatus, male genitalia.
Fig. 634. Phyllodinus flabellatus, male genitalia.
Fig. 635. Criomorphus conspicuus, male genitalia.
Fig. 636. Liburniella ornata, male genitalia.
Fig. 637. Saccharosydne saccharivorus, male genitalia.
Fig. 638. Stenocranus similis, male genitalia.
Fig. 639. Stenocranus similis, female genitalia.
Fig. 640. Stenocranus arundineus, male genitalia.
Fig. 641. Stenocranus arundineus, female genitalia.
Fig. 642. Stenocranus vittatus, male genitalia.
Fig. 643. Stenocranus dorsalis, male genitalia.
Fig. 644. Stenocranus dorsalis, female genitalia.
Fig. 645. Megamelus palaetus, male genitalia.
Fig. 646. Megamelus inflatus, male genitalia.
Fig. 647. Megamelus longicornis, male genitalia (after Dozier).
Fig. 648. Megamelus notulus, male genitalia (after Crawford).
Fig. 649. Megamelus distinctus, male genitalia.
Fig. 650. Megamelus æstus, male genitalia.
Fig. 651. Megamelus uncus, male genitalia.
Fig. 652. Megamelus anticostus, male genitalia.
Fig. 653. Megamelus angulatus, male genitalia.

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Fig. 654. Megamelus davisi, male genitalia.
Fig. 655. Megamelus piceus, male genitalia.
Fig. 656. Prokelisia marginata, male genitalia.
Fig. 657. Prokelisia setigera, male genitalia.
Fig. 658. Kelisia axialis, male genitalia.
Fig. 659. Kelisia crocea, male genitalia.
Fig. 660. Kelisia parvula, male genitalia.
Fig. 661. Megamelanus terminalis, male genitalia.
Fig. 662. Megamelanus lautus, male genitalia.
Fig. 663. Megamelanus elongatus, male genitalia.
Fig. 664. Megamelanus dorsalis, male genitalia.
Fig. 665. Megamelanus spartini, male genitalia.
Fig. 666. Peregrinus maidis, male genitalia.
Fig. 667. Pissonotus quadripustulatus, male genitalia.
Fig. 668. Pissonotus aphidioides, male genitalia.
Fig. 669. Pissonotus brunneus, male genitalia.
Fig. 670. Pissonotus dorsalis, male genitalia.
Fig. 671. Pissonotus ater, male genitalia.

Fig. 672. Pissonotus marginatus, male genitalia.
Fig. 673. Pissonotus pallipes, male genitalia.
Fig. 674. Pissonotus crawfordi, male genitalia.
Fig. 675. Pissonotus guttatus, male genitalia.
Fig. 676. Pissonotus basalis, male genitalia.
Fig. 677. Pissonotus delicatus, male genitalia.
Fig. 678. Pissonotus fulvus, male genitalia.
Fig. 679. Pissonotus nigridorsum, male genitalia.
Fig. 680. Pissonotus speciosus, male genitalia.
Fig. 681. Liburnia lutulenta, male genitalia.
Fig. 682. Liburnia obscurella, male genitalia (after Melichar).
Fig. 683. Liburnia analis, male genitalia.
Fig. 684. Liburnia campestris, male genitalia.
Fig. 685. Liburnia rotundata, male genitalia.

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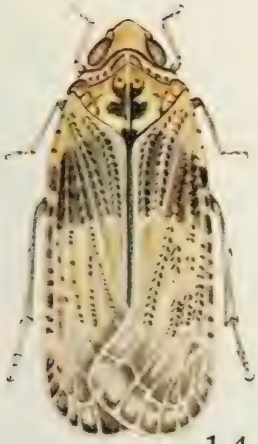
Fig. 686. Liburnia shermani, male genitalia.
Fig. 687. Liburnia occlusa, male genitalia.
Fig. 688. Liburnia nigridorsum, male genitalia.
Fig. 689. Liburnia slossoni, male genitalia.
Fig. 690. Liburnia foveata, male genitalia.
Fig. 691. Liburnia constricta, male genitalia (after Crawford).
Fig. 692. Liburnia osborni, male genitalia.
Fig. 693. Liburnia gillettei, male genitalia.
Fig. 694. Liburnia lineatipes, male genitalia.
Fig. 695. Liburnia pellucida, male genitalia.
Fig. 696. Liburnia consimilis, male genitalia.
Fig. 697. Liburnia kilmani, male genitalia.
Fig. 698. Liburnia waldeni, male genitalia.
Fig. 699. Liburnia basivitta, male genitalia.
Fig. 700. Liburnia magnistyla, male genitalia.
Fig. 701. Liburnia albolineosa, male genitalia.
Fig. 702. Liburnia triloba, male genitalia.
Fig. 703. Liburnia gerhardi, male genitalia.
Fig. 704. Liburnia alexanderi, male genitalia.
Fig. 705. Liburnia fulvidorsum, male genitalia.
Fig. 706. Liburnia staminata, male genitalia.
Fig. 707. Liburnia humilis, male genitalia.
Fig. 708. Liburnia detecta, male genitalia.
Fig. 709. Liburnia unda, male genitalia.
Fig. 710. Liburnia tuckeri, male genitalia.
Fig. 711. Liburnia lateralis, male genitalia.
Fig. 712. Liburnia teapea, male genitalia.
Fig. 713. Liburnia vanduzeei, male genitalia (after Crawford).
Fig. 714. Liburnia laminalis, male genitalia.
Fig. 715. Liburnia puella, male genitalia.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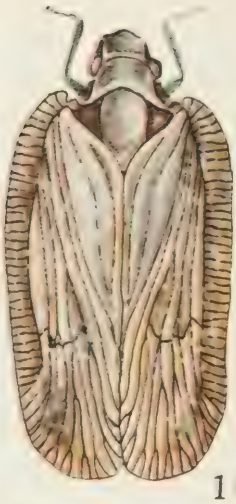
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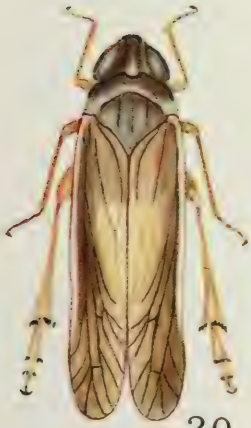
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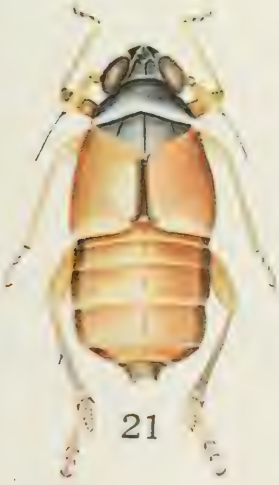
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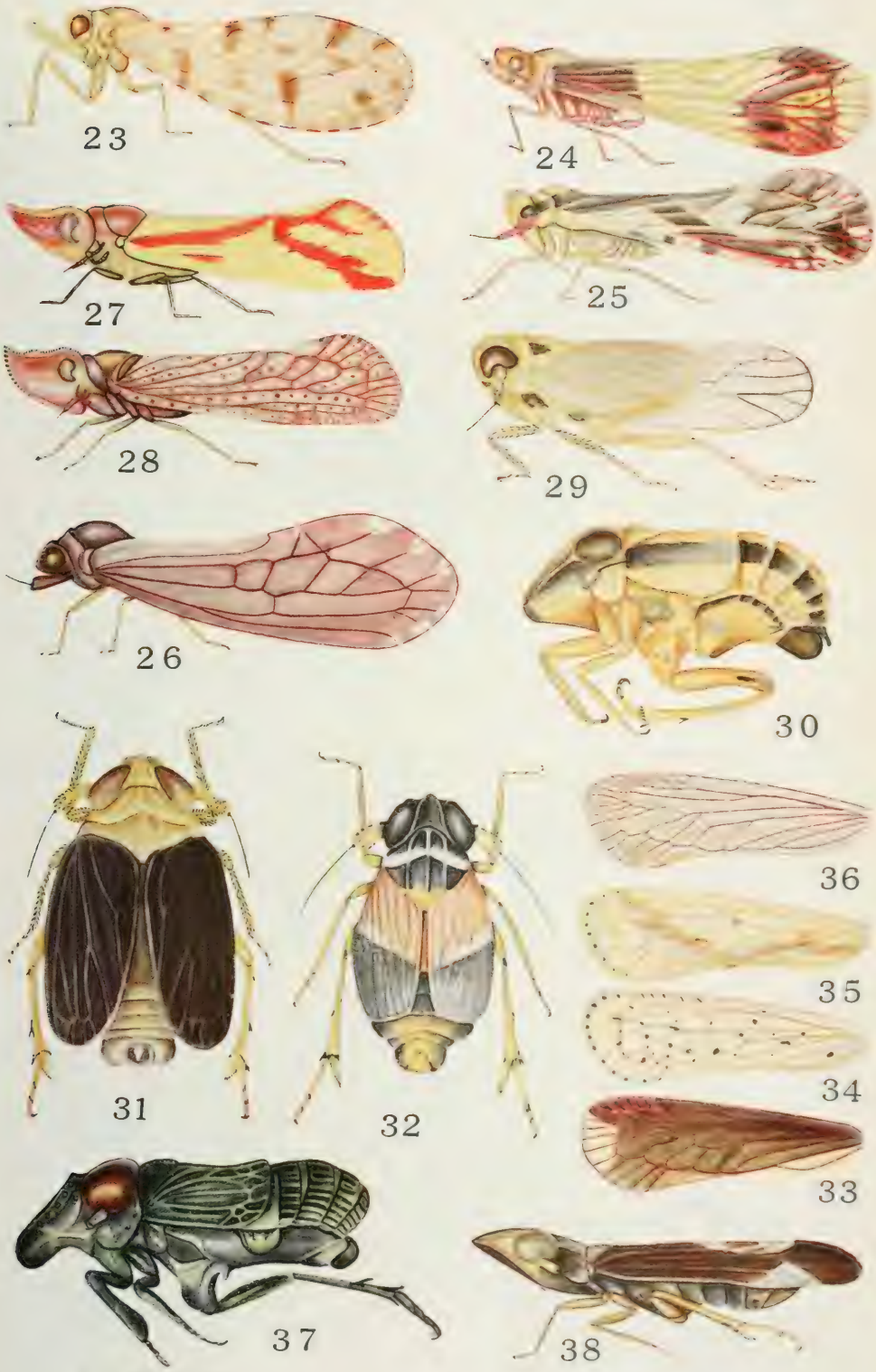

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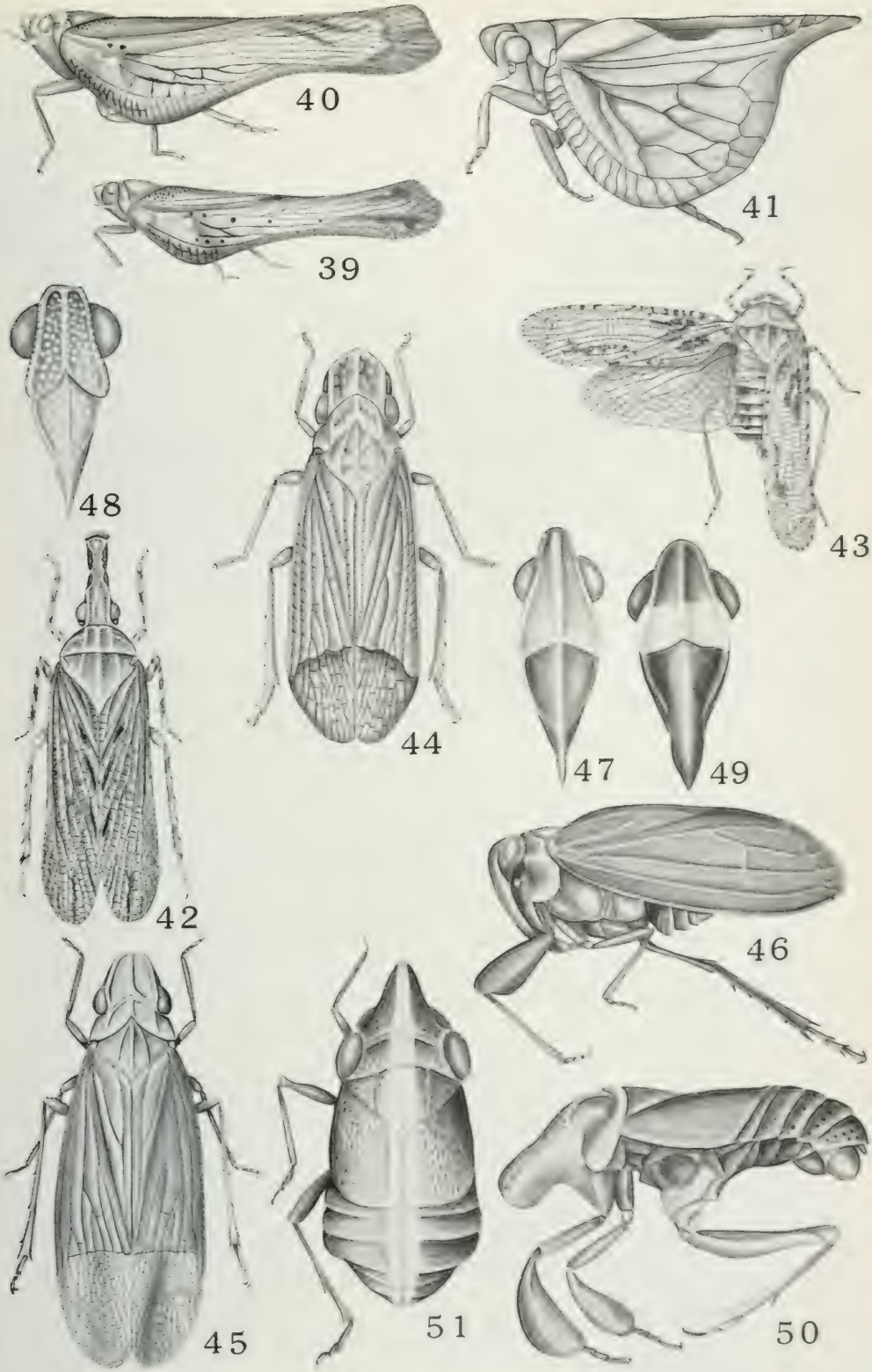

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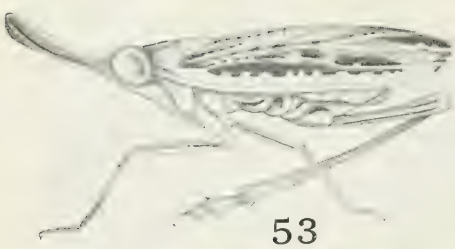
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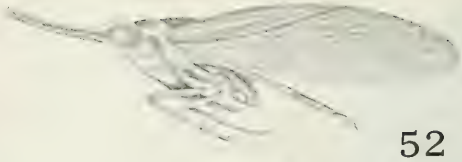
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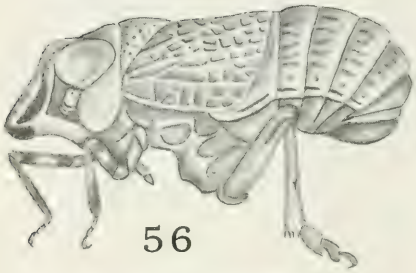
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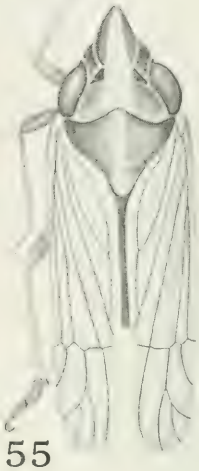
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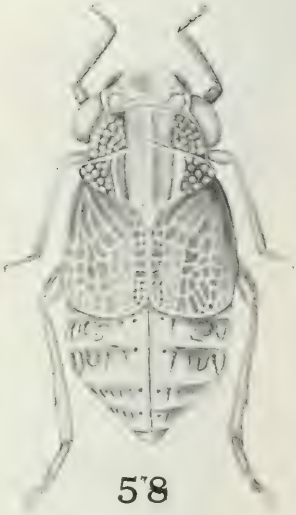
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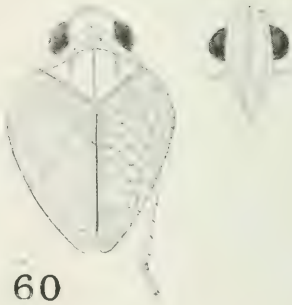
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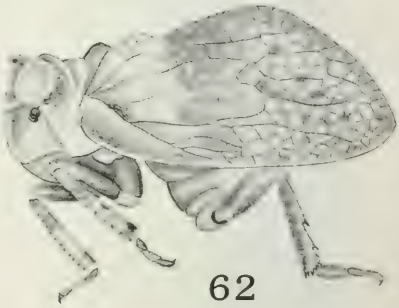
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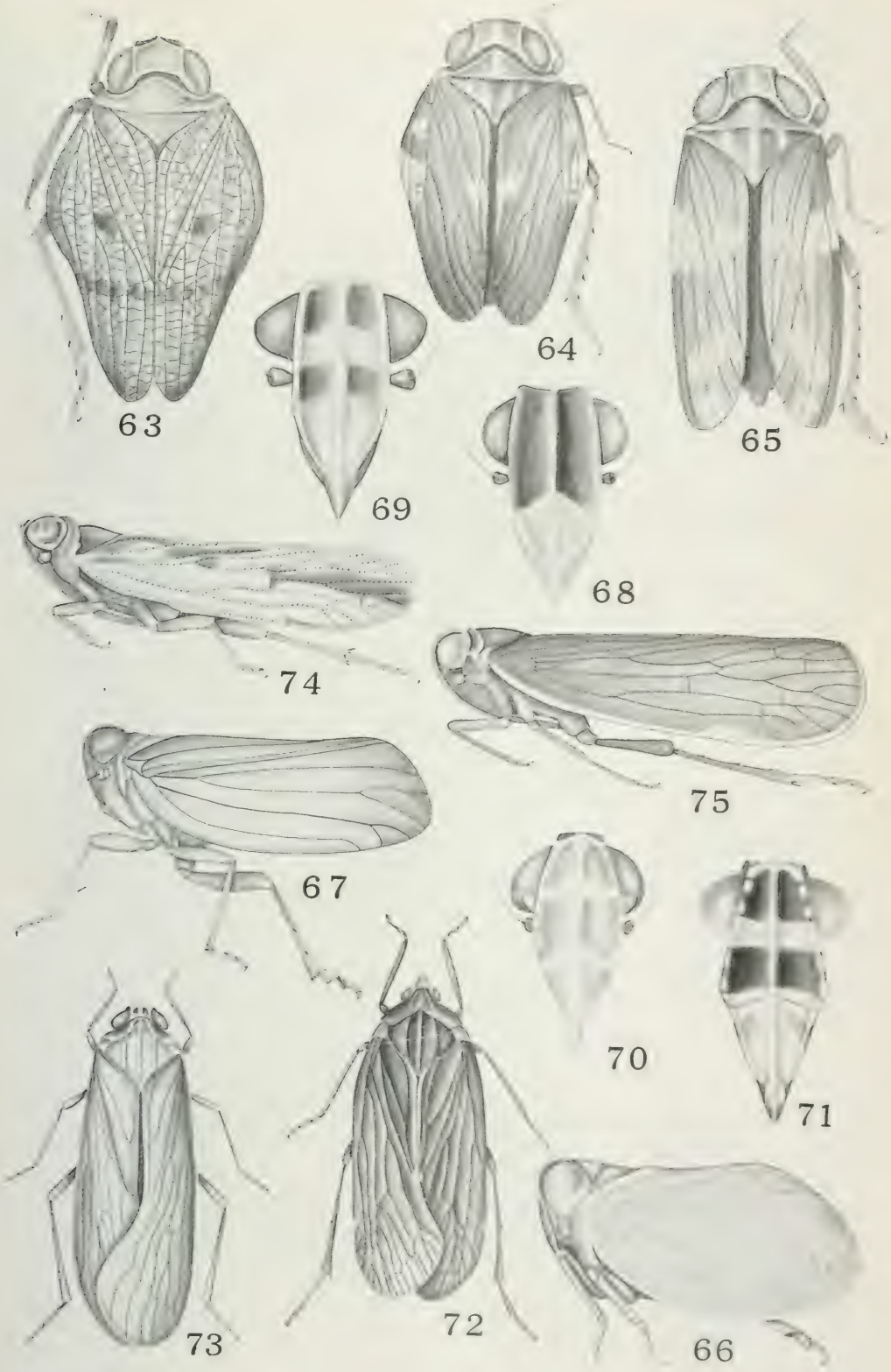

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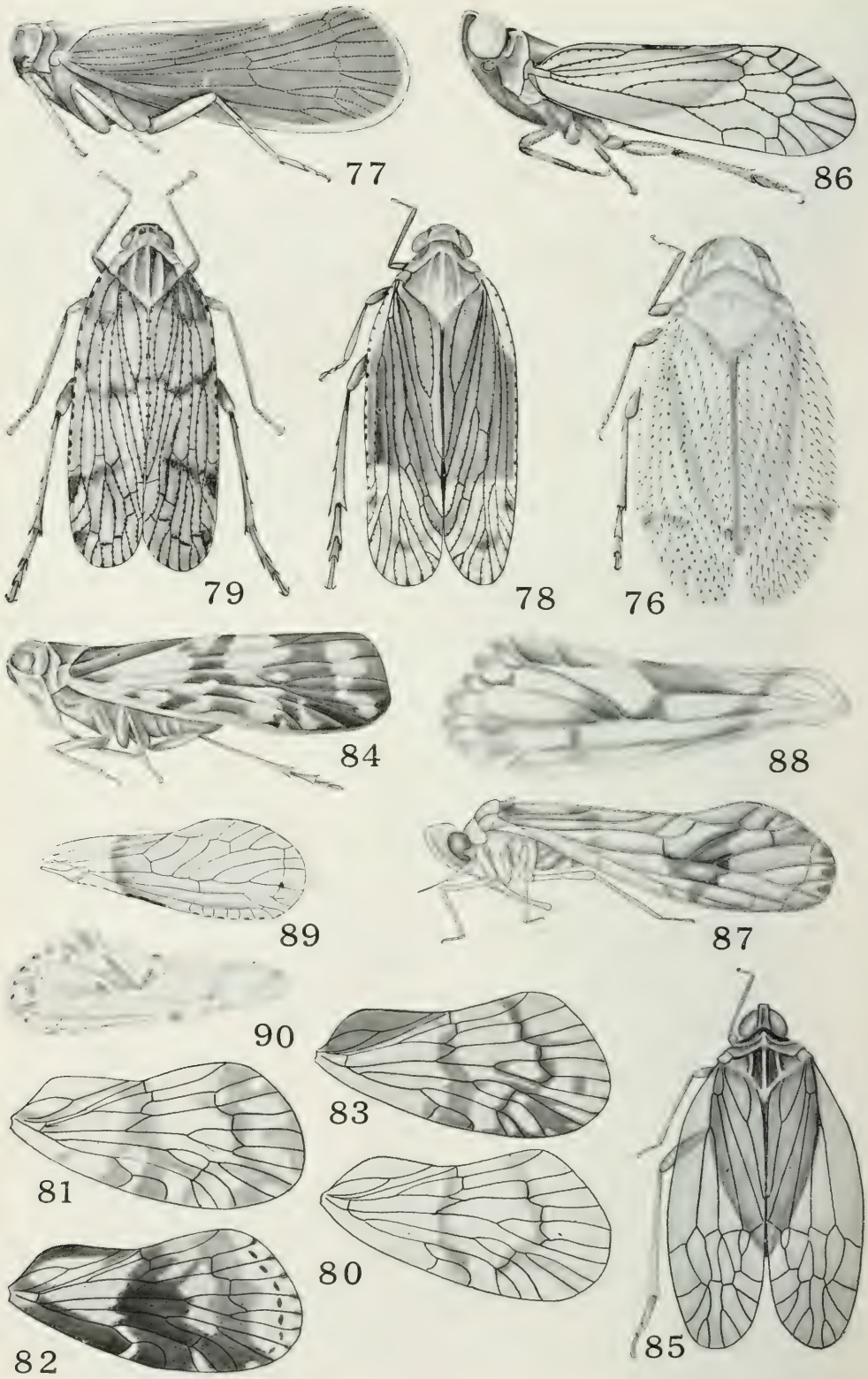
PLATE 44



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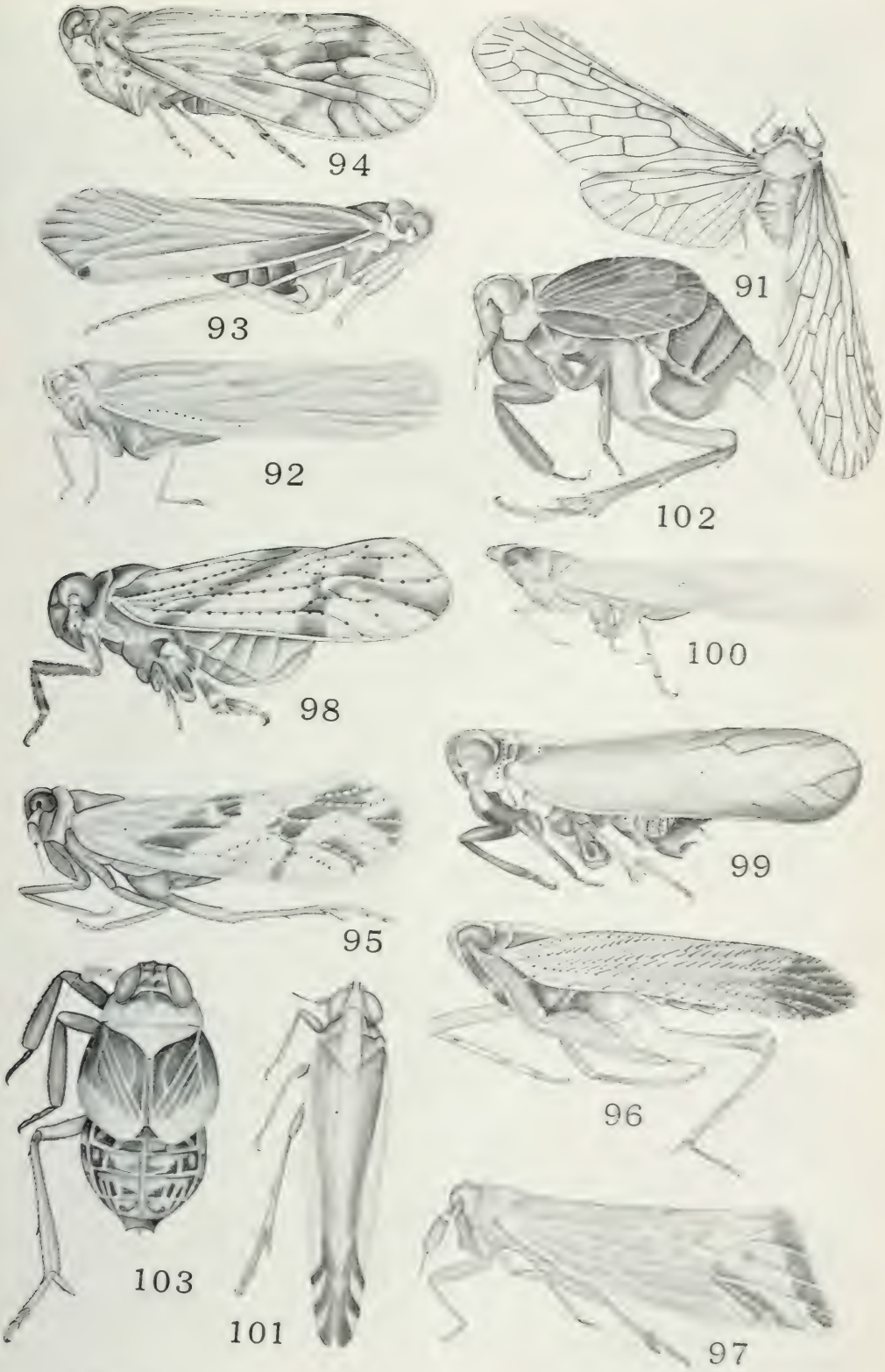

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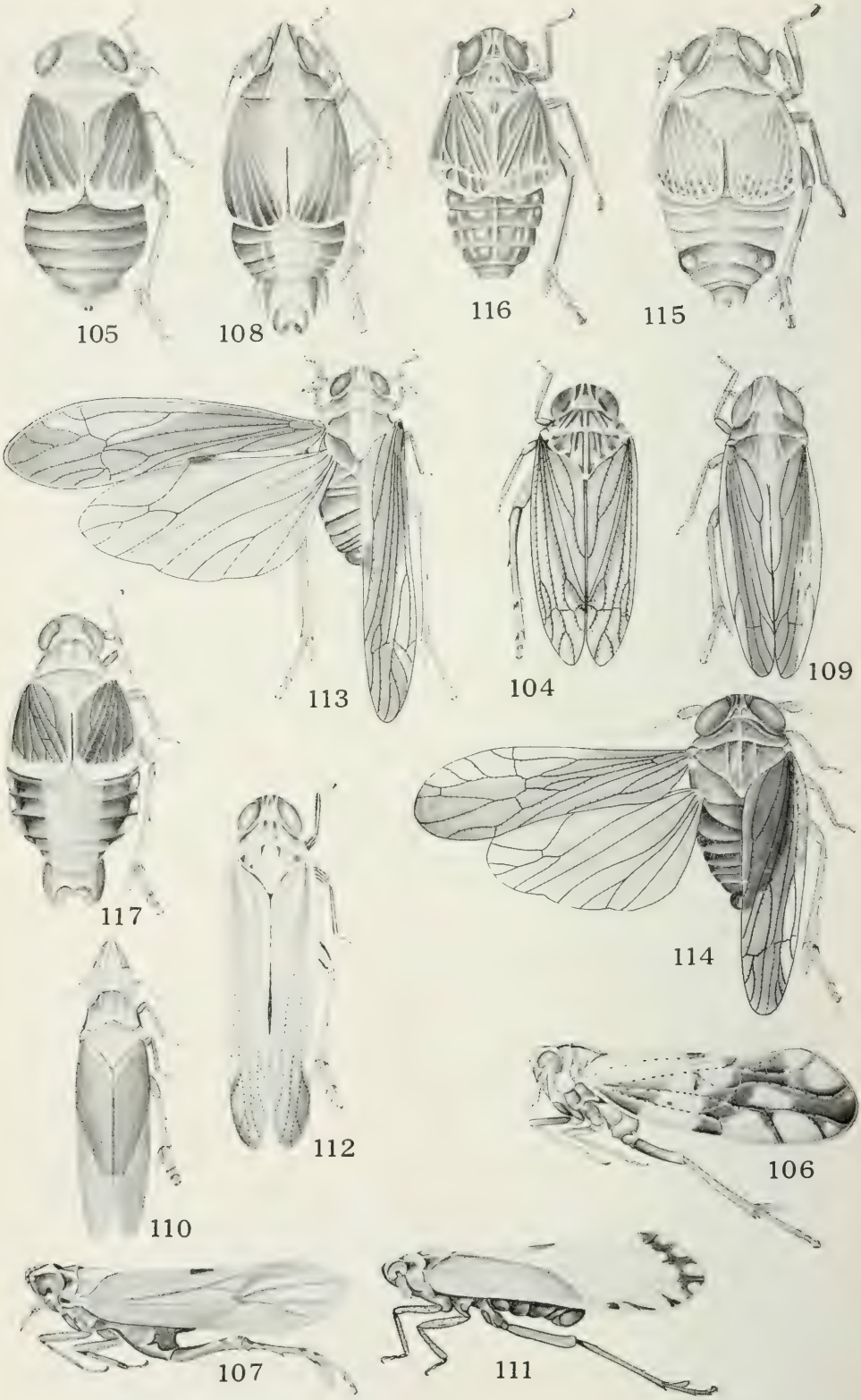

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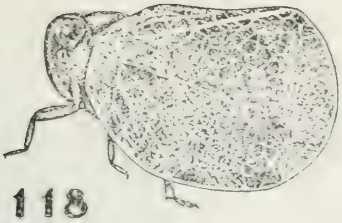

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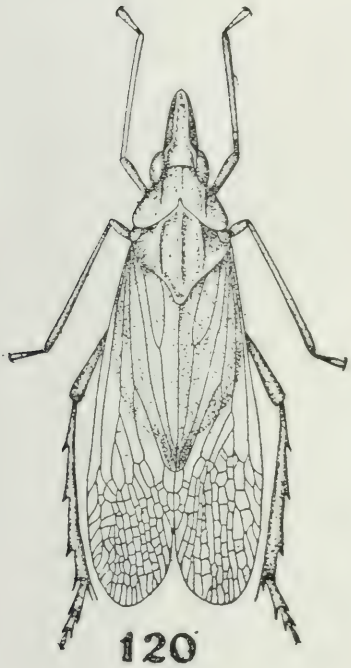

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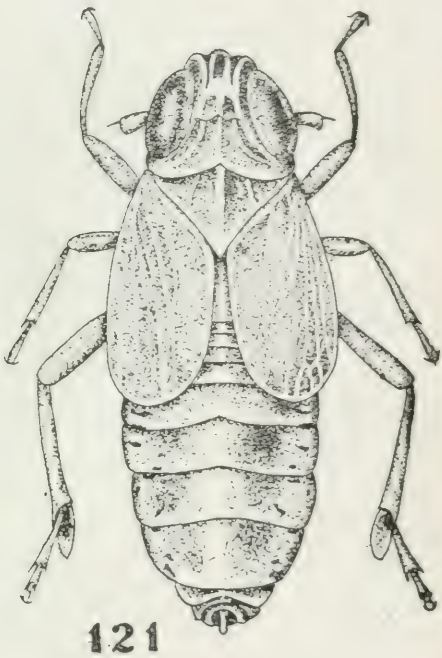

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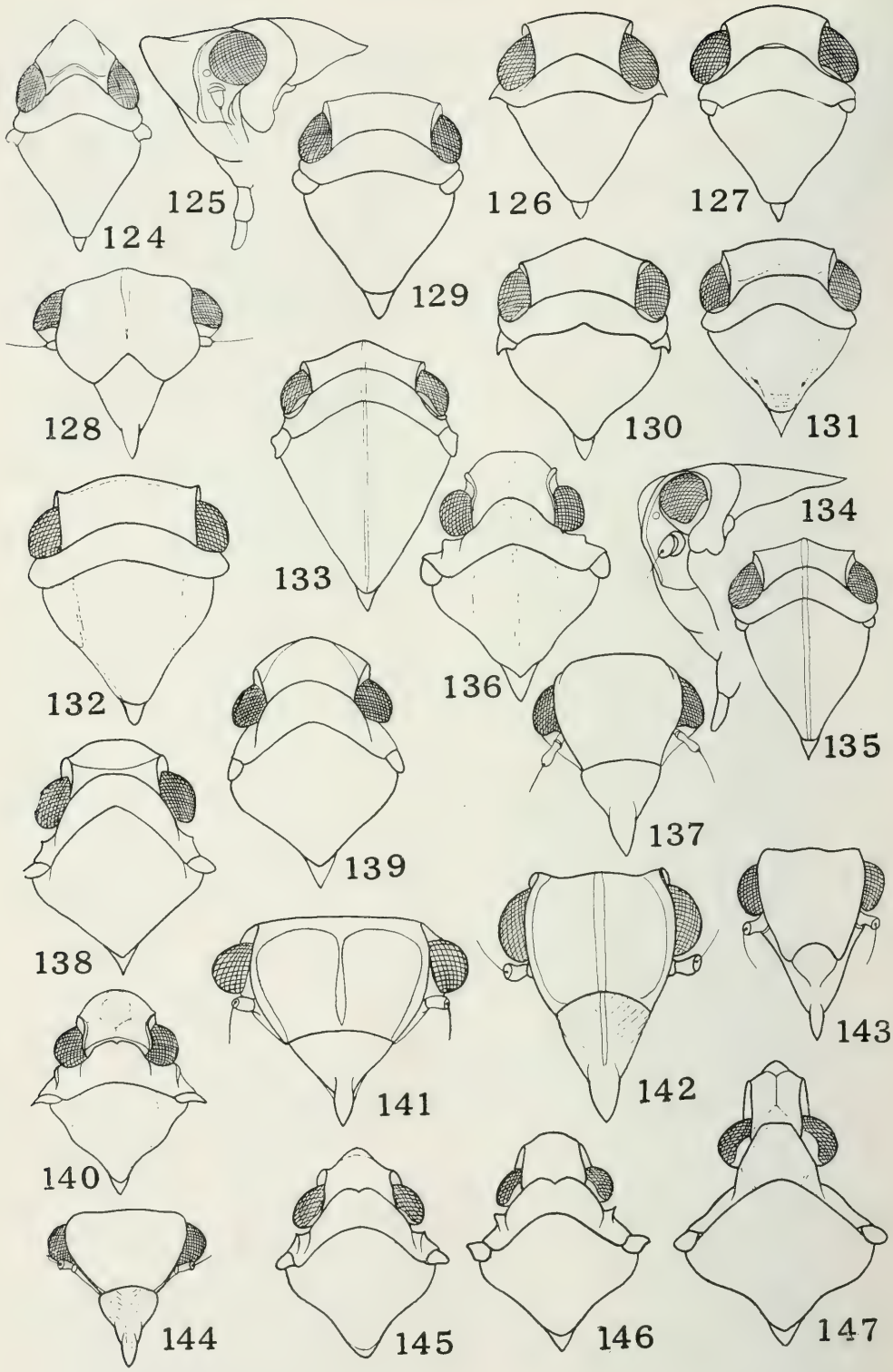

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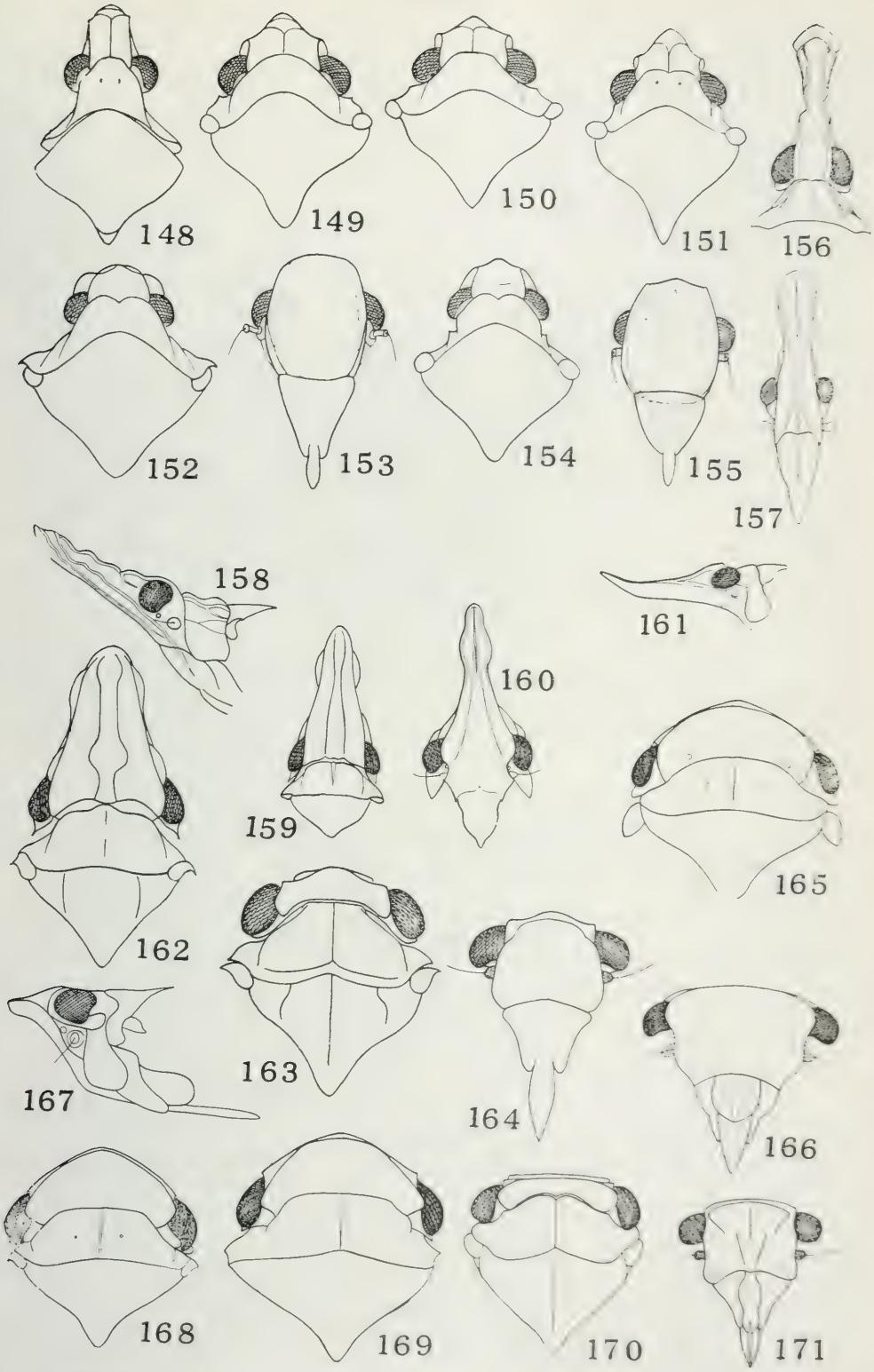

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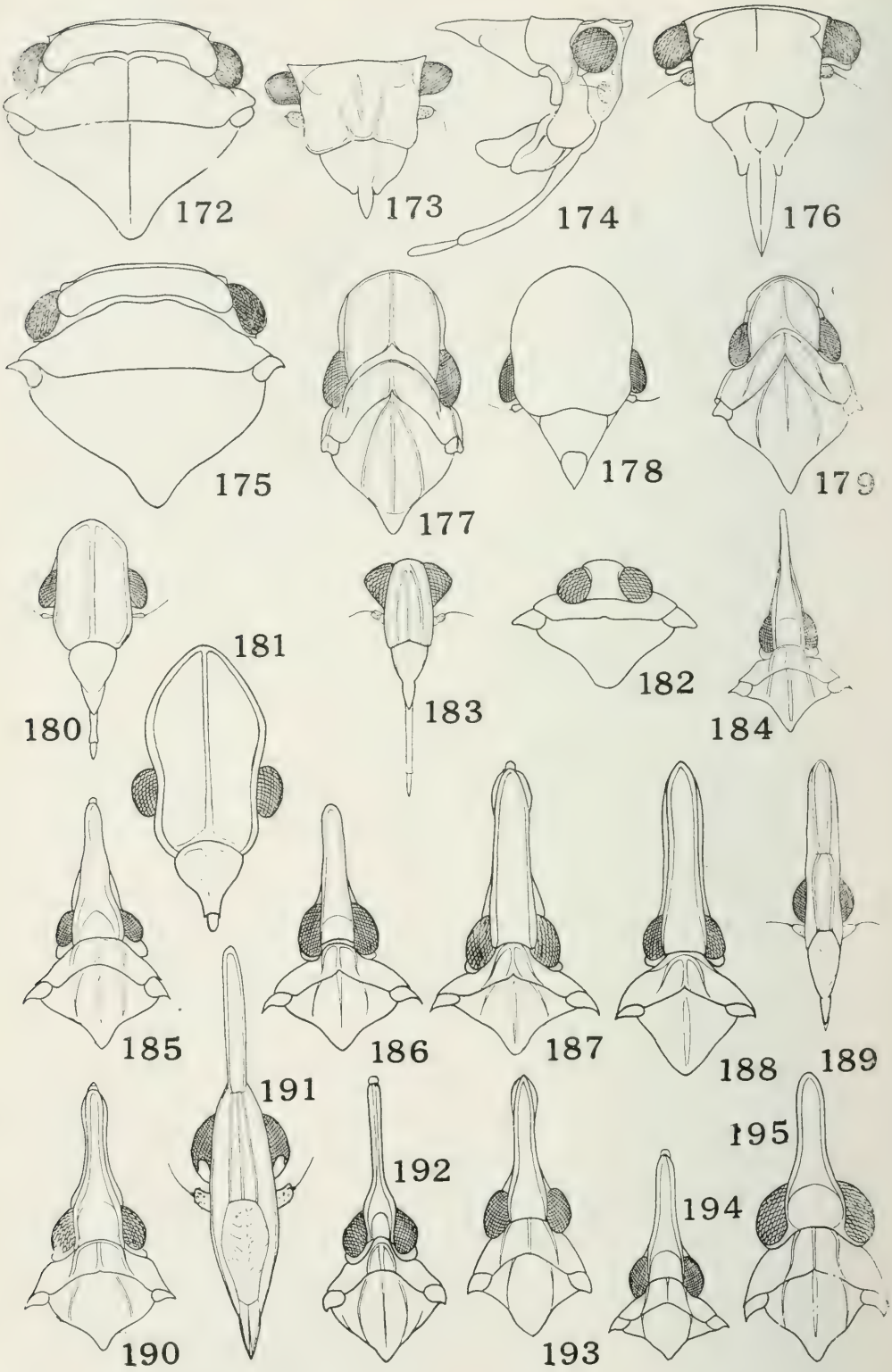

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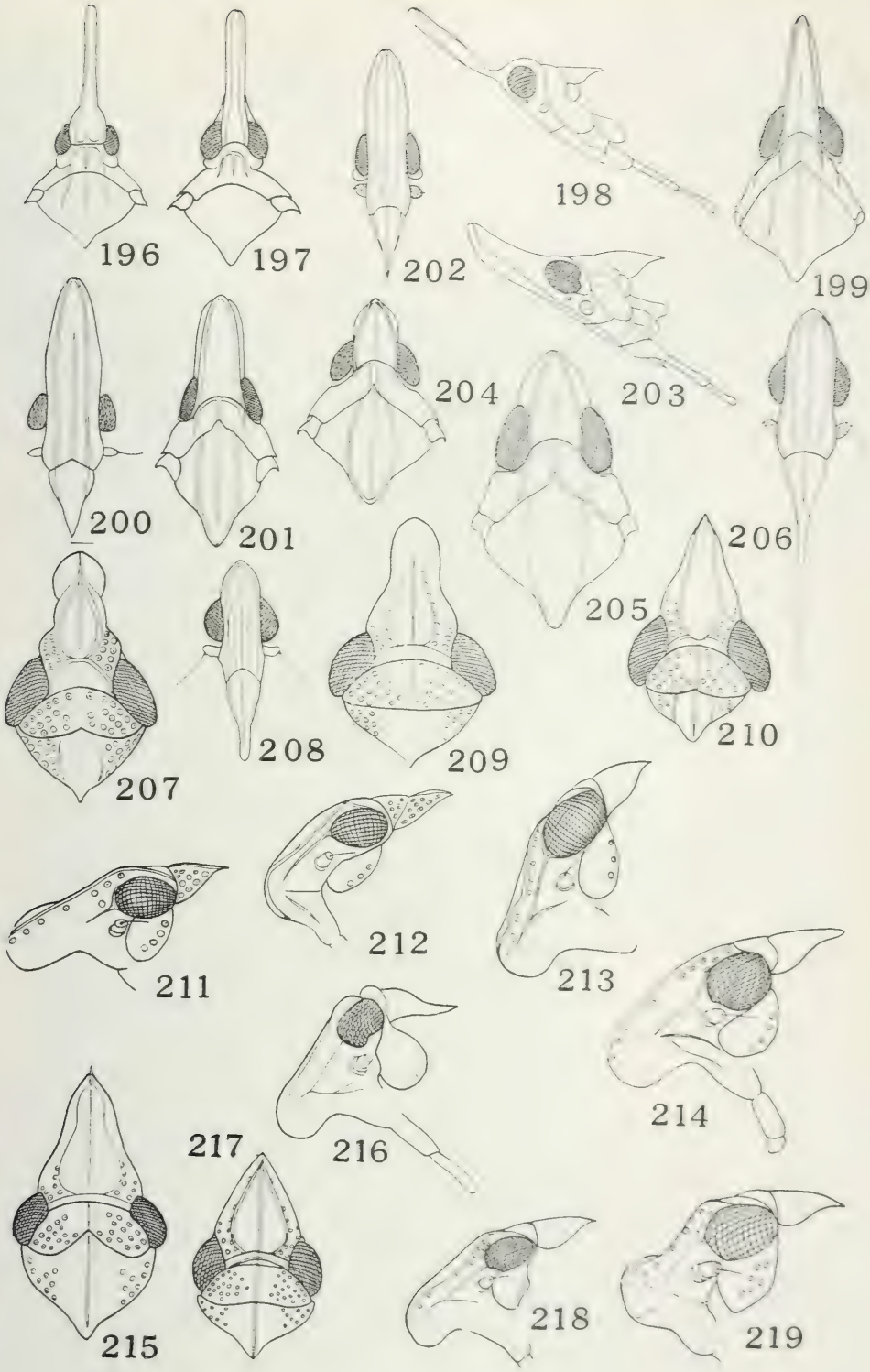

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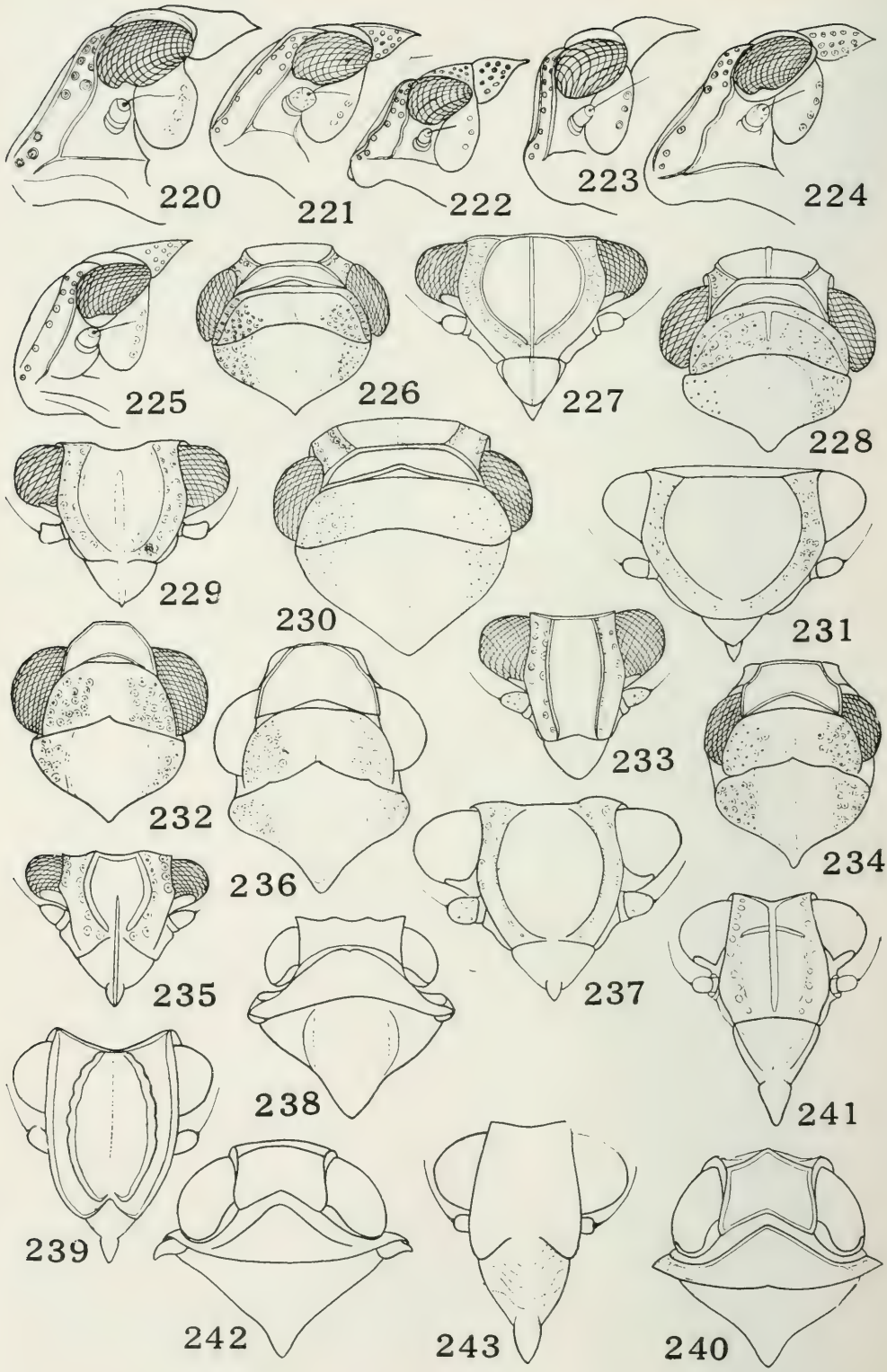

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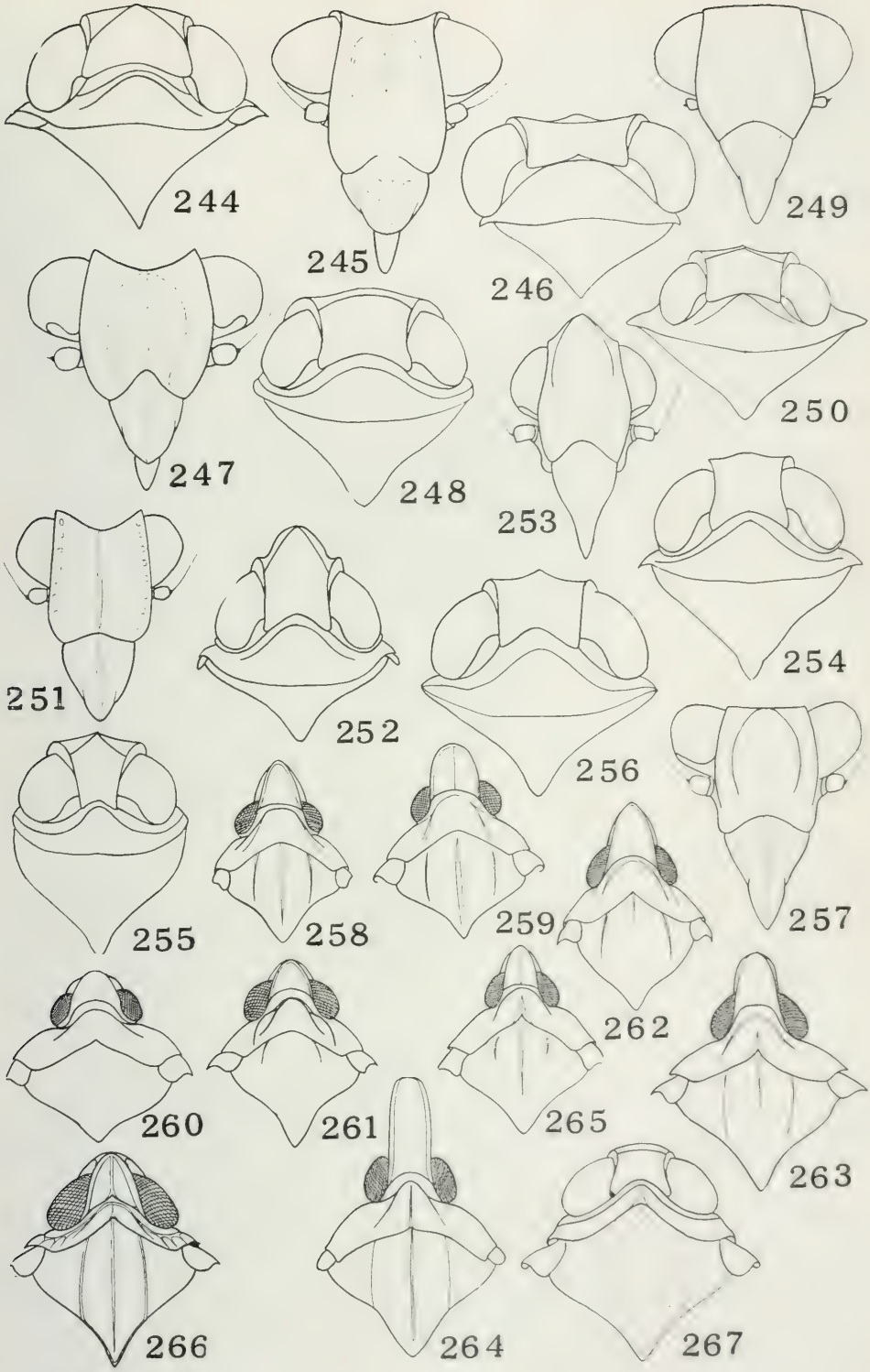

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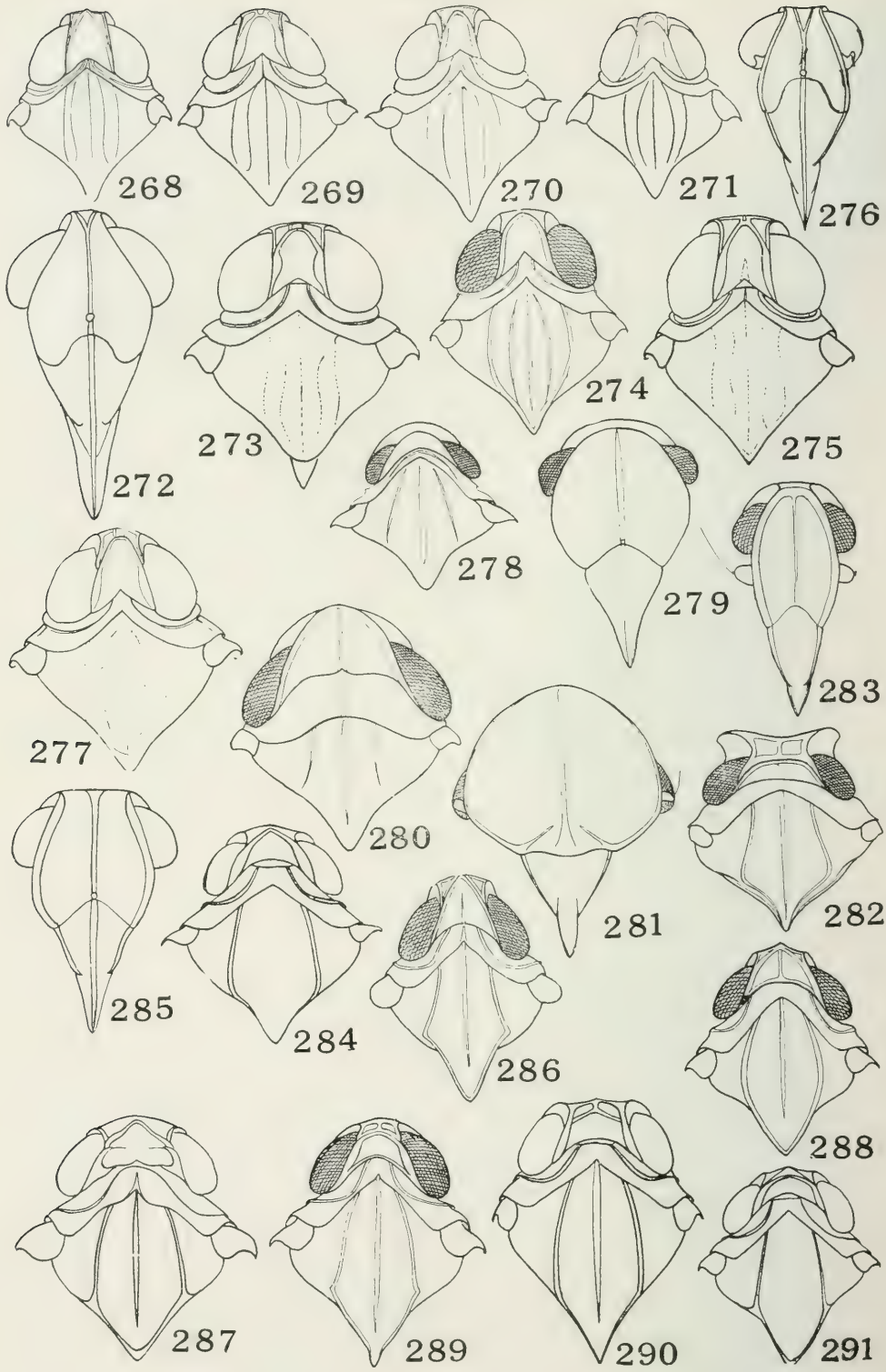

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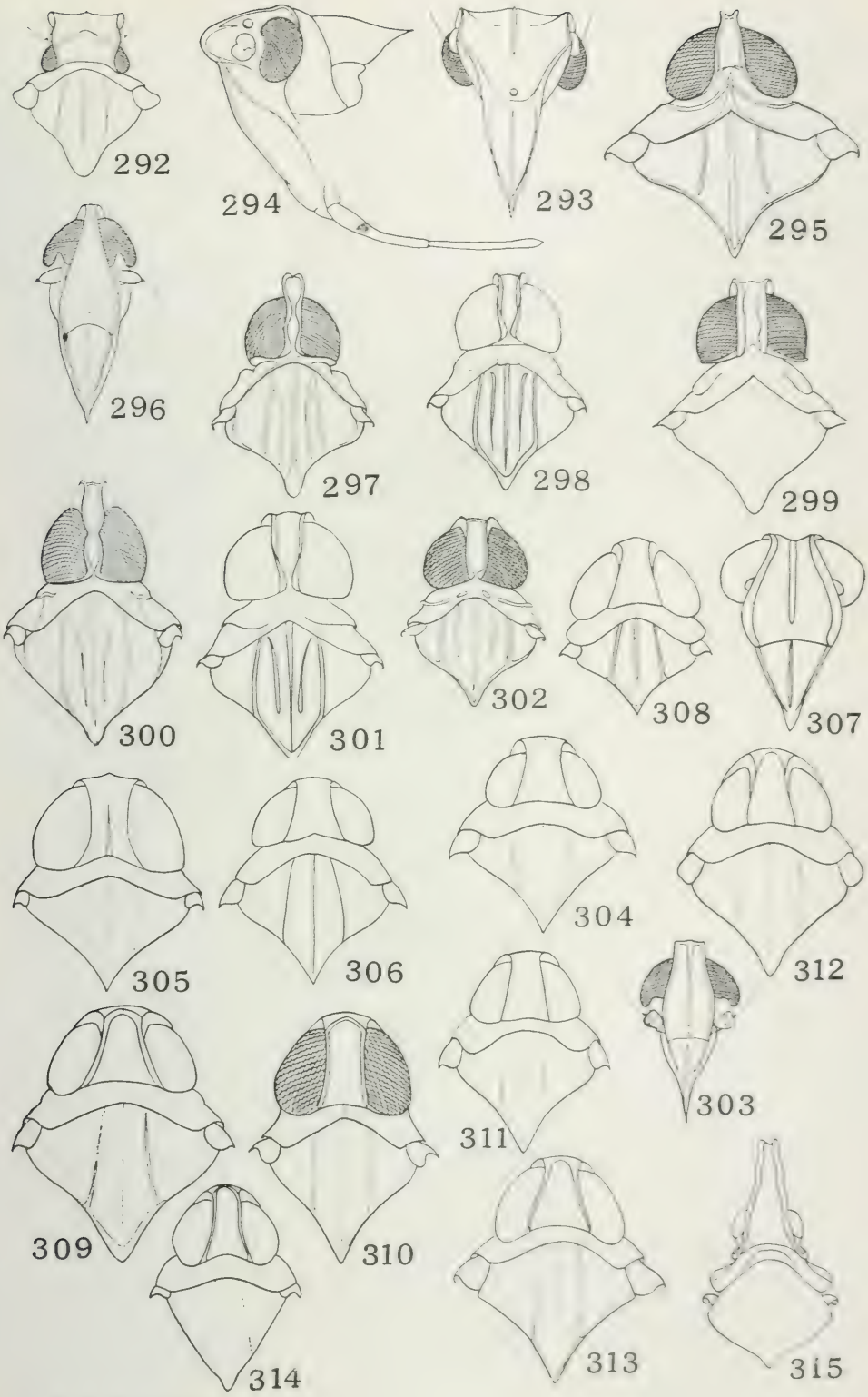

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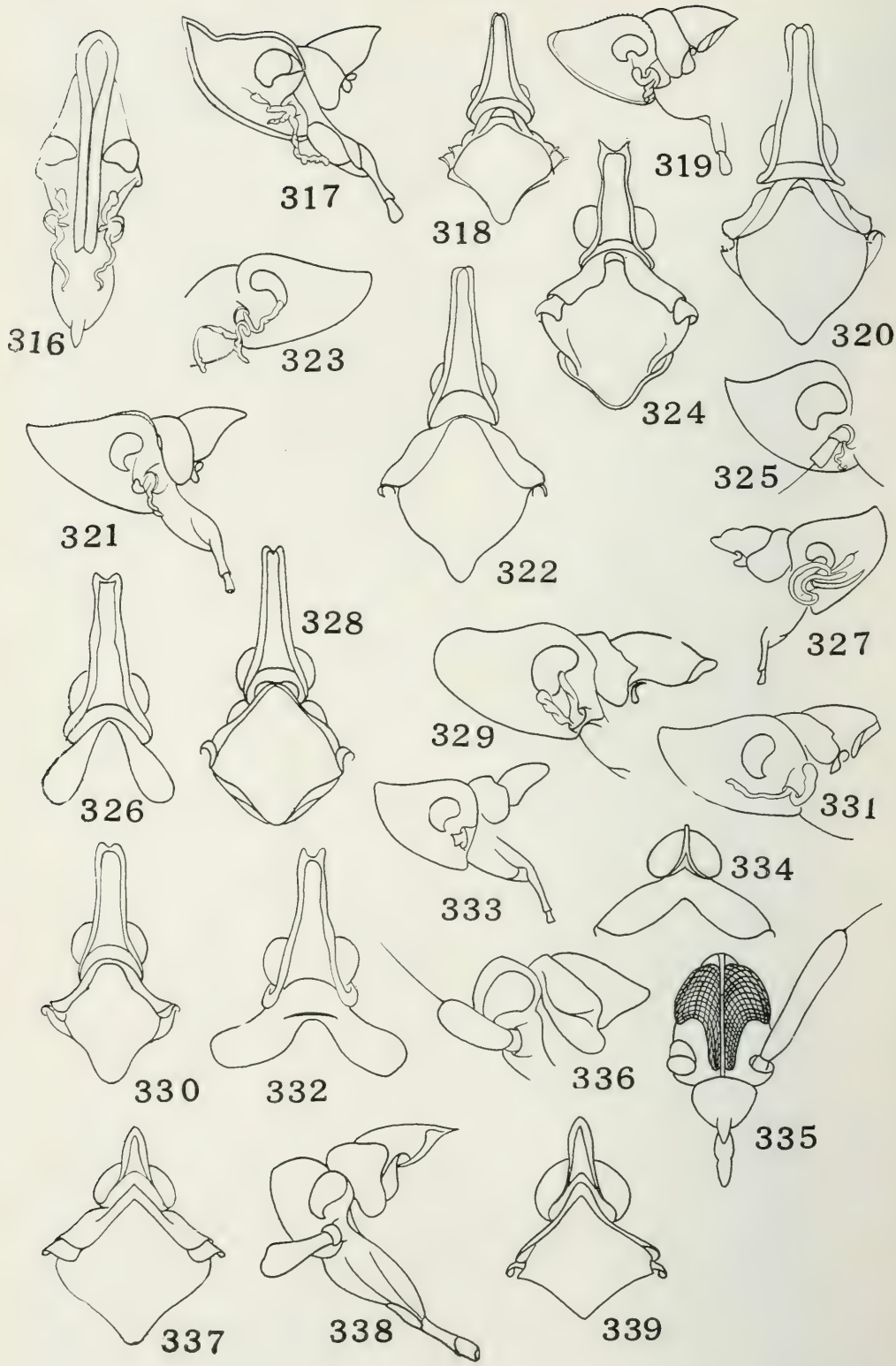

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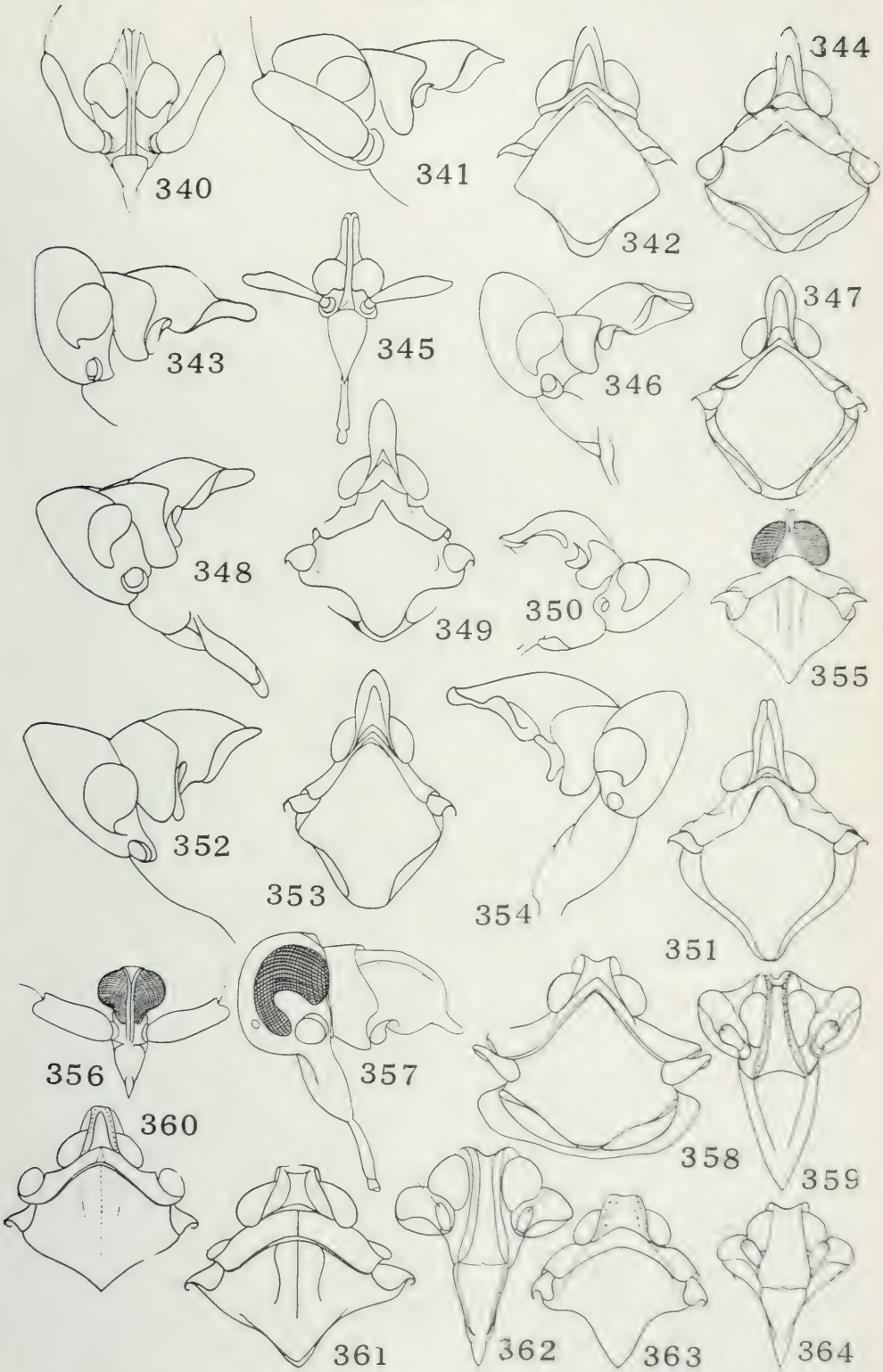

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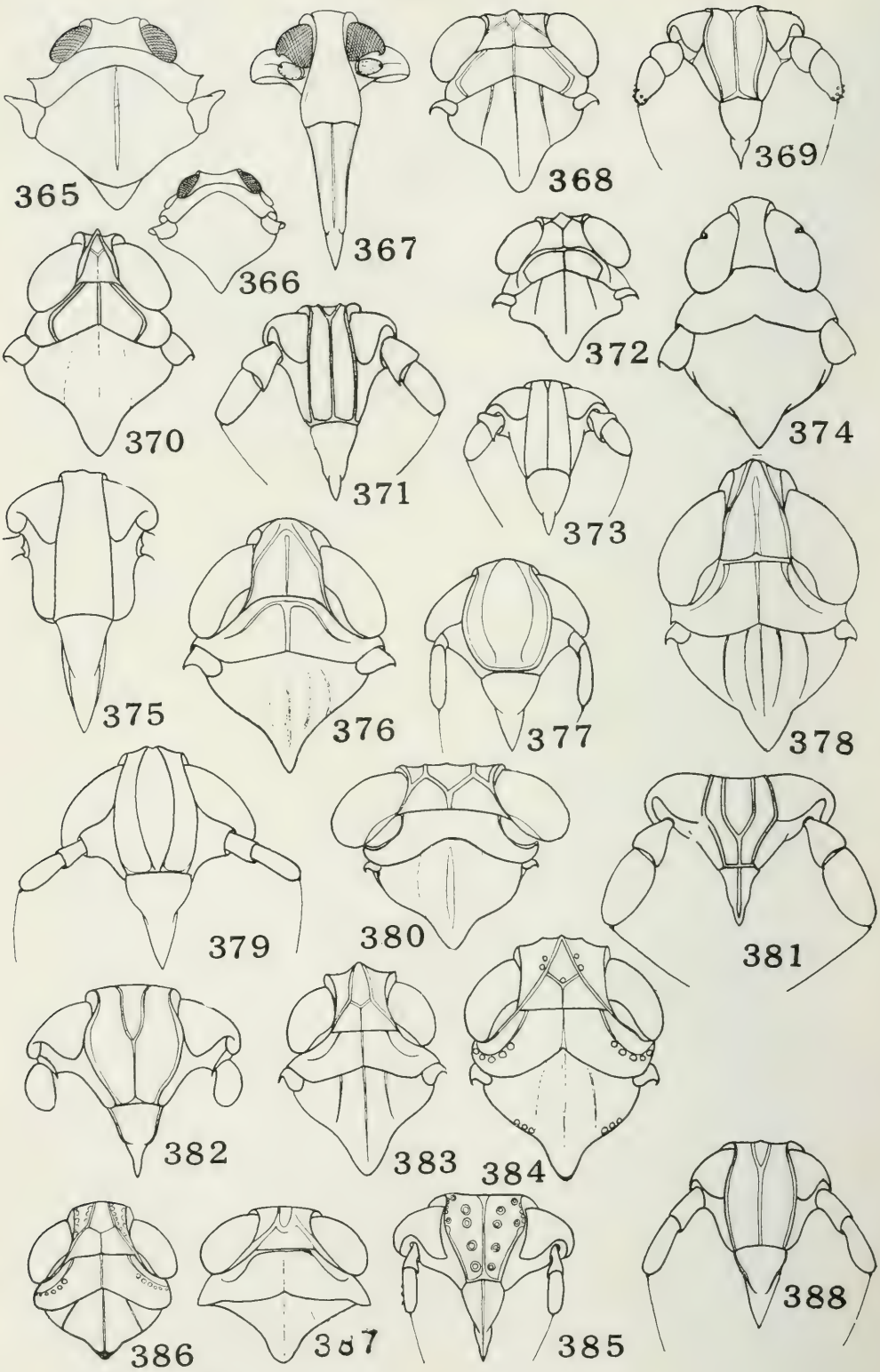
PLATE 58



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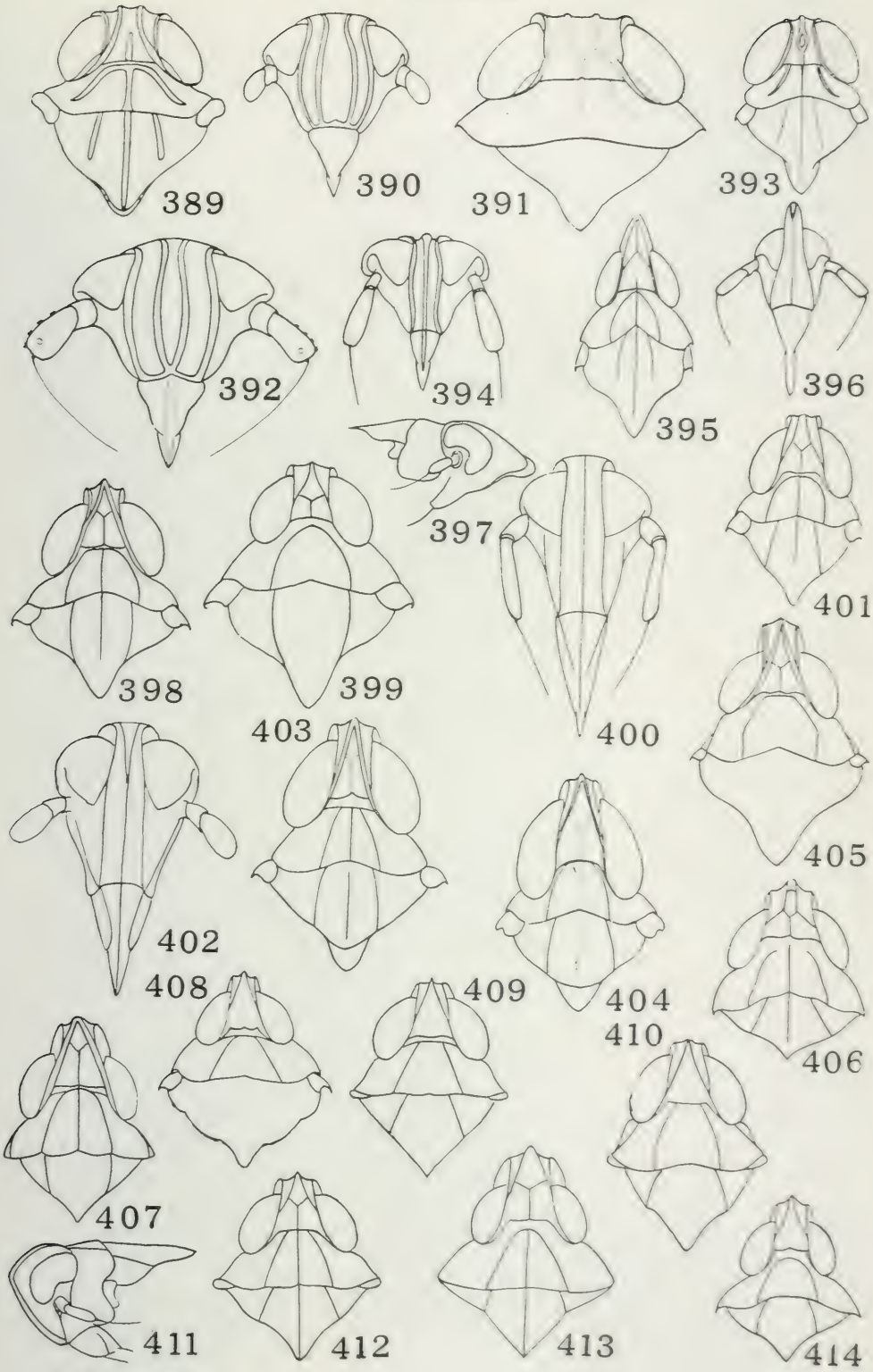

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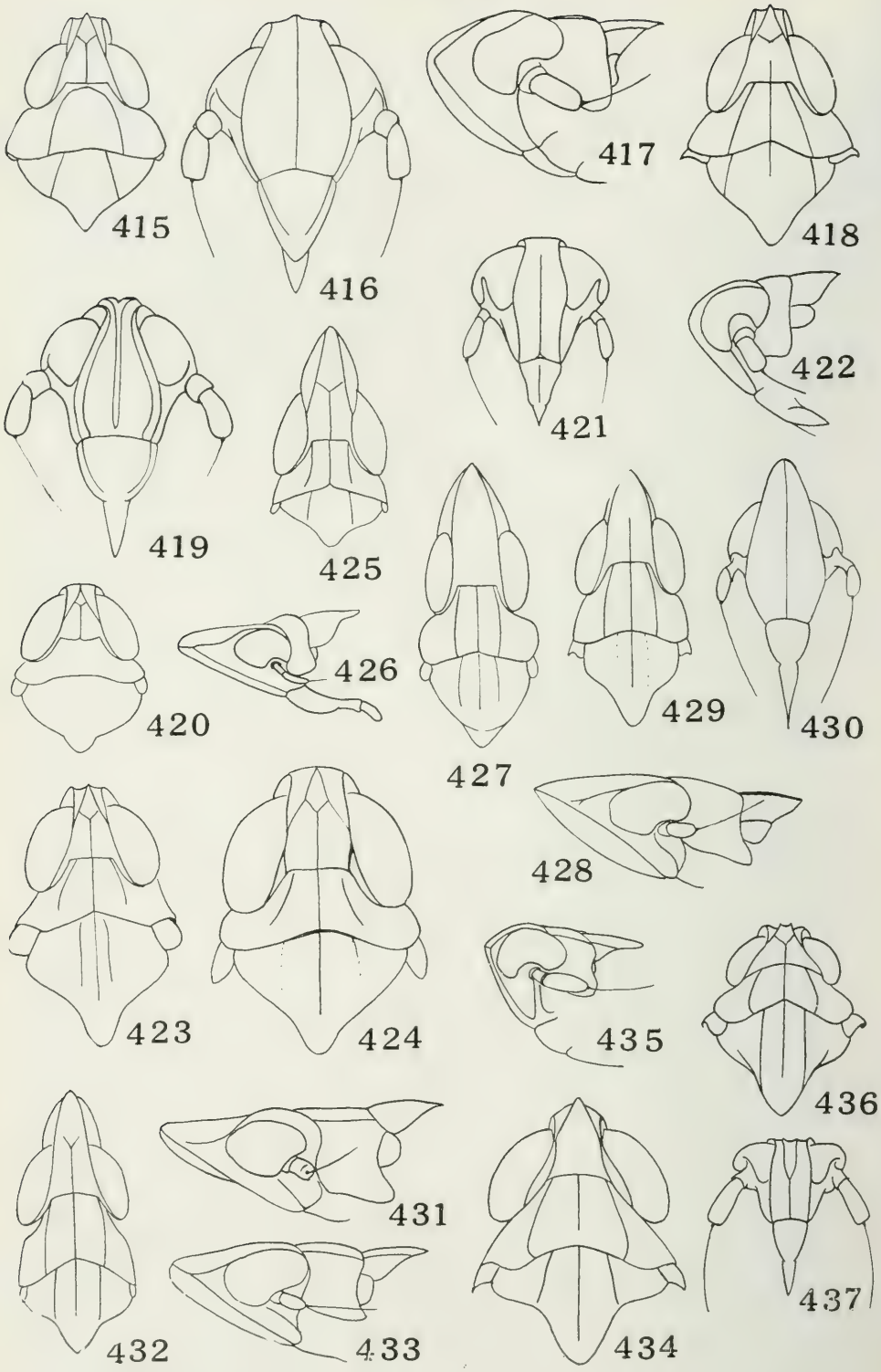

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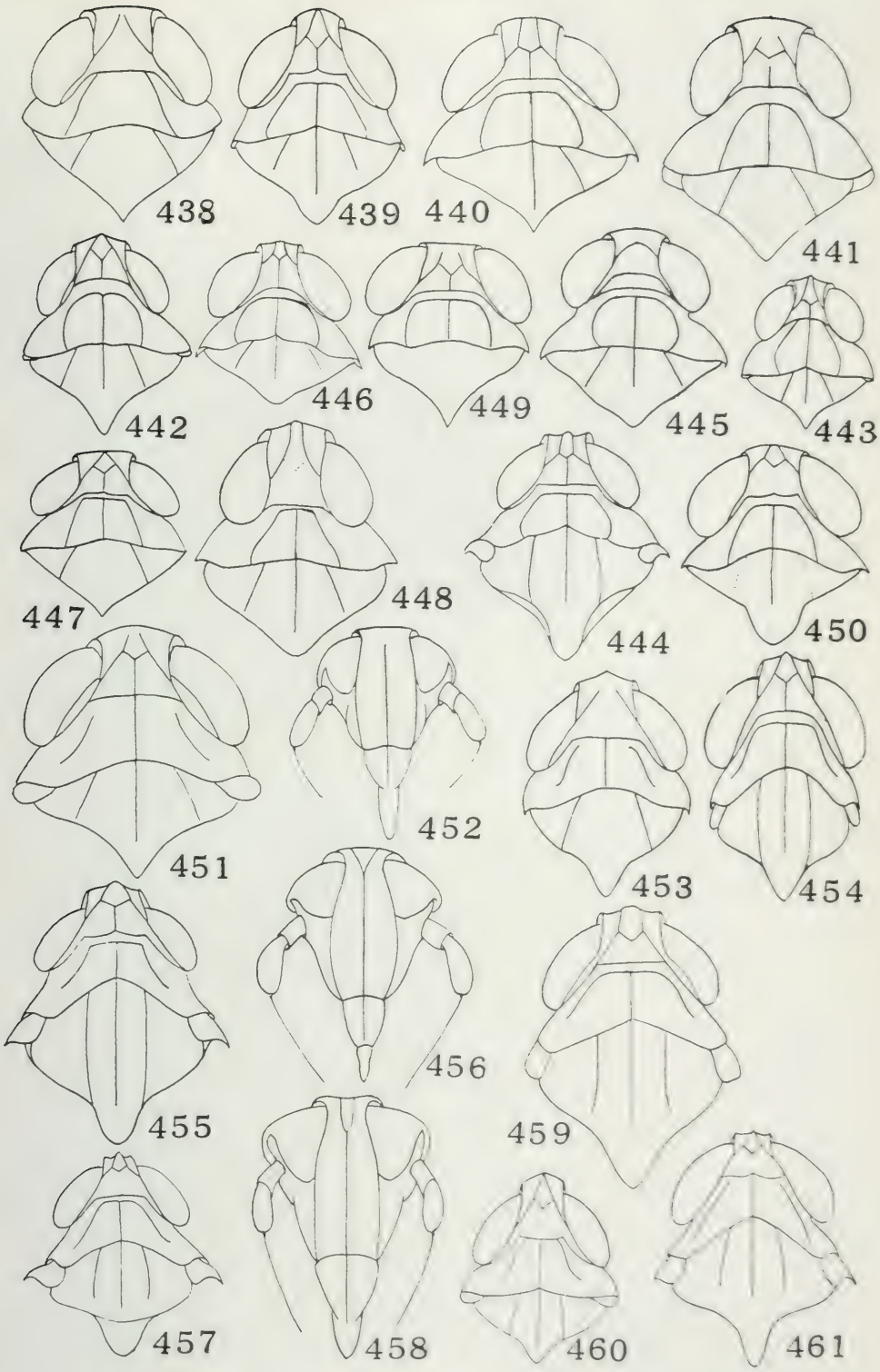

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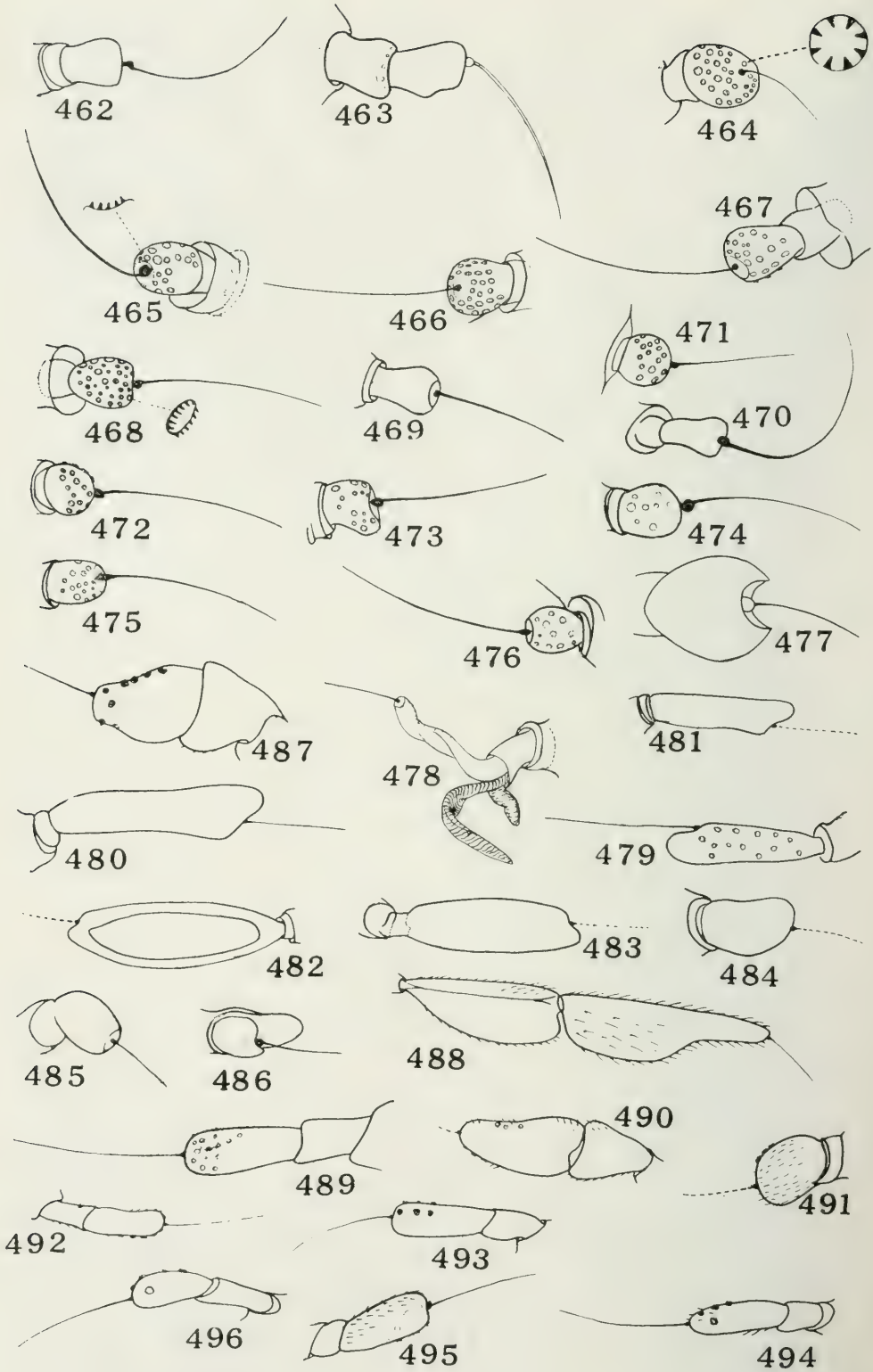

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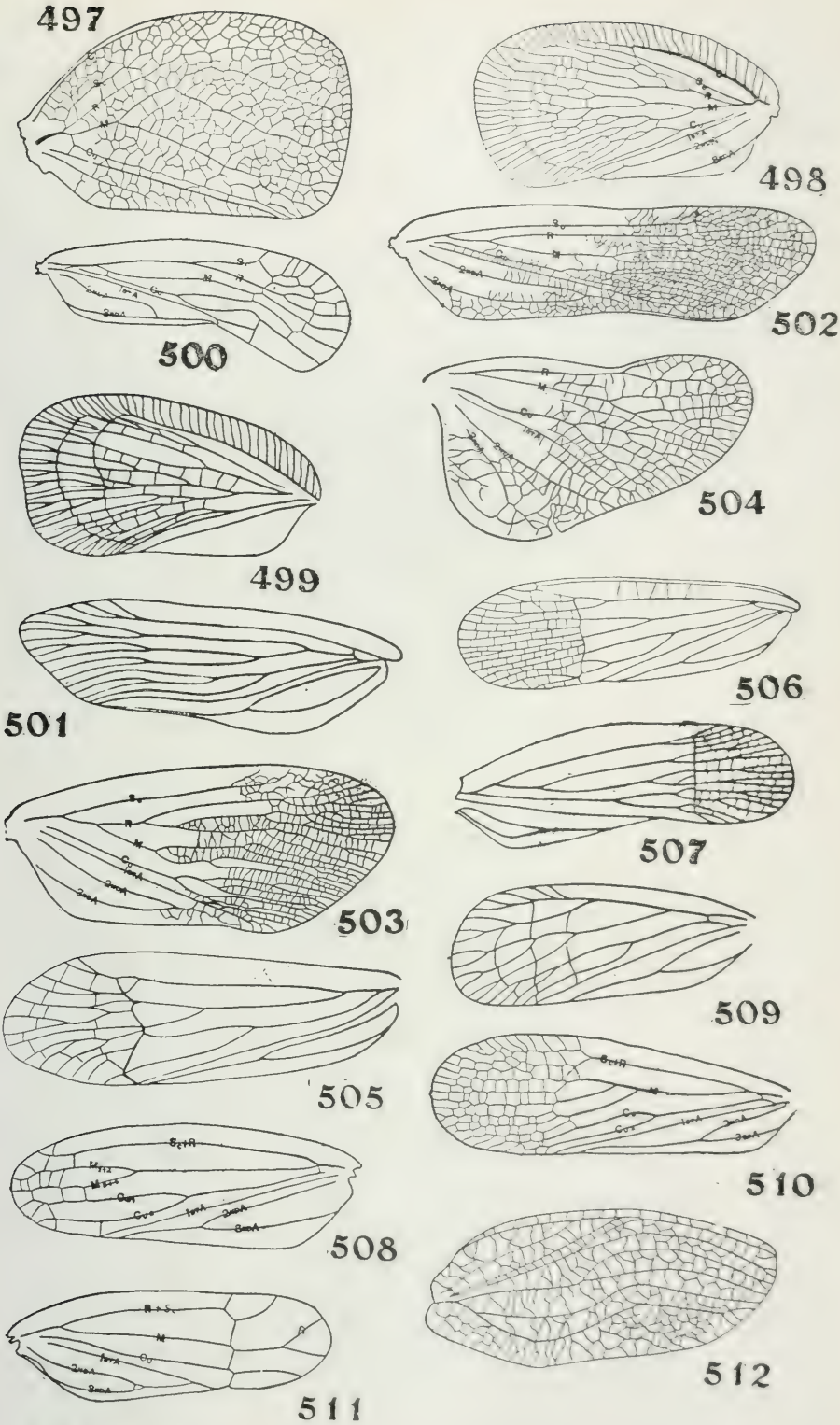

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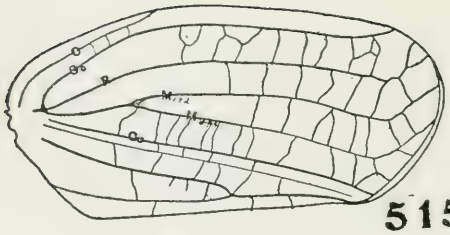

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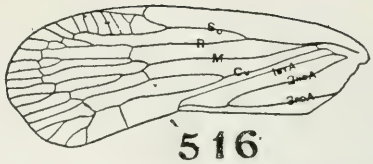

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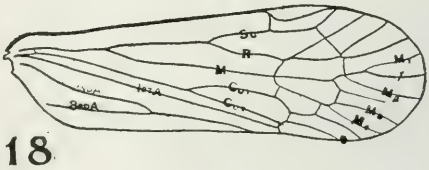

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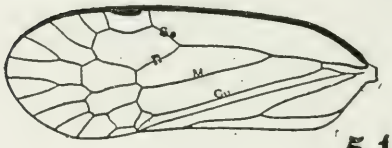

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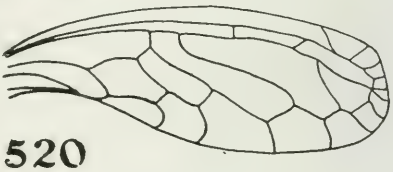

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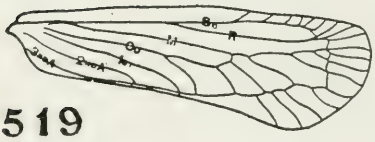

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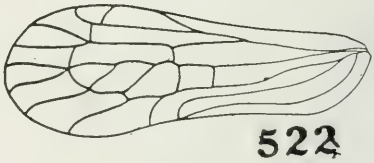

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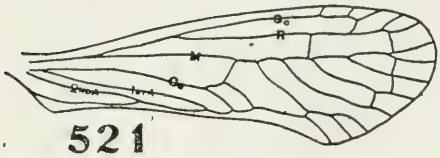

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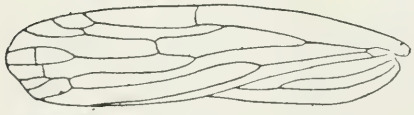

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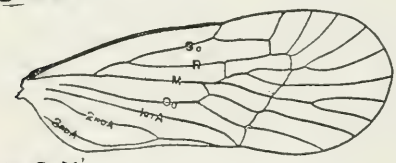

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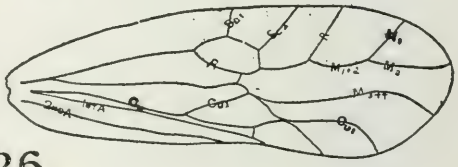

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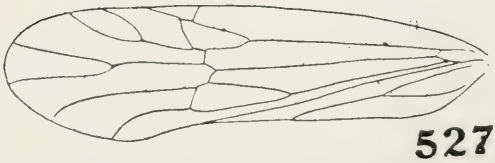

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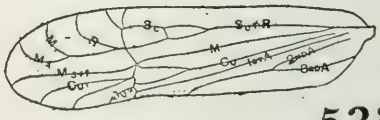

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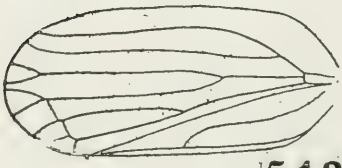

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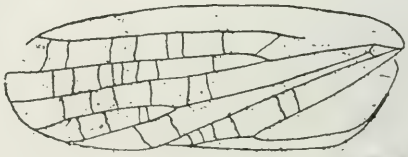

514

Z. P. Metcalf del.

PLATE 65

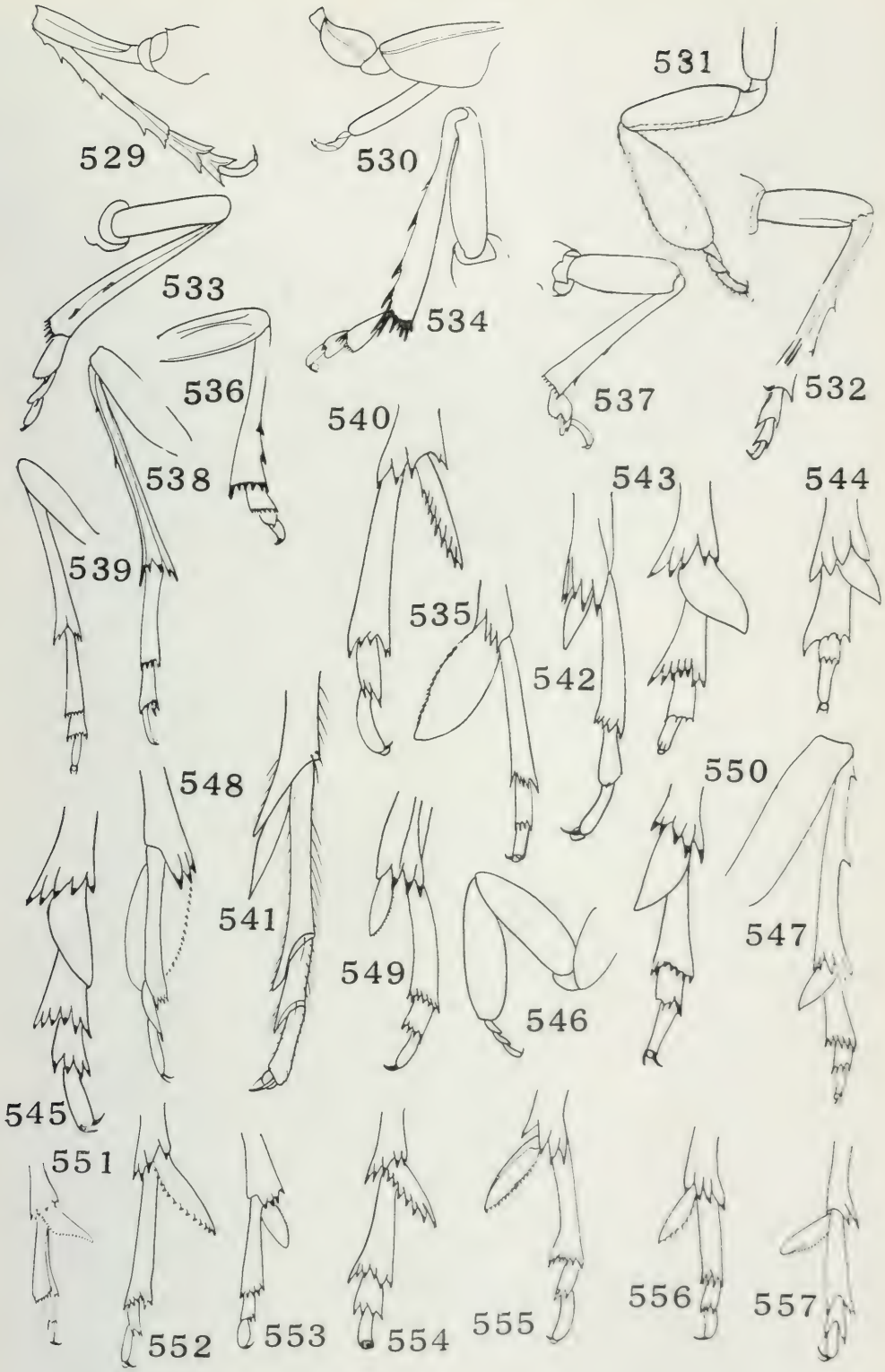

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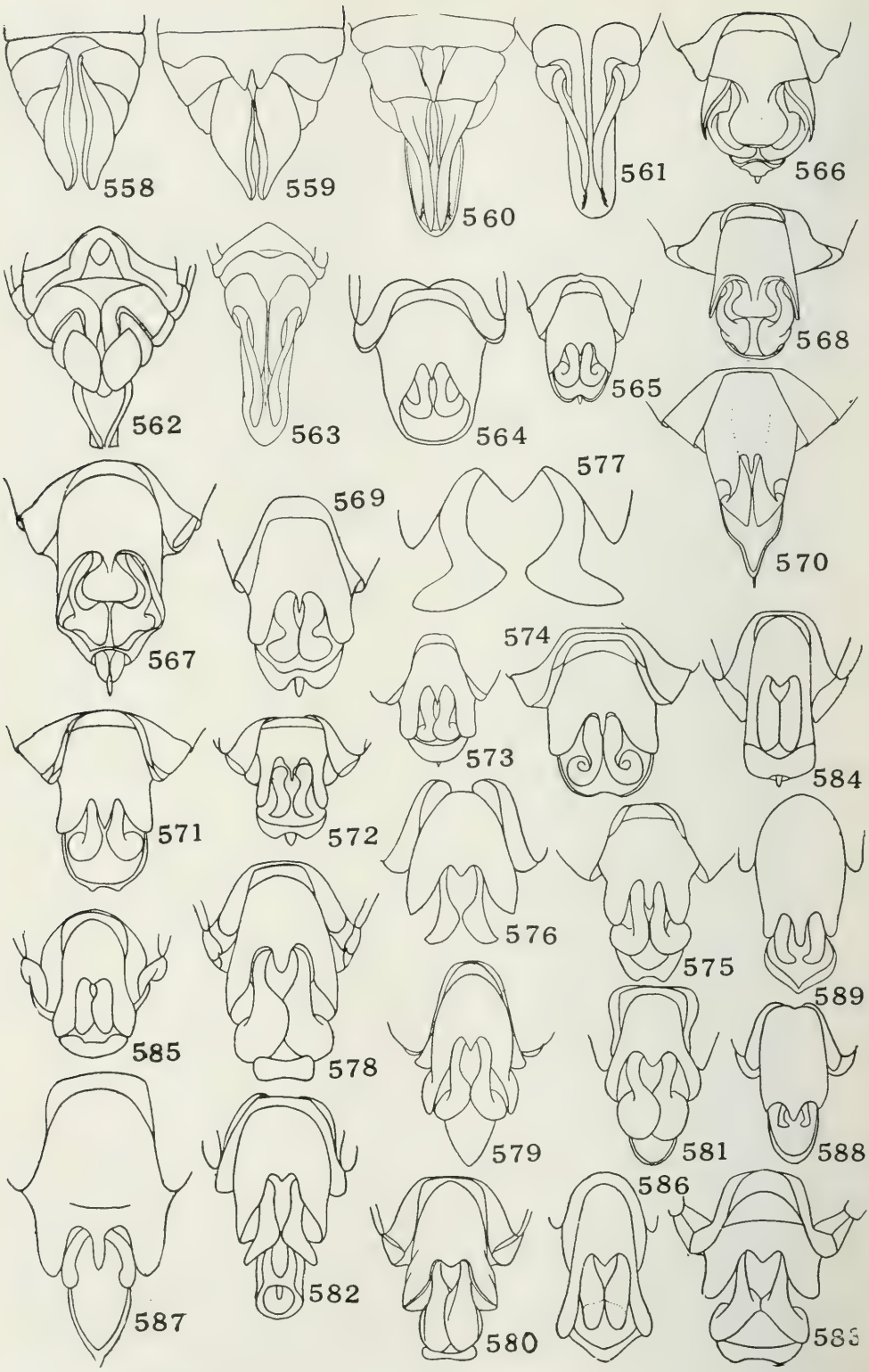
PLATE 66



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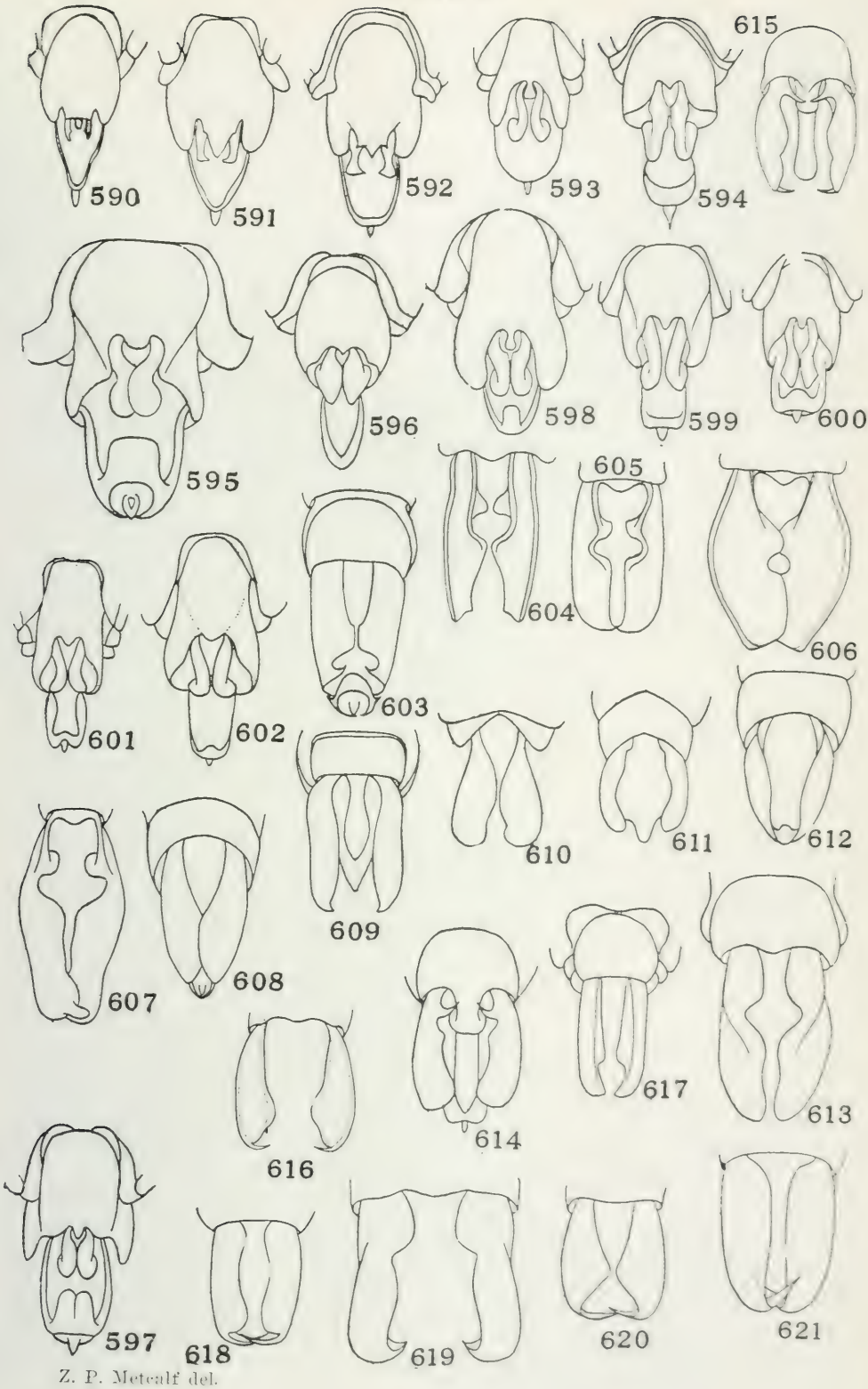

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PLATE 68

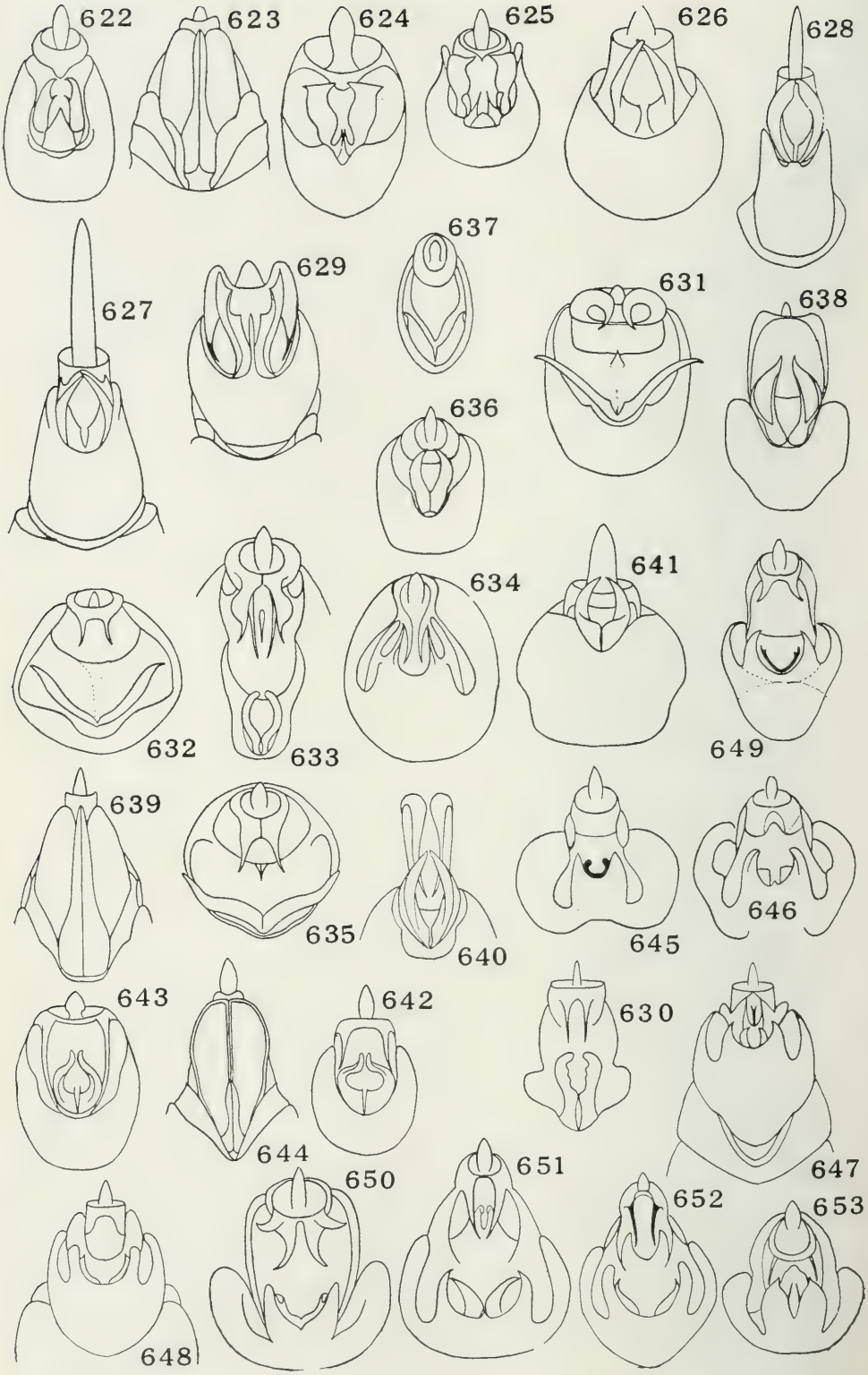

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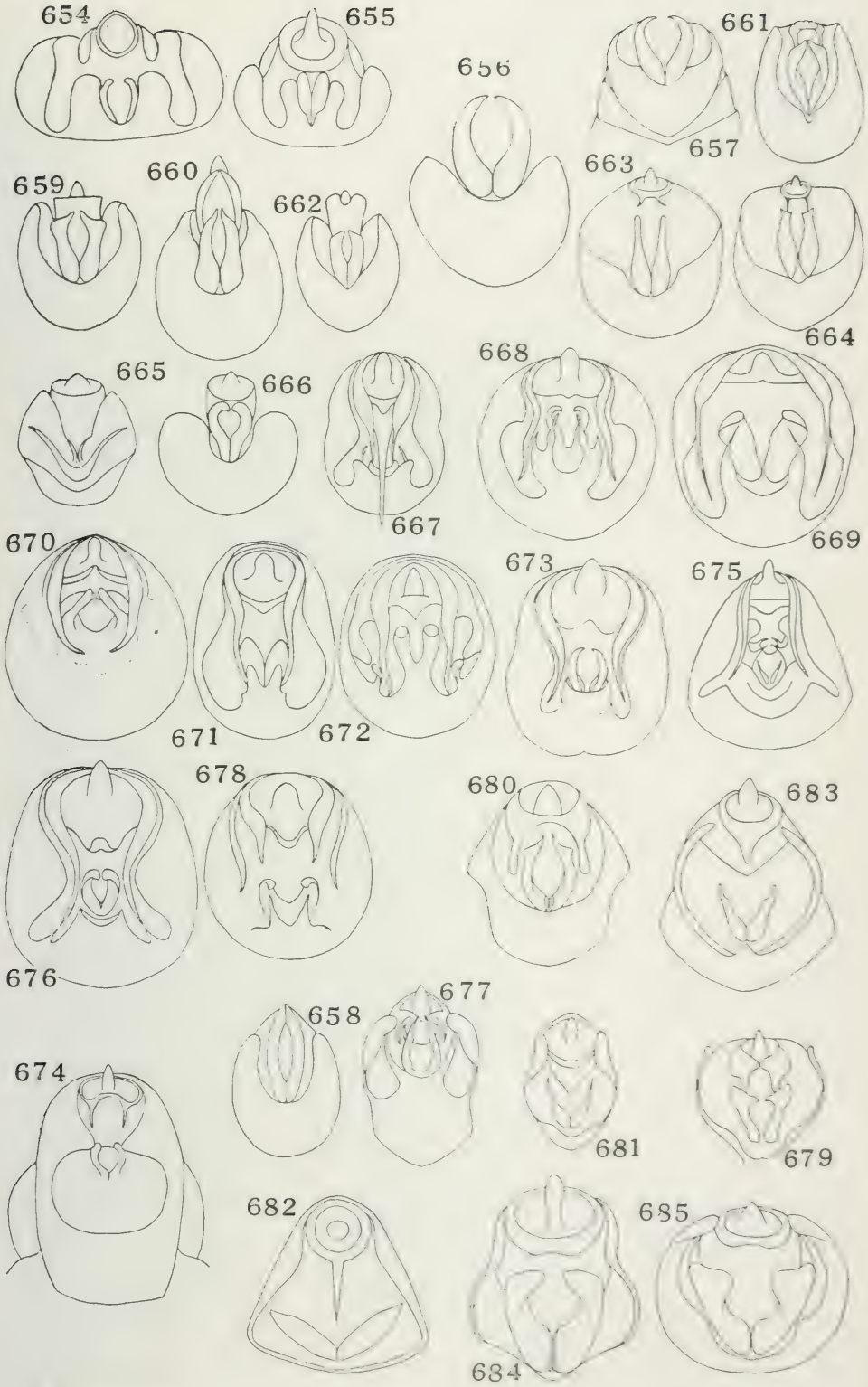
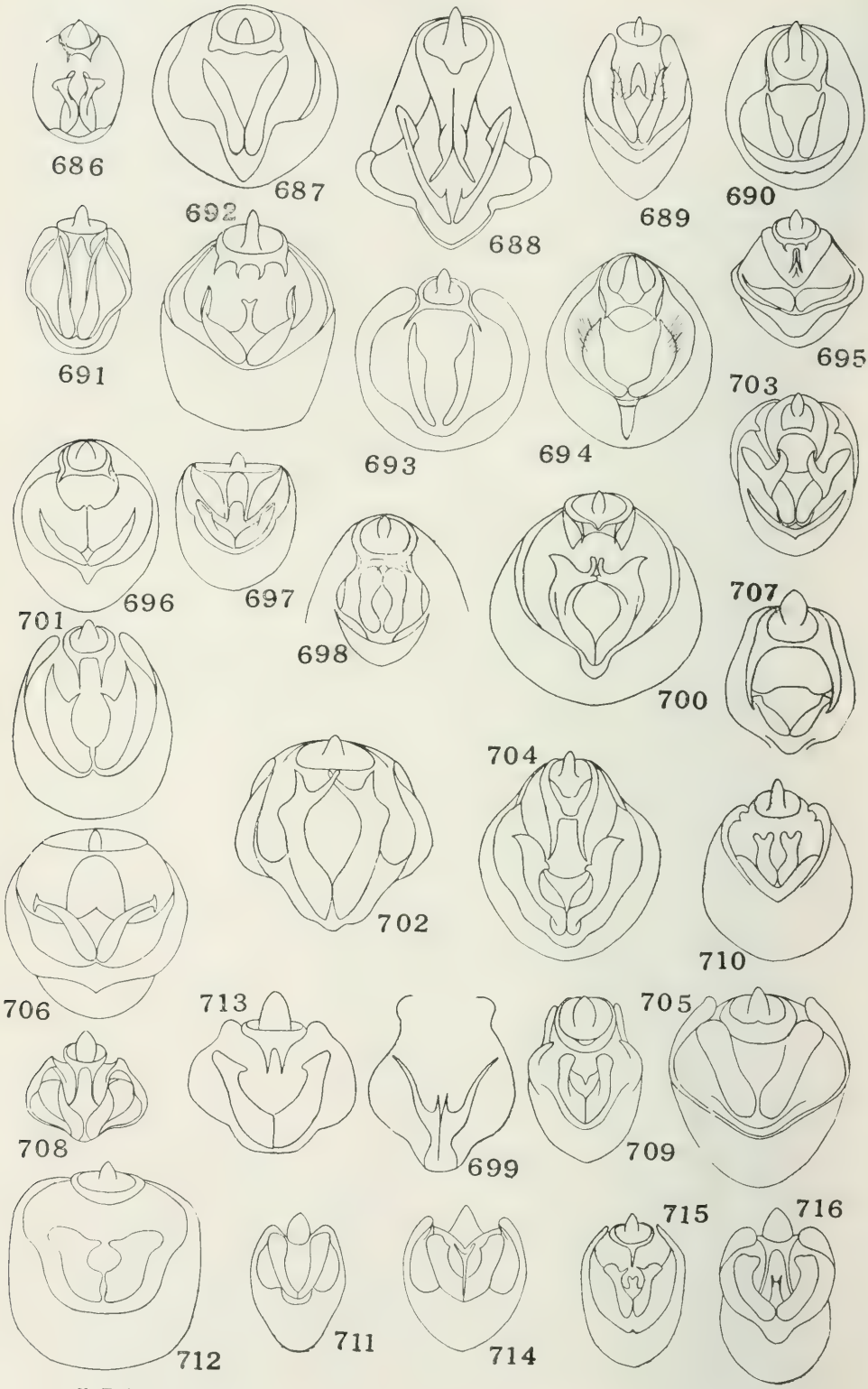
PLATE 69



Z. P. Metcalf del.

PLATE 79



Z. P. Metcalf del.

THE GASTEROMYCETES OF NORTH CAROLINA

By W. C. Coker and J. N. Couch

The Gasteromycetes include a large and varied order of fungi that are characterized by having the hymenium or spore-bearing surface enclosed within a protective coat or coats (volva or peridium) until the spores are ripe, when they are liberated in a powder or slime by the rupture or decay of the coat.* Included in the order are many well known plants that attract the attention by their interesting characters. Such are the puff-balls, earth stars, bird's-nest fungi and stinkhorns. A number are of subterranean growth and never become exposed; others are found just below the surface but become visible on expanding at maturity, others again are quite superficial and visible in youth. It is highly probable that many subterranean species will be unearthed in this state as soon as a careful search is made for them. The edible truffle which grows underground is not a member of this group, but an Ascomycete. The puff-balls when white inside (before the spores begin to ripen) are among the best of edible fungi.

In preparing this paper we have been assisted by other members of the botanical staff. All written matter and nearly all the photographs are by the senior author, and all microscopical preparations used have been carefully examined and compared by him with the drawings made from them. Most of the drawings (which will appear in the following issue of the Journal) have been made by Mr. Couch and inked in by Miss Alma Holland. Some microscopic work done by Mr. Curtis Vogler, a former instructor in this laboratory, has also been utilized. Mr. H. R. Totten has developed and printed most of the photographs. Mr. H. C. Beardslee has been so kind as to send us material from Asheville, which has enabled us to include two species that we had not found. All photographs are natural size unless otherwise stated.

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* In the peculiar genus *Gautieria* there is in most species no peridium at maturity, the chambers of the gleba opening directly on the surface. It is a small tuberous plant growing hidden in humus or earth, and therefore rarely found. It has been reported in this country from New York, California and Idaho and is to be expected in our state. See Zeller and Dodge, Ann. Mo. Bot. Gard. **5**: 113. 1918; Zeller, Mycologia **14**: 196. 1922; Atkinson, Bot. Gaz. **5**: 538. 1912; and Fitzpatrick, l. c., p. 135.

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KEY TO THE FAMILIES

Plants emerging at maturity from a soft volva or "egg;" the spores borne in a slimy, brown, bad-smelling liquid at the top of a stalk or net or several columns ..... *Phalloideæ*

Not as above

Plants with a distinct firm or gelatinous stalk which carries the spore-bearing sac, the latter in our representatives having a distinct apical mouth through which the spores escape as a dry powder.

Stalk firm and fibrous; mouth not red..... *Tylostomaceæ*

Stalk gelatinous; mouth red..... *Calostomaceæ*

Plants without a distinct, terete or gelatinous stalk; if a stalk is present it is thick and expands gradually into the swollen spore-bearing part above.

Plants small, shaped like cups or tumblers or subspherical, at maturity opening in most of the species over the entire top by the collapse of a veil (or rarely by the crumbling of the peridium) to expose a number of small peridioles with hard coats which contain the spores, the whole looking like a little nest containing eggs. In one genus of minute plants an outer peridium opens and an inner peridium evaginates itself with a snap and throws out for some distance a single, minute, black peridiole..... *Nidulariaceæ*

Not as above

Peridium without a distinct outer layer that falls away or splits; at maturity opening at the top by irregular lobes, or by an irregular tear, or by crumbling or rotting away. Elongated threads (capillitium) not present among the spores.

Gleba not formed of hollow chambers, but of sterile plates cutting out irregular blocks which are stuffed with the fertile tissue; at maturity crumbling into a dusty powder..... *Sclerodermataceæ*

Gleba formed of hollow chambers (at least when young) which are lined with the hymenium.

Peridium rotting away after maturity, the gleba (at least in species we are treating) turning into a slimy mass..... *Hymenogastraceæ*

Peridium crumbling away after maturity, the glebal chambers remaining intact and falling apart as fine sand-like particles.....Genus *Arachnion*

Peridium with a distinct outer coat which falls away in flakes or wears away by degrees at maturity, or dehisces equatorially, or (in *Geaster* and *Astræus*) splits into star-like rays to expose the thin, pliable or (in *Calvatia*) fragile and brittle inner peridium; gleba (except in *Astreæus* and *Disciseda*) composed of small, hollow chambers lined with the hymenium; spores mixed with a true capillitium of long, slender, branched or unbranched threads, and escaping as dust through a definite (except in *Calvatia*) pore or slit. (In several small species of *Lycoperdon* the outer peridium is very thin, obscure and persistent, and in *Myriostoma* there are several pores) *Lycoperdaceæ*

FAMILY PHALLOIDEÆ

Plants consisting at first of a white, elastic, oval or subspherical "egg," which consists of three coats, the central one soft and gelatinous, which break at maturity to allow the elongation and exposure of the curious, spongy, and in some species brightly colored receptaculum of various shapes which bears above either on itself or on a specialized appendage the slimy, deliquescing gleba which contains the minute, smooth spores, and which in nearly all cases has a very strong and offensive odor by which insects are attracted to scatter the spores.*

The family is divided into two subfamilies or by some authors (as Corda) into two distinct families which are separated by the position of the gleba and by other important microscopical characters. These subfamilies may be simply defined as follows:

Gleba (and spore slime) borne on the inner side of the receptaculum.....*Clathreæ*

Gleba borne on the outer surface of the receptaculum.....*Phalleæ*

In addition to the genera treated by us there has been found of the true phalloids in the United States only *Anthurus borealis* (see Burt, l. c., 1849, and Lloyd, Myc. Notes No. 17: 183. 1904), which is placed in *Lysurus* by Lloyd, and an undetermined species of *Lysurus* from Texas (Lloyd, Phalloids, p. 40; Gerard, l. c., p. 30). The unique genus *Phallogaster,* placed by Morgan, its author (l. c., **15**: 171, pl. 11. 1892), and by Thaxter (Bot. Gaz. 18: 117, pl. 19. 1893) in the *Phalloideæ*, but differing from them in the absence of a volva and in

* Drawings of spores in species of this family will appear on a plate to be published in the continuation of this paper.

other ways, and treated by Fischer in the *Hysterangiaceæ* (l. c., Pflanzenfamilien, p. 307), is known only from the United States and Canada (see also Lloyd, Known Phalloids, p. 71, figs. 93 and 94).

As the number of our species of Phalloids is small, we key all of them here under the family, and for the convenience of students we include all described species from the United States.

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KEY TO THE PHALLOIDS OF THE UNITED STATES*

CLATHREÆ

Receptaculum composed of a stout, netted globe.....Clathrus cancellatus

Receptaculum composed of two to five stout columns fused only above *Clathrus columnatus*

Receptaculum composed of a single distinct stalk bearing a subglobose, netted, spore-bearing part on the end; red above.....*Simblum sphærocephalum*

Receptaculum as above, but color yellow all over.....Simblum texense

Receptaculum stalked as in *Simblum*, but the apical spore-bearing part composed of several (usually six) short, hollow arms, incurved and meeting above at

* North Carolina species are given in italics.

first and enclosing the gleba; stalk white.....Anthurus borealis
As above, but gleba borne on outer surfaces of the arms.....Lysurus sp.

PHALLEÆ

Gleba (and spore slime) borne on the upper part of the stalk itself
Stalk 10-17 cm. long, tapering gradually from the center upward to a rounded point; spores 4-7μ long.....*Mutinus Curtisii*
Stalk 6-8 cm. long, nearly cylindrical except for the tapering base (at times), the tip rather abruptly rounded and the spore-bearing part more or less sharply delimited from the sterile part; spores 3.7-4.8μ long.
Mutinus Ravenelii
(and M. caninus, if that is different)
Gleba borne on a pendent cap hanging from the stem tip
An obvious netted veil absent
Stalk watery white.....*Ithyphallus Ravenelii*
Stalk reddish.....*Ithyphallus rubicundus*
(reported from N. C. by Curtis)
An obvious netted veil-like indusium pendent from the stem apex and exposed for some distance below the cap.....*Dictyophora duplicata*

ANOMALOUS

Volva absent; plant until mature looking like a long-stemmed puff-ball, but opening by holes and flaps to expose the green, slimy masses of gleba inside
Phallogaster saccatus

CLATHRUS

Receptaculum without a single distinct stem, but composed of an inflated hollow network or of several curved columns meeting and fused above; in all cases having the spore-bearing gleba attached to the inner side above as a slimy mass. Odor offensive. Only a few species are known and but two have been found in the United States.

For literature see under the family.

Clathrus columnatus Bosc

Laternea columnata Nees

PLATE 71

Eggs subspherical, about 2.5 cm. thick, bursting above into several flaps to allow the expansion of the receptacle which consists of 2-5 (in our plants 4-5) stout, spongy, curved and very delicate columns with separate, pointed, basal ends which remain in the volva, the distal ends incurved and completely fused into a flat roof from which hangs within the dark slimy mass of the spore-bearing gleba. Color of the

MUTINUS RAVENELII. No. 741 [left].
CLATHRUS COLUMNATUS. No. 4949 [right].

receptacle rosy red, the base pale to colorless; volva watery white, attached at base by a cord-like root. Odor about that of a stink horn, strong and fetid.

Spores (of No. 4949) smooth, elliptic, minute, 1.8-2.4 x 3.7-4.8μ.

This plant seems to be entirely southern in its range (but see Saccardo's Sylloge 7, part 1, p. 10) and our collections have come from the subtropical southeast corner of our state, where *Sabal Palmetto* grows, and from coastal South Carolina. It is said to be common in Florida, and Curtis reports it as occurring in the lower and middle districts of North Carolina in sandy woods. It was originally described from South Carolina and is also known from the Gulf States. An interesting anomaly is shown by one of our plants (pl. 71). There is a natural perforation on one side at the top just about the center of one of the columns, exactly like the more numerous perforations in *C. cancellatus* and in *Simblum*. For development and microscopic detail see Burt, Bot. Gaz. 22: 273, pls. 21 and 22. 1896. The beautiful species, *C. cancellatus*, has been found a few times in the United States and should be looked for. It has been reported from Georgia (Schweinitz, Syn. Fung. Car. No. 557, as *C. ruber*) and from Florida (Lloyd, Myc. Notes No. 24: 296).

Illustrations: Bosc. Mag. der Gesell. naturforschender Freunde Berlin 5: pl. 5, fig. 5. 1811.
Burt. As above.
Fischer. Pflanzenfamilien 1, pt. 1: fig. 120 B.
Lloyd. Myc. Works, pl. 92.
Lloyd. Myc. Notes No. 26: fig. 162.
Lloyd. Phalloids of Australia, fig. 20.

Smith's Island. Couch and Grant, No. 4949. In a sandy road, December 29, 1921.
Georgetown, South Carolina. Coker, No. 6013. In sandy soil near Silver Hill Farm, December 29, 1922.

SIMBLUM

Receptaculum formed of a distinct, hollow, delicate stalk which is transformed above into a somewhat larger inflated network which bears the gleba slime on the inside. Volva watery white; receptaculum bright colored, red (in our species) or yellow, rarely whitish; odor offensive.

Only a few species are known and only two are North American. For literature see under the family.

Simblum sphærocephalum Schlecht

Simblum rubescens Gerard

PLATES 72 AND 73

Stalk long, club-shaped, hollow, spongy, tapering downward to a narrow attachment in the bottom of the large, white, toughish, inflated volva; terminated above by the subglobose structure of thick, anastomosing strands that holds the dark slime containing the spores. Color bright red above, fading to pale below; odor strong and repulsive. The entire plant is about 7-9 cm. high and the stalk about 1-1.6 cm. thick above, its honeycombed wall 3-4 mm. thick near the top and only 1 mm. thick below.

Spores (of No. 1427) elliptic, smooth, 1.4-2 x 3.7-4.4μ.

This is a rare plant in the United States and has not been reported before from North Carolina (for distribution see Lloyd's Myc. Notes No. 19: 220. 1905). It is said to be common in South America. The only other North American species is *S. texense* which differs from the present one in its yellow color and longer spores, which are 3 x 7μ (see Long, l. c., p. 112, pl. 106, fig. 11).

Our plate 73 shows an abnormal variation of two plants springing from one volva and fused at their tips. This is apparently of not rare occurrence as a similar example is shown in Lloyd's Myc. Notes No. 24, fig. 133, from a photograph of a Brazilian plant by Rick, and another such is illustrated by Gerard in his plate 2 (as cited below).

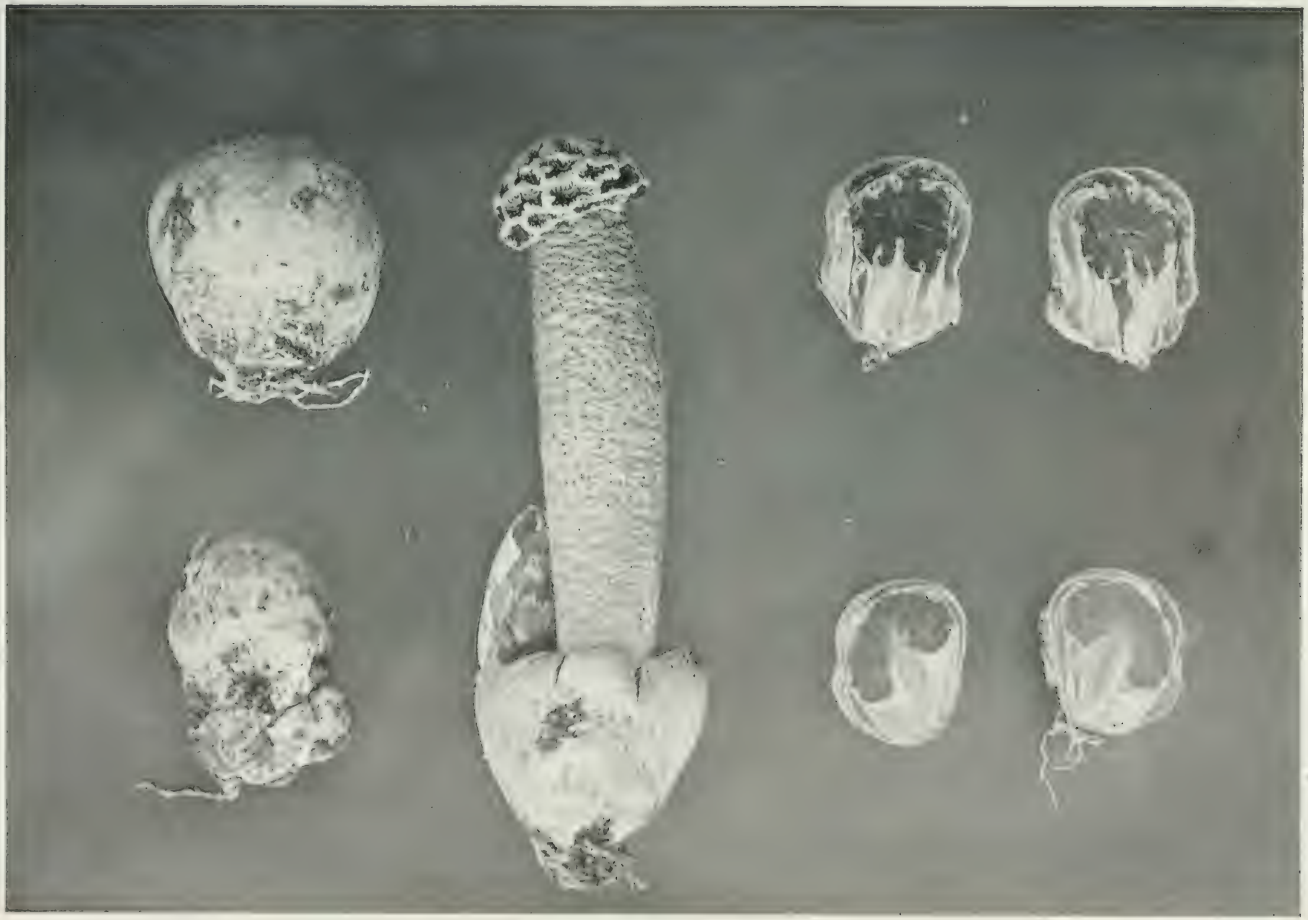
Illustrations: Gerard. Bull. Torr. Bot. Club 7: 8, pls. 1 and 2. 1880.
Long. l. c., pl. 106, fig. 10.

1426. In apple orchard, October 26, 1914.
1427. In grass on campus, fall of 1902. A large number of plants.
5910. On ground in pasture, November 20, 1922.
5917. On ground in pasture by branch, November 22, 1922. Several plants.

MUTINUS

Receptaculum formed of a distinct, delicate, hollow stalk as in *Simblum*, but differing in the spore slime being borne on the outside of the upper part of the stalk itself, which is smooth and more or less pointed, the tip often perforated. Color rosy red above (under and below the deep olive slime), fading downward. Volva soon collapsing against the base of the stalk.

For literature see under the family and species.



SIMBLUM SPHAEROCEPHALUM. No. 5917.

PLATE 73

SIMBLUM SPHAEROCEPHALUM. No. 1426.

Mutinus Ravenelii (B. & C.) E. Fischer

PLATES 71 AND 74

Plants about 6-8 cm. high, the ample volva 2.5-3.5 cm. long; stalk up to 1.3 cm. thick in center and typically tapering a little downward. again nearly cylindrical, the spore-bearing part about 2-2.5 cm. of the apex, more or less abruptly marked off from the sterile part by the narrower, radially elongated, definitely one-layered compartments of the wall. Color bright rosy red above (under and below the slime). fading downwards; apex with or without a small opening; odor strong and offensive. Wall of the stalk about 3 mm. thick in center and 1.5 mm. thick near base; that of the spore-bearing part about 2 mm. thick below and 1 mm. thick above; walls of the stalk compartments 55-75μ thick, with 3-4 layers of cells, those of the spore-bearing part 90-95μ thick, with about 5-7 layers of cells.

Spores (of No. 741) smooth, ellipitic, 1.6-2.2 x 3.7-4.8μ.

This is more common with us than *M. Curtisii.* For treatment of its development see Burt in Ann. Bot. 10: 343, pls. 17, 18. 1896; see also Bambeke, Mém. Acad. Roy. Belgique, 2nd. ser., 2: 1. 1910. Lloyd considers *M. Ravenelii* as different from *M. caninus,* both occurring in the eastern United States (Myc. Notes No. 24: 300; No. 26: 325; Syn. Known Phal., p. 28). Burt considers the two species the same (l. c., p. 344). Lloyd would probably consider the left hand plant on our pl. 74 as *M. caninus,* the two right hand plants as *M. Ravenelii.* We cannot find any important difference in structure among the forms we have collected. *Mutinus caninus* is common in Europe.

Illustrations: Lloyd. Myc. Notes No. 24, fig. 135; No. 28, fig. 183.
Marshall. Mushroom Book, pl. opposite p. 136 (as *M. caninus*).
For illustrations of the European *M. caninus* see:
Fischer. l. c., fig. 142 A-E.
Hollos. l. c., pl. 1, figs. 3-11.
Long. l. c., pl. 104, fig. 9.
Sowerby. Engl. Fungi, pl. 330.

22a. By stone wall near Battle's Park, October 24, 1902. Spores 1.4-2 x 3.7-4.4μ.
24a. Old Chapel Hill collection without label. Spores smooth, 1.6-2.2 x 3.7-4.8μ.
741. On ground near stream, September 12, 1913.
1312. Near brook just above Meeting of the Waters, September 17, 1913. Spores 1.2-2.2 x 3.7-4.6μ.
1729. In low place by branch, September 10, 1915.
1925. In grass in front of Davie Hall, October 25, 1915. Spores 1.6-2.2 x 3.7-4.8μ.

Mutinus Curtisii (Berk.) E. Fischer
M. bovinus Morgan
M. elegans Mont.

PLATES 75 AND 76

Plant about 10-17 cm. high, the white volva at first spherical then elongating and on rupturing at the apex collapsing against the stalk which is almost cylindrical for the first third and up to 2.5 cm. thick, then tapers gradually upward to the blunt point; spore-bearing (slimy) part composing about 3-5 cm. of the apical end, similar in superficial appearance to the rest of the stem except for the slime; color bright rosy red under and below the slime, gradually fading to watery white or flesh color below; apex perforated by a small opening; volva rooted by a strong cord; odor of the brownish slime very strong and offensive.

Spores (of No. 5113) smooth, elliptic, 2-3 x 4-7μ. Wall of the very hollow stem about 2-3 mm. thick and composed of one or two layers of small thin-walled chambers which are irregularly isodiametrical below and change gradually to radially elongated and definitely to a single layer in the slime-bearing part. Walls of the chambers of the stalk 90-95μ thick, with only 3-4 layers of cells; of the spore-bearing part 55-75μ thick with 3-4 layers of cells.

The plants usually appear singly in woods or groves.

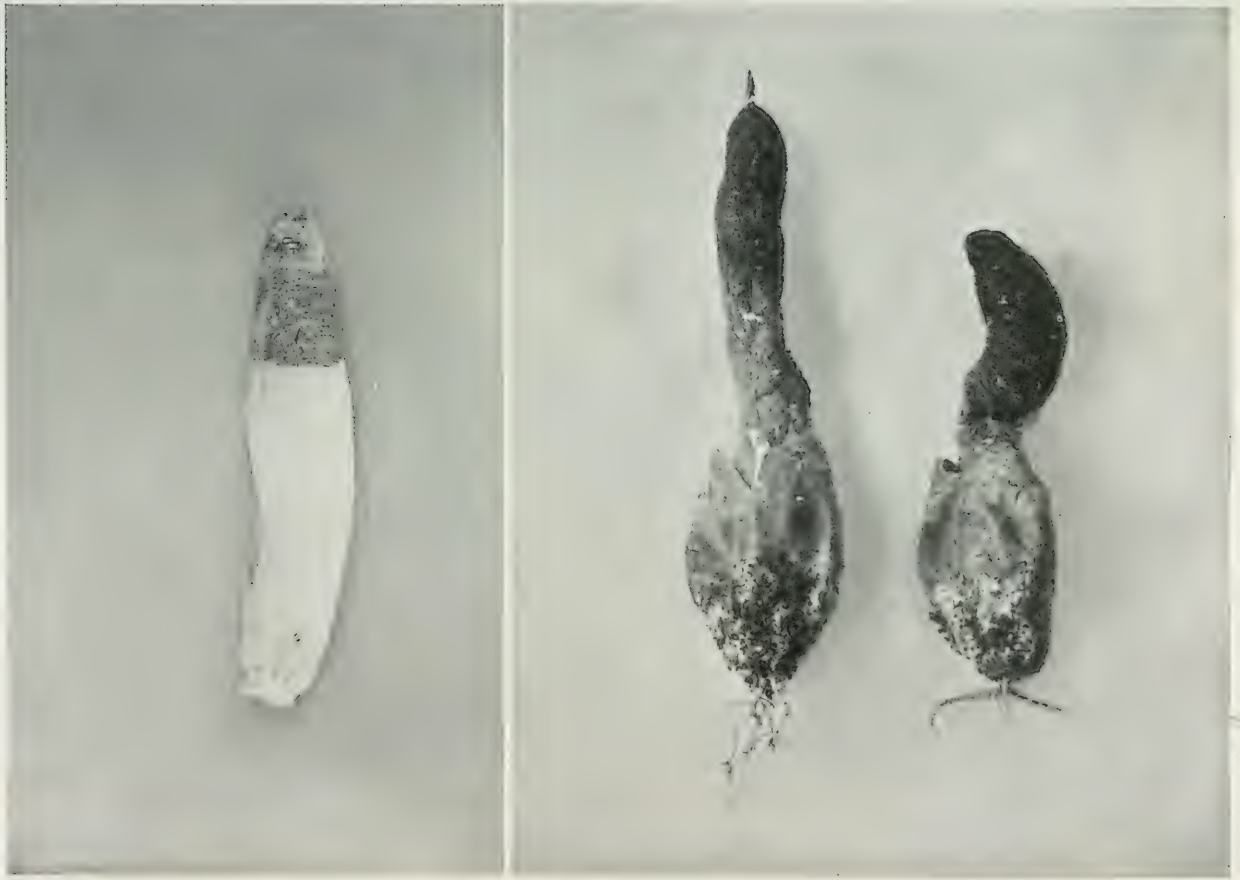
Illustrations: Hard. Mushrooms, pl. 56 and fig. 453.
James. Bull. Torr. Bot. Club **15**: pl. 86. 1888.
Lloyd. Syn. Known Phalloids, fig. 24 (as *M. elegans*).
Lloyd. Myc. Notes No. 28: fig. 182 (as *M. elegans*).
Morgan. l. c., **11**: pl. 3 (as *M. bovinus*). 1889.

2421. In woods mold, Battle's Park, July 24, 1916. Spores smooth, elliptic, 2-2.8 x 4-7μ.
5113. In rotting leaves, May 16, 1922.

Asheville. Beardslee.

ITHYPHALLUS

Volva and stalk as in *Mutinus*, but the spore slime is borne on the outside of a thin, pendent, campanulate membrane or cap which is free from the stem except at the tip. Between this cap and the stalk above and between the volva and the stalk below another delicate, white membrane or veil is obvious (at least in *I. Ravenelii*).



MUTINUS RAVENELII. No. 22a [left]; No. 1925 [right].

PLATE 75

MUTINUS CURTISII. No. 2421.

PLATE 76

MUTINUS CURTISII. No. 5113.

We are following Fischer and Atkinson in placing in this genus *Phallus Ravenelii* B. & C., a species closely related to the European *I. impudicus* but separated from it by the smooth surface of the cap. In addition to the former only one other American species is known, *I. rubicundus* (Bosc) E. Fischer, and it has been reported from this state by Curtis. It should be looked for in the coastal plain and can readily be recognized by the red stalk, the other species being white stalked.

For literature see under the family.

Ithyphallus Ravenelii (B. & C.) E. Fischer

Dictyophora Ravenelii (B. & C.) Burt

PLATES 77-79

Stalks usually 10-16 cm. high, tapering gradually upward or nearly equal, about 1.7-2.5 cm. thick, springing from an ovate egg or volva, which is pinkish, tough, thick, wrinkled below and connected with the earth and with other eggs by purplish pink strands or roots which grow out from the base. The eggs are large and just before rupturing may reach a height of 5 cm. and a thickness of 3.5 cm. The cap or pileus is conical and is attached around the raised white ring which terminates the stem. The upper part of the membranous veil is concealed beneath the cap while the lower half remains in the volva around the base of the stem. At times parts or rings of the veil may be torn loose in expanding and cling to the stalk so as to be visible beneath the cap. Surface of the cap minutely granular, not veined or honeycombed, covered at first by the dark, bad-smelling slime of the diliquescent gleba.

Spores (of No. 41a) smooth, elliptic, 1.2-1.8 x 3.7-4.4μ.

This interesting species is generally found growing in soil containing rotten wood such as old wood piles and rotting trash piles and often appears in large numbers from one colony.

Illustrations: Atkinson. l. c. pl. 2; pl. 3, fig. 7; pl. 4, fig. 10; pl. 6, fig. 14.
Hard. Mushrooms, figs. 447-449.
Lloyd. Syn. Known Phalloids, figs. 7 and 8.
Lloyd. Myc. Notes No. 28: fig. 168.
Peck. Bull. Torr. Bot. Club. 9: pl. 25. 1882.
Scofield. Minn. Bot. Survey 2: pls. 29-31. 1900.

41a. Chapel Hill. No other data.
618. In pile of chips and trash in road, October 24, 1912.
649. Same spot as No. 618, October 31, 1912.

Asheville. Beardslee.

DICTYOPHORA

With the characters of *Ithyphallus* except that there is a large campanulate, veil-like, netted indusium that is attached to the stem tip under the cap and extends far below it. Atkinson has shown (l. c.) that this indusium is a distinct organ and not homologous with the short, membranous veil of *Ithyphallus*. The species here included is the only one known in the United States.

For literature see under the family.

Dictyophora duplicata (Bosc) E. Fischer

PLATES 80-83

Our largest and most massive phalloid, arising from a large egg which is subspherical, ovate or sometimes flattened, about 4-4.5 x 4.5-5 cm., when flattened up to 7 cm. broad and 5 cm. high, white and plicate below as in a peeled orange, the upper half smooth, pale flesh color to deep fleshy brown; in the center below is given off a large, fleshy root, and sometimes one or two smaller, more lateral ones. The expanded plant may reach a height of 17 cm. with the fertile, pendent, apical cap about 5 cm. long and broad, its outer surface strongly chambered by anastomosing plates, over which the brownish olive slime is spread. Between the cap and the stem, and hanging from the top, is a beautiful net-like veil (technically the indusium) of a light rosy pink color that extends below the cap for about 3-5 cm., the perforations being rather regular and about 1-2 mm. broad except towards the margin where they become much smaller. Stalk about 4.5 cm. thick, nearly cylindrical, very hollow and with chambered walls; between its base and the volva is a thick, brownish yellow slime which is separated from the stem by a thin membrane. The odor of the dark spore slime above is offensive but not nearly so much so as in the species of *Mutinus*, being weaker and not so distressingly fetid.

Spores (of No. 5195) smooth, elliptic, 1.2-1.8 x 3.7-4.4μ.

Not rare in Chapel Hill, occurring usually in a scattered colony of several in woods mold in deciduous woods. *Dictyophora phalloides* (*Phallus indusiatus*) is a closely related tropical species.

Illustrations: Atkinson. l. c., figs. 6, 7, 11, 13, 16.
Hard. Mushrooms, pl. 55.
Lloyd. Syn. Known Phalloids, fig. 16.
Murrill. Chart of Edible and Poisonous Mushrooms, fig. 34.
Rau. Bot. Gaz. **8**: pl. 4 (as *Phallus togatus*).

836a. On lawn of president's house, October 22, 1911.
2286. On a ditch in woods, June 28, 1916.
5195. In rich woods, June 20, 1922.
5343. In deciduous woods near Forest Theater, July 8, 1922. Plant 12 cm. long.

Asheville. Beardslee.

ITHYPHALLUS RAVENELII. No. 649.

PLATE 78

ITHYPHALLUS RAVENELII. No. 649.

PLATE 79

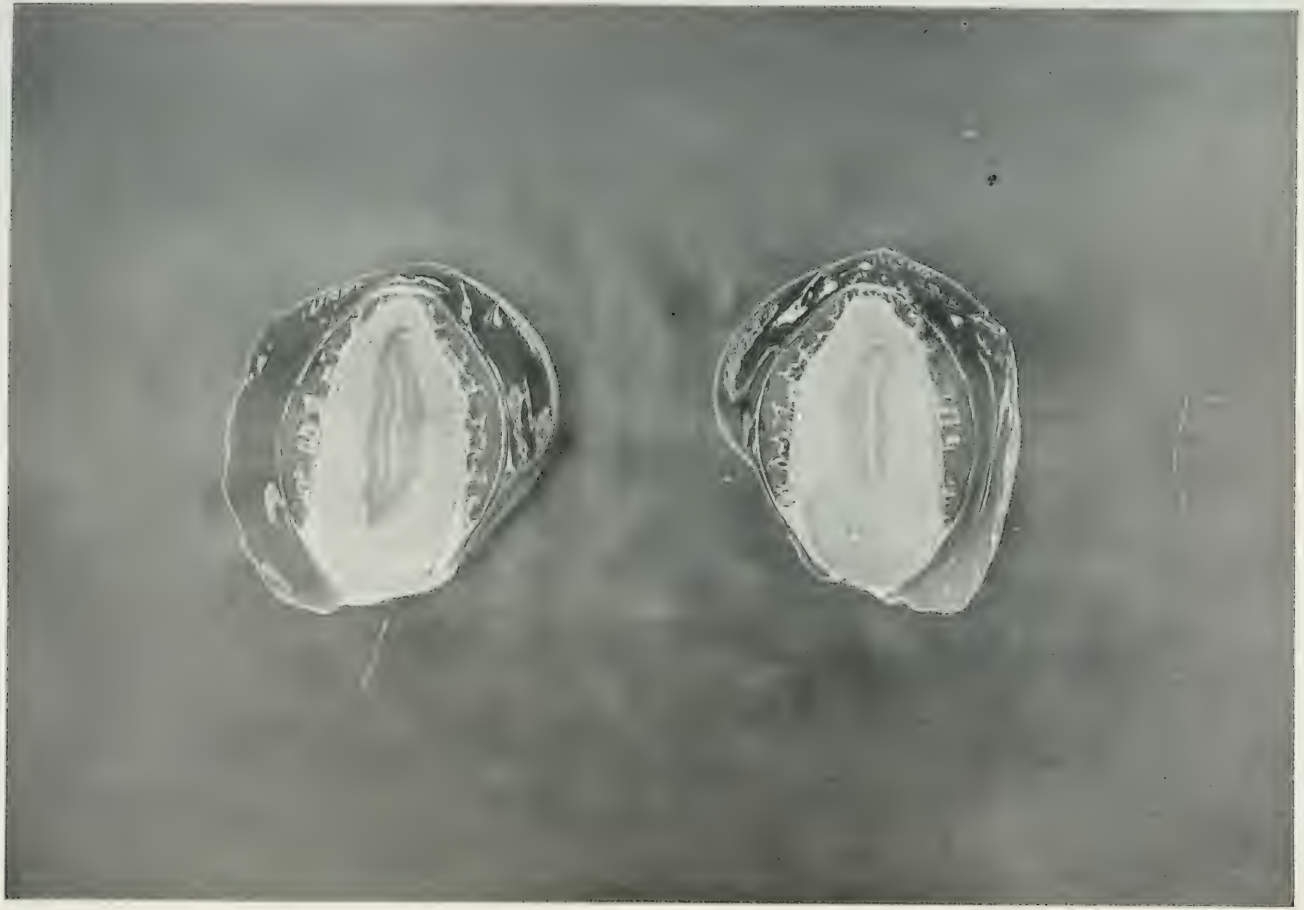
ITHYPHALLUS RAVENELII. No. 618.
Reduced. Largest plant 7¾ in. long.

PLATE 80

DICTYOPHORA DUPLICATA. No. 2286.
Much reduced (actual length 18.5 cm.).

PLATE 81

DICTYOPHORA DUPLICATA. No. 5343



DICTYOPHORA DUPLICATA. No. 5374.

PLATE 83

DICTYOPHORA DUPLICATA, "EGG." No. 2286.

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