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OF THE

Indiana Academy of Science,

1891.

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OF THE

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1885–1891.

O. P. HAY,
C. A. WALDO,
J. M. COULTER, } Editors.

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J. C. Arthur, J. M. Coulter, W. H. Evans.

EDITORS.

O. P. Hay, C. A. Waldo, J. M. Coulter.

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1887–88. J. P. D. John.
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1887–88. C. W. Hargitt, B. W. Evermann, O. P. Hay.

PROGRAMME.

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1890–91. C. Leo Mees, C. H. Gilbert, J. T. Scovell.

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1886–87. J. C. Branner, Stanley Coulter, P. S. Baker.
1887–88. D. W. Dennis, J. T. Scovell, J. S. Kingsley.

PAST COMMITTEES—Continued.

INCORPORATION.

1887–88. T. B. Redding, Maurice Thompson, J. P. D. John, A. W. Butler.
1890–91. O. P. Jenkins, B. W. Evermann, C. A. Waldo.

PUBLICATION.

1887–91. A. W. Butler, B. W. Evermann, Stanley Coulter.

LEGISLATION FOR THE PROTECTION OF NATIVE BIRDS.

1887–91. A. W. Butler, D. S. Jordan, B. W. Evermann.

ON DIVIDING THE ACADEMY INTO SECTIONS.

1887–88. J. P. D. John, J. C. Arthur, W. A. Noyes, O. P. Jenkins, D. W. Dennis.

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1887–88. P. S. Baker, C. A. Waldo.
1889–91. P. S. Baker, C. H. Gilbert.

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1889–91. C. A. Waldo, J. M. Coulter, O. P. Jenkins.

CO-OPERATION OF EDUCATIONAL SOCIETIES.

1890–91. D. S. Jordan, O. P. Jenkins, R. G. Gillum.

LEGISLATION FOR THE RESTRICTION AND DESTRUCTION OF WEEDS.

1890–91. J. C. Arthur, J. M. Coulter, W. H. Evans.

T. C. Mendenhall, J. C. Arthur, J. S. Kingsley, Daniel Kirkwood, P. S. Baker, H. W. Wiley and J. M. Coulter were appointed a committee to invite the American Association for the Advancement of Science to meet in Indianapolis in 1889 or 1890.

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M. L. Wells	Indianapolis, Ind.
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J. R. Wiest	Richmond, Ind.
H. W. Wiley	Washington, D. C.
William S. Windle	College Springs, Iowa.
William S. Wood	Seymour, Ind.
A. Harvey Young	Hanover, Ind.

Honorary member	1
Non-resident members	11
Active members	121
Total	133

FIELD MEETINGS.

It was fitting that the first "Field Meeting" of the Indiana Academy of Science should be held at Brookville. There the idea of such an organization originated. There the steps were taken, through the Brookville Society of Natural History, by which the scientific investigators of the state were brought together at Indianapolis, December 29th, 1885, to adopt articles of association and effect an organization.

This first Field Meeting began Thursday evening, May 20th, 1886. The Academy was welcomed by Mr. D. W. McKee, President of the Brookville Society of Natural History. President D. S. Jordan responded to his greetings. Dr. John C. Branner delivered an address on "The relations now existing between geologists and the people." The next day was devoted to visiting the localities of interest to the persons attending. Luncheon was served at "Templeton's ford," on the east fork of White Water river. In the deep, clear water of the pool above the ford the baptism took place and the first "Field Meeting" was declared by the president to be a success. Recollections of that day—the first of united scientific work in Indiana, a meeting more successful by far than had been dreamed of, and yet which bespoke the fuller fruition to which the child of our minds should come in later years—can never be effaced.

At night a public meeting was held in the Town Hall. Dr. Jordan delivered an address on "Charles Darwin." He also told "How to go fishing." Dr. Branner gave an account of methods of coral fishing. Dr. P. S. Baker spoke of recent progress in Toxicology. The number of persons attending that meeting, and strange so say, several others, was thirty-three.

The second "Field Meeting" of the Academy began its session at Waveland, Ind., May 19th, 1887. The meeting that evening was informal—thoroughly so. The recollections of it will remain with those who participated, and it would hardly be just to attempt to give an account of the proceedings for the benefit of others.

The following morning the members were driven to "Shades of Death," a delightful spot adjacent to Sugar creek. There the day was spent and luncheon served. Every one had heard of this beautiful spot, shaded, well watered, with its cañons, the cliffs of which were topped with pine and hemlock, and the walls draped with ferns and bedecked with mosses;

its "buzzard's roost;" its lack of snakes, its peaceful dells and shady glens of all of which "the half has not been told."

At night a public meeting was held at the M. E. church in Waveland, when Dr. T. C. Mendenhall delivered an address upon "Weather Predictions." An informal discussion of the natural features of the region visited was held. C. R. Barnes, J. M. Coulter, W. S. Blatchley and Stanley Coulter spoke of its botanical interest, O. P. Jenkins of the fishes, B. W. Evermann of the birds, A. W. Butler of the reptiles and amphibians, T. C. Mendenhall of the southern limit of the white pine, P. S. Baker and W. W. Byers of the geology.

The following day the members were taken to "Pine Hills," in the valley of Indian creek, about a mile above the locality of the preceding day's explorations. The features of the country were somewhat different from those noticed the day before. A pleasant day was spent and luncheon was served at the club house. At this meeting also there were thirty-three persons.

The third "Field Meeting" was begun at Paoli, Orange county, May 2, 1888. The meeting was held in the public hall and was presided over by Vice President O. P. Hay.

Prof. James E. Humphrey delivered an address entitled "Asa Gray."

Prof. J. M. Coulter gave a lecture on "The Yellowstone Park."

The day following the persons present, thirty-three in number, drove to Wyandotte cave, in Crawford county, going, in the way they traveled, about forty miles. The evening and the early part of the night was spent exploring the cave. The next day the party returned to Paoli, stopping at Marengo cave. The journey was a hard one, but it had its pleasures and they were noteworthy. All will remember that meeting, some, in some respects, unpleasantly, others as a season of unusual brightness in their lives. The annals of that meeting are classic to Indiana's scientists. How unfortunate the chronicler cannot always write the whole truth!

At Greensburg, Ind., May 8th, 1889, the fourth "Field Meeting" began. The session was held at 8:30 o'clock P. M. in the rink. Vice President J. L. Campbell presided. Dr. J. P. D. John delivered an illustrated lecture on "Our Celestial Visitors."

The day following was pleasantly spent visiting the Upper and Lower Silurian exposures along Cobb's Fork of Sand creek. After luncheon, which was kindly provided by the hospitable people of Greensburg, the members went to the Harris City quarries, thence returned to Greensburg. In the evening another session was held in High School Hall. The following persons spoke of some of the observations made during the day:

J. L. Campbell, on Topography.

G. K. Greene and W. P. Shannon, on Geology.

J. M. Coulter, D. H. Campbell and J. C. Arthur, on Botany.

Hon. Will Cumback then gave his impressions of the meeting.

Edward Hughes gave an account of the Amphibians noted.

A. W. Butler spoke of the reptiles.

O. P. Jenkins spoke of the fishes of Cobb's Fork, and was followed by D. S. Jordan, who spoke of fishes also.

Rev. Mr. Torrence and J. P. D. John made appropriate remarks, the latter moving the adoption of a vote of thanks to the citizens of Greensburg for their hospitality, which was voted.

The roll showed twenty-seven persons present.

The next day the members divided, a part going to St. Paul and Waldron, others to Clifty creek. The former spent the day among the fossils of these famous localities, while the latter fished or lounged beside the quiet stream drinking inspiration and absorbing wisdom at the same time. Over a small fire the champion of "vegetable beefsteak" might have been seen, giving instruction in primitive culinary methods as applied to his favorite food, while sitting about were several individuals who discussed the governor's jokes, the *true* name of the stream explored yesterday, and the unaccommodating manner of the fishes who persisted in refusing to be caught, as with rapid flow alike of words and saliva they watched the slowly growing mushroom pile. And thus we remember Greensburg.

The next "Field Meeting" was appointed for Greencastle, where the meeting was called to order in Meharry Hall of DePauw University, at 8 o'clock P. M., May 8, 1890, by Prof. C. A. Waldo, acting president. Prof. C. Leo Mees delivered an address on "Inertia with reference to electricity." Dr. Daniel Kirkwood was elected the first honorary member of the Academy. President J. P. D. John, of DePauw University, extended to the members the courtesies of the university.

The following morning the members, according to previous arrangement, went to "Fern," an interesting spot, where the day was pleasantly spent. In the evening the party returned to Greencastle.

At 8 o'clock P. M. the Academy convened in Meharry Hall with ex-President John in the chair.

J. C. Arthur presented "Some observations on parasitic plants taken at 'Fern.'"

C. R. Dryer gave an account of the "Surface Geology of Putnam county." C. W. Hargitt spoke on "Some observations on Economic Entomology." Stanley Coulter gave some notes on the day's work. D. H. Campbell spoke of the ferns at "Fern." C. A. Waldo referred to the proposed meeting of the American Association for the Advancement of Science at Indianapolis in August next. A vote of appreciation of the kindness and courtesy shown the members of the Academy by the citizens of Greencastle and University authorities was passed. O. P. Jenkins, being called upon, spoke concerning the influence of associations such as the Indiana Academy of Science upon the individual worker. After discussing plans for welcoming and entertaining the American Association the Academy adjourned.

According to appointment, the sixth "Field Meeting" was convened at the Arlington Hotel, Lake Maxinkuckee, May 14, 1891, at 8 o'clock P. M. President Hay occupied the chair. Dr. P. S. Baker delivered an address upon "The Spirit of Scientific Work," for which the thanks of the Academy were tendered him. The Executive Committee was instructed to prepare an abstract of the new law for the protection of birds, and to have a copy of the same mailed to each newspaper in the state. It was recommended that special attention be called to the fact that the English sparrow is not protected by law. J. T. Scovell spoke of the desirability of an effort being made to determine the height of Mt. Orizaba, Mexico, and of the advantages to be derived from such work being undertaken by running a line of levels from some determined point to the summit and definitely fixing each thousand foot mark as a reference point for biological investigations. The Academy voted approval of the plan as presented and agreed to assist in any way in its power should such plan be undertaken.

The next day was spent in exploring the lake and its shores, and was very much enjoyed. Boating, fishing, turtle hunting and collecting in many lines represented the various ways in which the members were employed.

In the evening the Academy met again at the Arlington Hotel. A committee consisting of J. M. Coulter, P. S. Baker, A. J. Woolman, A. P. Carman and A. W. Butler was appointed to consider the relation that should be sustained by teachers in the High Schools to the Academy of Science. The natural characters of the region about Lake Maxinkuckee were then discussed until the close of the session.

Richmond was the place chosen for the "Field Meeting" of 1892. The kind and urgent invitation of the representatives of Earlham College made each one feel an assured welcome to Richmond and to Earlham. On the morning of May 12th the members met at the Arlington Hotel, and under the guidance of Professors Dennis and Moore proceeded to Thistlethwaite's Falls, above the city. The morning was agreeably spent along the several outcrops of the fossiliferous limestone. Before noon the party reached the college grounds. After examining the collections, dinner was served in the dormitory. In the afternoon, by the kindness of the people of Richmond, the members were driven in carriages to Elkhorn Falls, five miles down the Whitewater river. Upon their return they were driven about the city and given an opportunity to see its beauties, comforts and advantages.

Thursday evening the Academy met in Lindley Hall, Earlham College. President J. L. Campbell occupied the chair. J. M. Coulter spoke briefly of the objects and plan of the Academy. Dr. Alfred Springer then delivered an address upon "The Cell and Its Functions."

The thanks of the Academy were tendered Dr. Springer for his address.

The next morning the members visited the limestone outcrops below the city, going thence to the college where they again partook of dinner. Those who could remain spent the remainder of the day in the libraries, museums and laboratories All regretted when leaving time came. The meeting was too short in time but was full of pleasures for which all will hold the Richmond friends in grateful remembrance.

AUTHOR LIST AND BIBLIOGRAPHY

OF

Papers Presented to the Academy

FROM 1885 TO 1891 INCLUSIVE.

Abbreviations explained on the page following the list.

ADAMS, B. F.

'85. [See Van Nuys, T. C.]

ANDERSON, V. C.

'89. Town geology—what it is and what it might be.

ARTHUR, J. C.

'87. Lile history of the plum leaf fungus.

'89. Variation of plants from unripe seeds.

'90. A remarkable oscillating movement of protoplasm in a Mucor.

'90. Accelerating germination by previous immersion of the seed in hot water.

'91. Relation of available enzym in the seed to the growth of the plant.

'91. The potato tuber as a means of transmitting energy.

BAKER, P. S.

'85. Indiana entomology.

'86. The new alkaloid, cocaine. [Not published.]

'89. Vapor densities of the volatile metalic "Halids." [Am. C. J., XI, 134.]

'89. Oxidation by means of the fixed alkaline hydrates. [Not pub.]

'89. Action of chloroform on aluminum chloride. [Not published.]

'89. The "Perkins Synthesis." [Not published.]

'91. A copper ammonium oxyde. [Not published.]

BARNES, C. R.

'86. Collecting mosses. [Not published.]

BEACHLER, C. S.

'91. The relation of the Keokuk groups of Montgomery county with the typical locality. [Am. G., Aug. '92. A part of paper entitled "Keokuk group of the Mississippi valley."]

'91. Comments on the description of species. [Not published.]

BIGNEY, A. J.

'91. Preliminary notes on the geology of Dearborn county, Ind. [Pr. V.]

'91. Notes on Elaps fulvus. [Pr. V.]

BLATCHLEY, W. S.
'88. Lists of the plants of Monroe county, Ind. [Not published.]
'89. Some rare batrachians. [Not published.]
'89. The compositæ of Vigo county, Ind. [Not published.]
'89. On some plants new to the state list. [Not published.]
'90. The butterflies of Indiana. [17th Report on the Geol. and Natural History of Indiana.]
'90. The batrachians and reptiles of Vigo county, Ind. [J. of C. S. of N. H., Apl., '91, p. 22.]
'80. Acrididæ of Vigo county, Ind. [C. E. XXIII, '91, pp. 74, 98; also I. F., May 16, '91, under the title, "Some facts about grasshoppers.
'90. On a bird new to the state fauna. [Not published.]
'90. On Cnicus discolor as an insect trap. [C. E. XXIV, '92, November.]
'91. The Gryllidæ of Indiana. [Pr. V.]
'91. Entomologizing in Mexico. [E. N. III, '92, pp. 111, 131.]
'91. Notes on Indiana Acrididæ. Description of one new species. [C. E. XXIV, '92, p. 28.]

BOLLEY, H. L.
'88. A study of the sub-epidermal rusts of grasses and sedges. [B. G. '89, p. 139.]
'90. Notes on a new Puccineæ. [Am. M. M. J., X, pp. 168–180.]
'90. On the manufacture of plant infusions for the culture of bacteria. [Not published.]

BOLLMAN, C. H.
'86. Notes on the Acrididæ of Bloomington, Ind., with descriptions of four new species. [Not published.]
'86. New North American myriapods, chiefly from Bloomington, Ind. [Not published.]
'88. The sunfishes. [Not published.]
'88. The myriapods of Indiana. [Not published.]

BRANNER, J. C.
'86. An Indiana earthquake. [Not published.]
'86. The limit of the drift in Kentucky and Indiana. [Not published.]
'86. The deep well at Bloomington, Ind. [Not published.]
'87. A sketch of the geology of Arkansas. [Vol. I, Geological Survey of Arkansas, '89.]
'87. The meanderings of the Arkansas river below Little Rock. [To be published in '93. Miscellaneous papers by Geol. Surv. of Arkansas.]
'88. Observations upon the erosion of the hydrographic basin of the Arkansas river above Little Rock. [As above.]
'88. The fauna of Fernando de Noronha. [Am. N., Oct., '88, pp. 861–171.]
'89. The training of a geologist. (Presidential address.) [Am. G. Mar., '90, pp. 147–160.]

BRANNER, J. C. AND J. H. MEANS.

'89. Preliminary location of a parting in the sub-carboniferous of Monroe county, Ind. [Not published.]

BRANNON, M. A.

'89. Some Indiana mildews. [Not published.]

BROWN, R. T.

'85. Indiana geology.

BROWN, W. V.

'87. [See O. P. Jenkins.]

'88. Effect on personal equation of single and double-line reticules.

'88. [See O. P. Jenkins.]

'91. The sections of the anchor ring. [Annals of Mathematics, Vol. 6, '92, No. 6.]

BRYAN, WM.

'88. Investigations in physiological time.

'88. Outline of work in physiological psychology.

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'89. The portable water supply of the City of New York.

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'86. Natural gas and petroleum.

'86. Loantharia rugosa.

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'88. [See Waters, E. G.]

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'91. The contest against infection. [Cincinnati Lancet-Clinic, August 6, '92.]

QUICK, E. R.

'85. The progress of the study of mammalogy in Indiana.

'86. Our blind mice.

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'85. Meteorology in Indiana.

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'87. Man an evolution — biological proofs. [Souvenir of Western Writers' Asso., 1890, pp. 173–184, and Pulpit and Pew.]

'91. The prehistoric earthworks of Henry county, Ind. [New Castle Courier, Dec. 20, '89, and Pr. V.]

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'89. [See Drew, Frank M.]

'89. Morphology of the siphonophores. [Not pub.]

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'86. The mildews of Indiana. [B. G., XI, pp. 60–63.]

'87. Characters in Umbelliferæ. [B. G., XII, pp. 237–243, and Coulter and Rose's Revision of Umbelliferæ, pp. 9–16.]

'90. Distribution of Umbelliferæ in North America. [Not yet pub.]

'90. Plants collected by Dr. Palmer in Arizona in 1890. [Cont. fr. U. S. Nat'l Herb., I, pp. 117–127.]

SCHNAIBLE, JOHN F.

'89. Soap analysis. [J. of A. C., IV, p. 157.]

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'85. Geographical studies in Indiana. [Not pub.]

'86. The geology of Vigo county, Ind. [Not pub.]

'86. The Niagara river. [Not pub.]

'87. Erosion in Indiana. [Not pub.]

'88. The old channel of Niagara river. [Not pub.]

'90. Sections of drift in Vigo county, Ind. [Not pub.]

'91. Exploration of Mt. Orizaba. [Not pub.]

SEATON, HENRY E.

'88. The epidermal cells of Tillandsia.

'89. Some stem characters in Compositæ.

'90. Notes on Gautemalan Compositæ.

'91. The flora of Mt. Orizaba. [Pr. V.]

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'91. On the occurrence of certain western plants near Columbus, Ohio. [Partially B. G., 1891, p. 155, and Pr. V.]

SHANNON, W. P.

'86. The physical geography of Decatur county, Indiana, during the Niagara period. [Not pub.]

'87. A list of the fishes of Decatur county, Ind. [Published privately. Apply to the author.]

'87. List of butterflies of Decatur county, Ind. [Not pub.]

'90. The occurrence of Veratrum woodii in Decatur county, Ind.

SMITH, ALEX.

'91. Condensation of acetophenone with ketols by means of dilute potassium cyanide. [Pr. V.]

'91. Condensation of acetone with benzoin, by means of dilute potassium cyanide. [Pr. V.]

'91. Pyrone and pyridone derivatives from benzoyl-acetone. [Pr. V.]

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'89. A comparison of the life histories of different forms of plants.

'89. The height of the atmosphere.

'90. A refraction rainbow.

'90. Geological section at Vincennes.

'90. Preliminary list of Knox county plants.

'90. Introduction of noxious weeds.

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'89. The carbohydrates of the sweet potato. [Ag. S., IV, p. 31 and B. d. c. G., XXIII, p. 1406.]

'89. Specific reaction for the penta glucoses. [Not pub.]

'90. Notes on xylose. [Not pub.]

'90. On qualitative and quantitative reactions for furfurol. [Journal of Analytical and Applied Chem. V. No. 8, and B. d. c. G., XXIV, p. 3019.]

'91. The digestibility of the pentose carbo-hydrates. [Am. C. J., XIV, No. 1 and B. d. c. G., XXV, p. 563.]

'91. The action of phenyl-hydrazin on fufurol. [Not pub. elsewhere.]

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'90. On a pentaglucose obtained from corn cobs. [Am. C. J., XIII, No. 5, and B. d. c. G., XXIV, 1657.]

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'88. [See Waters, E. G.]

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'88. An objection to the contraction hypothesis as accounting for mountains.

'88. The sun's light.

'90. The highest old shoreline on Mackinac Island.

'90. The effect of the Great Lakes on the ice sheet.

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'88. A new kind of phosphorescent organ in Porichthys. [Bulletin Essex Institute, XXI, pp. 43–52.]

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'91. An apparatus for determining the periodicity of root pressure. [B. G., 1892, p. 212, and Pr. V.]

'91. The scales of Lepidoptera. [Not pub.]

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'85. Mineralogical investigation in Indiana.

'87. The secondary functions of the hyoid cornua in Picus and Colaptes. [Chapter on "Hyoid Hints" in the author's "Sylvan Secrets," pp. 125-139, John B. Alden, N. Y., 1887.]

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'91. [See Moore, J. E.]

TUDOR, JOSEPH H.

'90. Some features of the occurrence of Viola pedata var. bicolor. [Not pub.]

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'91. A review of the Embiotocidæ. [Pr V.]

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'91. The distribution of tropical ferns in peninsular Florida. Pr. V.]

'91. Some additions to the state flora from Putnam county.

'91. Connecting forms among the polyporoid fungi. [Zoe, III, pp. 91-95.]

VAN NUYS, T. C.

'88. Estimation of water in oils. [Not pub.]

'91. Some suggestions to teachers of science or mathematics in high schools. [Pr. V.]

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'86. The estimation of carbonic acid in the air. [Am. C. J., IX.]

VAN NUYS, T. C. and ROBERT HESSLER.

'88. Researches in invertin fermentation. [Not pub.]

VAN NUYS, T. C. and R. F. LYONS.

'88. Review of the methods of estimating starch in cereals. [Not pub.]

'90. A new method for quantitative determination of albumen in urine. [Am. C. J., XII.]

'91. Carbonic acid in the urine. [Am. C. J., XIV, and Pr. V.]

WALDO, C. A.

'87. The problem of the earthquake center. [P. A. A. A. S., 1888.]

'88. A note on maxima and minima. [Not pub.]

'89. Probable future of petroleum in southwest Indiana. [Indianapolis Journal.]

'91. Some geometrical propositions.

'91. Notes on numerical radices.

WALKER, CHAS.

'86. [See Noyes, W. A.]

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'85. Chemical work in Indiana.

WATERS, E. G. and J. B. PEDDLE.

'88. A new automatic repeater.

WATERS, E. G., and R. G. SWEENEY.

'88. A new switch for telegraph and telephone use.

WEBSTER, F. M.

'86. Some biological studies of Lixus macer, Say, and L. concavus, LeC. [Entomologica Americana, V, pp. 11-16.]

'87. An unusual appearance of Apatura celtis along the St. Francis river, in Arkansas. [Insect Life, I, p. 29.]

'87. Drouth, and its effect upon insect increase and decrease. [Not pub.]

'87. Distribution of some species of injurious insects, throughout Indiana, during the season of 1887. [Not pub.]

'87. The overflow of the Mississippi river and its effect upon the species of Simulium (buffalo gnats) infesting the smaller inland streams of the adjacent country. [U. S. Dep. Agr. Bureau An. Industry. 4th and 5th reports '87-'88, pp. 156-65.]

'91. Contributions to a knowledge of the grain Toxoptera (Toxoptera graminum.) [Insect Life, IV, pp. 245-8.]

'91. Buffalo gnats (Simulium) in Indiana and Illinois. [Pr. V.]

'91. Some insects of Tasmania. [Pr. V.]

'91. Early published references to injurious insects. [Insect Life IV, pp. 262-5.]

WILEY, H. W.

'86. The scientific study of psychic phenomena. [Not pub.]

'86. Causes of variation of sucrose in sorghum. [B. G., XII, p. 54, and Bulletin 18, Chem. Div. U. S. Dept. Agl. p. 114.]

'88. The value of the refractive index in determining the adulterations of lard. [J. of A. C., II. Part 3 and Bulletin 13. Chm. Div. U. S. Dept. Agl. Part 4, p. 442.]

'88. The present condition of the sorghum sugar industry in the United States. [Proc. of 8th Ann. Meeting of Soc. for Promotion of Agl. Science.]

WILEY, W. B.

'88. [See Noyes, W. A.]

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'87. The skull of Necturus lateralis.

'88. Raphides in fruit of Monstera deliciosa.

WOODFORD, A. B.

'86. The nation—the subject matter of political science.

WOOLMAN, A. J.

'89. Notes on Indiana butterflies. [Not pub.]

'90. The fishes of the interior of Kentucky. [Bulletin U. S. Fish Com.]

ABBREVIATIONS IN THE PRECEDING AUTHORS' INDEX.

A. N. Y. A. S.—Annals of the New York Academy of Sciences.

Ag. S.—Agricultural Science.

Am. C. J.—American Chemical Journal.

Am. G.—American Geologist.

Am. J. S.—American Journal of Science.

Am. M. M.—American Monthly Microscopical Journal.

Am. N.—American Naturalist.

B. d. c. G. Berichte der deutschen chem. Gesellschaft.

B. G.—Botanical Gazette.

B. I. E. S.—Bulletin Indiana Agl. Experiment Station.

C. E.—Canadian Entomologist.

I. F.—Indiana Farmer.

J. C. S. of N. H.—Journal of the Cincinnati Society of Natural History.

J. of A. C. Journal of Analytical Chemistry.

J. of M.—Journal of Morphology.

N. A. J. of H.—North Amer. Journal of Homeopathy.

O. & O.—Ornithologist and Oologist.

P. A. A. A. S.—Proceedings of the American Association for the Advancement of Science.

P. C. A. S.—Proceedings California Academy of Science.

P. S. M.—Popular Science Monthly.

Pr. U. S. N. M.—Proceedings U. S. National Museum.

Pr. V.—Current volume of Proceedings of the Indiana Academy of Science.

ADDRESS BY THE PRESIDENT.

O. P. HAY, Butler University, Irvington, Ind.

A CONSIDERATION OF SOME THEORIES OF EVOLUTION.

We find in the physical history of the earth an illustration of evolution in the modern sense of the word, a progress in accordance with fixed laws from the simple to the complex, from the undifferentiated to the differentiated.

That philosophical minds should suspect that the world of organic beings, animals and plants, had been the subject of a similar course of evolution is not strange; and we find that such a suggestion has been often and long ago made. In modern times Lamarck has led the way; but neither were his theories adequate, nor were the men of his time ready to abandon their ancient conceptions. But when, in 1859, Darwin and Wallace published the results of their independently pursued studies and proposed a theory, definite and supported by a multitude of facts, their works attracted immediate and sustained attention. It is doubtful if any doctrine so subversive of universally accepted ideas has ever, in so short a time, received the recognition of so many of the educated and thoughtful minds of the world.

The doctrine of organic evolution, which attempts to explain the various differences and resemblances which exist among organic beings, depends on two laws, *heredity* and *variability*. The one law ordains that the living thing shall possess the essential characters of its parent or parents; the other law that it shall depart from those characters to a greater or less extent. Neither law can be questioned by anybody; only the extent to which the one law prevails over the other is in dispute. The evolutionists maintain that the law of variability may prevail over heredity to such an extent that after a greater or less number of generations, the deviations from the original form and structure may be so great that a new species may be produced.

In the attempt to explain how it is that new species originate, Darwin and Wallace hit upon the idea of "natural selection." In nature no two individuals of a species are just alike. Each varies in some slight respect from the type. Of these variations, some may be indifferent, some useful, some harmful. According to these authors, these variations may affect all parts of the body, the form, the size and strength of single organs, color, or mental qualities. Again, all species tend to increase beyond the limits of space and food supply. From this latter cause there arises between the members of any species a struggle for existence. Moreover, all species are warred upon by many others, by which their food is appropriated and through which they themselves may be appropriated as food. In such a dire struggle it is, on the average, the best endowed individuals that will succeed in maintaining themselves and in producing offspring to inherit their useful characters; that is, the most vigorous individuals, those which have developed in the highest degree weapons of offense and defense, or protective colors, or the greatest cunning. The weakest, the most exposed, the most stupid, will perish and leave few or no young. From all the young produced by every species there is thus a constant and unsparing selection being made in favor of those individuals which can best endure the stress of the conditions. Hence the meaning of Darwin's phrase "natural selection," and of that used by Spencer, "survival of the fittest." Through the selection, for many generations, of the individuals possessing certain beneficial characters, these at length become fixed in the organization and strengthened until the organism is no longer what it was, but may have departed widely therefrom. Since success in the struggle is constantly demanding greater strength of limb and body, more efficient organs for each function, more weapons for assailing and repelling, more perfectly protective coloration, the general tendency of evolution has been upward; but the vigor with which the battle is waged may result in driving some species into such situations that degeneration may occur. Such are many burrowing animals and most parasites.

This process of natural selection is therefore quite similar to the artificial selection which is practiced by breeders in their effort to develop new varieties of animals and plants. Those individuals are selected which possess in the highest degree the desired quality; they are crossed with others having, if possible, the same quality, and the offspring of the pair are treated in the same manner, until the character sought is fully developed.

The rigorousness of the selective process that is going on in nature can hardly be appreciated by one who has not given attention to the matter. To a casual observer, it may appear as if the most worthless individuals got a living, while the better perished. The well-favored do often succumb, and in ordinary times the weak may escape; but when periods of great food-scarcity, or of intense heat or cold, or of drought come, then the weak perish miserably. The eggs produced by some fishes reach into the millions. Could each one develop into an adult fish, which should in its turn give origin to an equal number of offspring, a very few years would suffice to fill all the seas with that fish. As it is, only perhaps one egg in a million becomes an adult fish. The least protected eggs are swallowed by enemies, the weakest young fishes die from disease and exposure, while only the most vigorous escape.

Our wild rabbits produce several young at a litter and a number of litters each year; yet the number of rabbits does not, on an average, increase. As many rabbits must therefore die each year as are born, and they seldom die of old age. Dogs and men, extreme cold and hunger, carry them off by thousands. Is there not here abundant opportunity for the development of swiftness of foot, acuteness of eye and ear, and of endurance?

As long as the environment remains about the same, little or no change may occur in the structure or specific characters of animals; but the whole organization is kept up to the highest grade of efficiency. Should there, however, be a gradual change in the conditions under which any animal is living, there would come about a corresponding change in the animal itself. Should there, for example, be developed a gradual increase in the speed of our dogs, there would, I doubt not, occur a corresponding improvement in the swiftness of our rabbits. I can see no reason for supposing that natural selection would not have the same effect here as man's selection does in the case of trotting horses.

Darwin's theory of natural selection was based almost entirely on observations made on domesticated animals and plants. Organisms in a state of nature did not seem to him to be subject to such frequent and extensive variations. We are only now beginning to appreciate how numerous and how important these variations are. They do not affect in only a slight degree a single organ of one individual in a decade or a century, but probably every organ of every individual, and to a very appreciable extent. The proverbial unlikeness of the individuals of every species is due to this variation. Wallace, in his "Darwinism" has given us most impressive illustrations of this variation. Most of these illustrations have been drawn from the publications of our countryman, Dr. J. A. Allen, and relate to the winter birds of Florida. Allen made large collections and took accurate measurements of those portions of the body which are especially depended upon by naturalists in determining species, the length of body, wings, tail, tarsus, toes, and bill. All these parts were found to vary independently of one another, and the variations from the mean length often amounted to from 12 to 25 per cent. of the mean length. While, too, most of the parts measured were not far from the mean on each side, yet there were always a considerable number of individuals of each species that furnished measurements wide of the mean. The same principle is shown by Wallace to hold good among such lizards and mammals as have been studied. What is greatly needed is more extended observations among all classes of animals. I have examined some of our common snakes with reference to this matter of variation. We get the specific characters among snakes from the number of rows of scales across the back, the number broad plates along the abdomen and on the tail, and from the kind and arrangement of the colors. Anybody who has studied snakes has soon learned how extremely variable are their colors. Among specimens of the spreading adder, for example, may be found snakes of a plain gray or olive color without other markings, snakes with mere indications of blotches, snakes with most conspicuous spots of bright red or yellow and black, and snakes which are plain black. The other characters vary to a perplexing extent. What are merely individual, or at most, varietal peculiarities, have often furnished the basis for new species. In order to bring before you the range of the variations in important parts of these animals, I present the results of estimates which show how four species of our common snakes vary.*

These are the common garter snake (*Eutainia sistalis*), the black snake (*Bascanion constrictor*), the smooth, green snake (*Cyclophis vernalis*), and the ring-necked snake (*Diadophis punctatus*.) From these it appears that in the number of the body vertebræ the garter snake varies from the average to the extent of 14 per cent., the black snake 6 per cent., the green snake only 4.5 per cent. and the ring-necked snake 13 per cent. In number of caudal vertebrae, the garter snake varies 35 per cent., the black snake 20

* The results here given have been deduced from the tables of measurements and counts of ventral and caudal plates given in Baird and Girard's "Serpents of North America." Any considerable collection of the species above studied would furnish still greater deviations from the means.

per cent., the green snake 23 per cent., and the ring-necked snake 23.5 per cent. In proportion of tail to body the garter snake varies 9.4 per cent., the black snake 28 per cent., the green snake 25 per cent., and the ring-necked snake over 35 per cent. There is scarcely a doubt that every character in each of these species will be found to be as unstable as those which have been studied. And it must be observed, too, that each of the characters varies independently of the others, so that we may get any combination that we may want. If breeders should find it to their interests to raise a varied assortment of black snakes they could, doubtless, by careful selection and crossing, produce short-bodied snakes with long tails, long-bodied snakes with short tails, or snakes extremely short or very long in both parts. Much more might we expect that natural selection, which has more abundant materials to work upon and unlimited time, should be able to produce varieties and species to suit the requirements of the changing conditions of geological periods.

While the main proposition of Darwin and Wallace that species arise from earlier species by descent with modification, has been almost unanimously accepted by the scientific world, a number of scientific authorities have, within recent years expressed more or less dissatisfaction with the prominence that Darwin and Wallace and their followers have given to the doctrine of Natural Selection as an explanation of organic evolution. This dissent has expressed itself in degrees from questioning whether or not natural selection has been the only factor concerned, to open declarations that it has had little or nothing to do with evolution. Of course, those who deny the efficiency of selection to transform species endeavor to find some other principles or forces which, in their estimation, act as efficient causes, and thus we are beginning to witness the evolution of various schools of evolution. And here it seems proper, as a matter of justice to Darwin, to deny that he, at least in his later works, maintained that natural selection is the only influence at work to bring about changes in organisms. One cannot read his works with even moderate attention without recognizing that he admitted the operation of the very forces and principles that many of these later evolutionists rely on to explain the phenomena of organic change. Only Darwin did not assign the same high value to these factors that some authors do now. Wallace, on the other hand, in his latest work advocates the earlier position of Darwin, and stands for what he calls the "overwhelming importance of Natural Selection over all other agencies in the production of new species."

Now, it matters not the degree of importance that we give to Natural Selection as a principle in organic evolution, it does not appear that we can regard it as furnishing a final solution of the phenomena to be explained. This objection has been justly urged: Natural selection acts only on characters which have been already produced and have become either useful or hurtful. By what means have they been produced? Before they can be selected they must exist; what principles or forces gave them their existence? It has been urged that if there are influences that can bring characters up to the stage where selection can begin to act on them, the same influences might continue to perfect them. Darwin saw the situation clearly. He says, in his "Descent of Man:" "With respect to the causes of variability, we are in all cases very ignorant, but we can see that in man, as in the lower animals, they stand in some relation with the conditions to which each species has been exposed during several generations." He then mentions, as some of the probable causes of change, the direct and definite action of changed conditions, the effects of increased use and disuse of parts, arrests of development, correlated variations, &c. Under such circumstances it becomes a legitimate subject of inquiry what those forces and conditions are which have been active in initiating changes in organisms, and what effect, if any, Natural Selection has had in perpetuating and accumulating these new characters and of repressing others.

One of the most recent and most thoroughly elaborated attempts to account for the variations of organisms is that of Dr. Aug. Weismann. It is presented in a series of lectures delivered between the years 1880 and 1890. The fundamental idea of his theory he has denominated "*the continuity of the germ-plasm.*" All except the lowest animals are produced from eggs, which are essentially cells. When the egg is fertilized, it develops into an embryo by a process of division which leads to the production of an immense number of cells. These, becoming more and more differentiated in definite ways, form the tissues and organs of the adult being. Thus, from a simple egg there arises an animal which inherits the general features of the parent and even many of its minor peculiarities of form and habits. At some time during embryonic development there are separated from the other cells of the organism certain cells which in due season develop into eggs, as a provision for the continuation of the species. It appears hitherto to have been assumed that the materials of these eggs, or germ-cells, is derived by some process of transformation from that composing the ordinary, but not yet greatly modified, cells of the body. Dr. Weismann, on the other hand, maintains that the egg, or more exactly the nucleus of the egg, contains a substance, his *germ-plasm*, which possesses a peculiar chemical, and more especially molecular, structure, and which is the bearer of "the whole of the inherited tendencies of development." In the process of the development of the embryo, not all of this germ plasm is consumed in the construction of the body; but a small portion is set aside and remains in the body of the embryo unchanged, and destined to enter at the end into the formation of the eggs which shall give being to the next generation. The materials of the body cells Weismann calls *somatoplasm*, to distinguish it from the germ-plasm. The germ-plasm, although borne about in the body of the organism that in time will produce offspring, and though nourished by its somatoplasm, is wholly distinct from the latter, and is very slightly if at all affected by it. Weismann says of it: "The germ-plasm, or idioplasm of the germ-cell, certainly possesses an exceedingly complex minute structure, but it is nevertheless a substance of extreme stability, for it absorbs nourishment and grows enormously without the least change in its complex molecular structure." Weismann even maintains that this reproduction of the germ plasm without change may go on for thousands of years. He has compared the germ-plasm to a creeping rootstock which at intervals sends up a vigorous shoot. The shoot flourishes for awhile and dies, but the rootstock survives, to produce other shoots in indefinite number. The germ-plasm enjoys a sort of immortality.

The cause of heredity has always been a mystery. How is it that a cell which has not the slightest resemblance to the animal that produced it can go through a complicated series of divisions and transformations and at last gradually, but unerringly, reproduce even to minute details the structure and form of the parent? How is it that two eggs, indistinguishable from each other, but laid by different animals, developing perhaps under identical circumstances, can reproduce exact copies of their respective parents? Darwin attempted to give an explanation by assuming that each cell of any organism emits minute particles, called by him *gemmules*, which enter the germ-cells and become there representatives of the cells of the whole body. The germ-cells must according to this theory contain millions of gemmules. When development of the egg occurs the contained gemmules determine the reproduction of their respective cells in due order of time, place, and form. When any part of the body of the parent has undergone variation, this will be represented in the egg by the gemmules of the part and may thereby be inherited. The immense number of gemmules required to effect the results, as well as the lack of sufficient evidence of a positive kind in favor of Darwin's theory, have prevented its general acceptance.

On Weismann's theory, heredity follows from the assumption that both parent and offspring are derived from the same mass of germ plasm. That which had given origin to the parent must be expected to develop into a similar organism in the offspring. That the germ-plasm develops into the peculiar structure and form of both is due to its molecular structure, the result of gradual modifications which have been accumulating during the ages that have elapsed since their earliest ancestor received its being.

Some extremely important conclusions issue from the acceptance of this theory of Weismann's. If the germ-plasm, borne about in the body of any organism, protected and nourished by it, does not have its molecular constitution, on which the character of the offspring depends, at all affected by the state of the parent's body then none of what are called acquired characters can be transmitted from one generation to another. This fact, if fact it be, strikes at the very root of other promising theories. Then none of the results of the use and disuse of organs will be transmitted; none of the direct effects of the climate or soil, or any of the environment on the body of the parent, will show in the descendants; nor will any mutilations be inherited. The heat or the cold, the drought or the flood, may produce the most profound effects on the animal or the plant, in the way of altering its form or structure or color, but the offspring will not directly inherit any of these results.

Since, however, Weismann firmly believes that existing species have been derived from older species by descent and modification, how does he account for the variations that must have arisen? This is done on the theory of *sexual mixture*. The germ-plasm of every individual of every species has certain peculiarities, which are passed on, with greater or less intensity, to the next generation. The male animal or plant has certain hereditary tendencies, that of the female different tendencies. When the germ-cells of the two individuals have united, an organism develops that is different in some respects from both the parents, being, as Weismann expresses it, a compromise between the two developmental tendencies. Since the numbers of individuals of every species are numerous and no two are alike, new combinations of the germ-plasm are continually arising, and these express themselves in still other individuals which are different from any that have ever lived. Amid all these variations, which indeed will affect every organ, are some which are hurtful to the organism, and others which are advantageous. Such variations will come under the influence of natural selection, the individuals possessing hurtful variations being destroyed, those with advantageous variations being preserved and made the means of transmitting on to future generations the improvement. Organic evolution, then, according to Weismann, depends on two factors, variation brought about by sexual mixture, and natural selection. Indeed, according to him, the production of variations that may be inherited constitutes the whole significance of sex; it is simply a device of nature for the origination of variations through which natural selection may effect improvement. As a corollary from this proposition Weismann deduces the conclusion that any organisms which do not reproduce sexually, such as certain parthenogenetic insects and crustaceans, cannot undergo variation; and should their environment change to any considerable degree they must perish. However, since the publication of his lectures, Weismann has been compelled to recede from this position.

But if it be true that external influences have had nothing directly to do in bringing about inheritable changes in organisms, and if the species of one age have descended from more ancient species, how did the hereditary individual differences arise in the beginning? With most other evolutionists he believes that the Metazoa have been derived from the Protozoa. In the Protozoa, there is no reproduction by means of eggs. The animal is at once parent and egg. When reproduction occurs, it is usually accomplished by the division of the animal into two portions of equal size and similar form, so that it is impossible to say that either is parent or offspring. Each part reproduces in a similar way; and since there appears to be no reason why, in case the environment remains favorable, any of the products of division should ever die, Weismann regards them all as having potential immortality.

It must be remembered now that Weismann admits that external forces and conditions, as well as the use and disuse of organs, may affect profoundly the organization of even the higher animals, although he denies that any of the direct effects will be passed on the next generation. In like manner the *Protozoon* is influenced by external conditions and would have changes wrought in its body. Now since its *body* is at the same time the *reproductive element*, whatever modifications have arisen in the body would be inherited by the two portions into which it would divide. "If," says Weismann, "a Protozoon, by constantly struggling against the mechanical influence of currents in water, were to gain a somewhat denser and more resistant protoplasm, or were to acquire the power of adhering more strongly than the other individuals of his species, the peculiarity in question would be directly continued on into its two descendants, for the latter are at first nothing more than the two halves of the former." By the time, therefore, that some of the Protozoa, through more and more intimate association into colonies, by differentiations of the cells for the performance of different functions, and the production of germ-cells as distinguished from the body-cells, became modified into the primitive Metazoa, those individual differences had arisen which, constantly multiplied ever since by sexual mixture, have furnished the materials on which Natural Selection has worked to produce all the living animal forms that now exist.

It must be understood that, as regards the reproductive elements of the higher animals, Weismann contends for the continuity of the germ-*plasm*, not for that of the germ-*cells*. Embryology proves that the latter cannot be maintained. As Weismann says, "continuity of the germ-cells does not now take place, except in very rare instances." In certain insects there are, at the very beginning of development, a few cells separated from the others and afterwards received into the body of the embryo, in order later to develop into eggs. In some crustaceans, the germ-cells become distinct when about thirty cells have been produced. In vertebrates they do not usually become distinct from those composing the body until the embryo has been completely formed. Among the Hydroids, reproduction occurs largely by budding. The buds may develop into independent bodies, jelly fishes, which swimming away and attaining a large size, give origin to the germ cells. These do not make their appearance until after hundreds and thousands of cell-generations have been passed through. They arise originally from certain cells of the ectoderm, but make long migrations to the places where they finally undergo development into perfect eggs. Among plants, a fertilized ovule gives origin to an embryo. This may develop into a large tree, which finally will, at the tips of branches a hundred feet away, produce new ovules. Through millions of cells the germ-plasm must have made its way to reach those terminal buds. And the cells must contain this precious substance without showing its presence. Weismann says, "It is therefore clear that all the cells of the embryo must for a long time function as somatic cells: and none of them can be reserved as germ-cells and nothing else." How then does he explain the transferrence, through such long distances, of the germ-plasm? Referring to the Hydroids he says: "I concluded that the germ-plasm is present in a very finely divided and therefore invisible state in certain somatic cells from the very beginning of embryonic development, and that it is transmitted through innumerable cell-generations to those remote individuals of the colony in which the sexual products are formed."

But this transportation of the germ-plasm through so many generations of cells is by no means the only difficulty that besets Weismann's theory. There is a number of plants, among them the begonia, which may be propagated from pieces of the leaves. It would almost appear as if single cells of the leaf would reproduce the plant perfectly. Among the ferns it is no uncommon thing for new plants to spring from the surface of the leaves or of the stalks. Among mosses almost any cell of the root-hairs will develop into new plants. As pointed out by Strassburger, the germ-plasm must, in these cases, not merely travel through the plant to the *reproductive organs*, but be widely diffused throughout every part of the plant, and Weismann admits that this is the case. Similar phenomena occur among animals. If the fresh water *Hydra* is divided into two pieces, each will develop into a perfect *Hydra*. Trembly, in his experiments on these things, minced some of them into as small pieces as he could, and almost every piece developed into a perfect animal. It is stated that as many as forty were thus reproduced from a single one. When certain worms are cut in two, each part develops into a perfect individual. All animals show some power of reproducing lost and injured parts. How shall we explain these facts of reproduction and restoration? Is the restoration of the hydra due to the presence of germ-plasm or not? If it is claimed that it is due to the germ-plasm, it may be replied that it has not reproduced the animal, but only a part, that part which was missing, it may be the half of it or the greater part of it. When the worm is cut in two one cut surface may develop a new tail, the other surface a new head. Had the cut been made the thickness of a cell further forward, those cells that in the first case engaged in developing a new head would probably as readily have gone to work to produce a new tail. Does germ-plasm possess the power of reproducing the whole animal, or the head end or the tail end, according to circumstances? If the germ-plasm is concerned in these restorations of parts, we can hardly exclude it from other cases of restorations, and this will lead us to the admission that germ-plasm is present in nearly all the tissues of all animals. If the position is taken that the germ-plasm is not concerned in the cases that have been referred to, but some degraded product of germ-plasm, then we may say that such materials have powers curiously similar to those of germ-plasm itself, but even more wonderful. To what extent is the material of the cells of the cut surface of the worm different from that of germ-plasm itself, when those cells have the inherited power to produce either head or tail as demanded by the needs of the worm? If the molecular structure of germ-cells and of body-cells is so similar, is it impossible that some of the body-cells may undergo retransformation into germ-cells? Furthermore, whether this suppositious reproductive material is or is not concerned in the restoration of the minced hydra it must, if it exists at all, be present in all the cells. For, so far as we may judge, each hydra that has grown from a minute bit of hydra is capable of giving origin, when divided, to many new hydras, and these to others indefinitely. Since the last of such a series would, without doubt, be able to produce eggs the germ-plasm must have been contained in all the cells of all the series.

Weismann's conception is that the highly organized germ-plasm found in the nucleus is, after the first division, no longer what it was before, except that part which has been reserved,—is indeed no longer germ-plasm at all. At each subsequent division its structure becomes simpler as it gives origin to more and more complex tissues; that is, its energy runs down as it does work in forming tissues. He claims that, when the germ-plasm has thus become simplified, its character as germ-plasm can never be restored. It might be supposed that, if we could find any cells which, having once formed a part of any body-tissue, should take upon itself the powers of a reproductive cell, Weismann's theory would stand disproved. We then direct attention to the somatic cells of hydroids which develop into eggs. But Weismann accounts for this by supposing that the germ-plasm enters the cells and takes the place of the germ-plasm.

However, it appears to me that it must be admitted that the germ-plasm is so widely diffused through the tissues of many, if not all, organisms, and is so much like the substance of many other cells in its reproductive powers, as to make it doubtful whether there is any such distinct material. We may not be able to prove that it does not exist, but we may do as we do with other ghosts, prove the superfluousness of its existence. It is indeed a wonderful property that is possessed by the germ-cells of the animal, that of reproducing the form, organs, tissues, and millions of cells of the parent; but the cells that can reproduce the severed head of any animal, with its many sense organs, appear to me to possess a property even more wonderful. For the germ-cell has a structure and corresponding capacities which are the ingrained results of countless repetitions of the act of reproduction, while nothing of this kind can be said with regard to the cells which reproduce the head, or the tail, or the foot. It looks as if every cell of the whole body were originally endowed with the capability of reproducing all the others in due order; as if, indeed, something like Darwin's theory of pangenesis were really true. Through subsequent high differentiation of structure, or through unfavorable surroundings, the cells may not be able to accomplish the restoration, but they show that they possess at least a memory of their old duties.

In his last essay, that which treats of the transmission of acquired characters, Weismann reasserts strongly their non-transmissibility, be they produced in any way whatever. At the same time, he seems to me to introduce a new explanation of variation, and to make admissions which may prove fatal to his theory. It must be recollected that Weismann has been contending for the stability of the germ-plasm; that, in order to account for the variations that individuals show, he has invoked the agency of sexual mixture, which he regards as an invention of nature for that special purpose; that he has claimed that animals reproducing by parthenogenesis can undergo no adaptive changes. When speaking of the effect of external influences he says: "Without altogether denying that such influences may directly modify the germ-cells, I nevertheless believe that they have no share in the production of hereditary individual differences." He has just previously maintained that the transformation of a species can take place only through the accumulation of these individual differences. Now in the last essay, in discussing certain objections which have been urged against his doctrines, he contends that external conditions, light, heat, moisture, nutrition, and their opposites, can produce great changes in the body, but none directly in the germ-plasm. He grants, however, that the environment may act *indirectly* on the germ-plasm, so as to bring about important changes in the characters of animals and plants. He declares that he has never doubted the transmission of changes which depend on alterations of the germ-plasm. He then inquires: "And how could the germ-plasm *be changed* except by the operation of external influences, using the words in their widest sense?" To this we may reply, that he has hitherto attributed all changes to sexual mixture alone. If he is willing to admit that use and disuse of organs, changes in nutrition, and in the environment in general, may bring about modifications of organisms, he will not find it difficult to come to an agreement with many of his opponents, even if he does insist on postponing the results for a few generations. A few may insist that some characters acquired by the parent, for instance by the use of an organ, may be inherited by the next generation, but most persons would contend only that a predisposition to the reproduction of the character is inherited.

PAPERS READ.

CONDENSATION OF ACETOPHENONE WITH KETOLS BY MEANS OF DILUTE POTASSIUM CYANIDE. By ALEX. SMITH.

[ABSTRACT.]

It has been proven for some years that when benzaldehyde is boiled in dilute alcohol with a small quantity of potassium cyanide, two molecules of benzaldehyde unite to form benzoin. The present paper describes a class of cases where the same reagent has the power of causing the union of two bodies with the elimination of water—a condensation. The interaction takes place between a ketol such as benzoin, on the one hand and a ketone such as acetophenone on the other. For example benzoin and acetophenone in dilute alcoholic solution, in presence of a little potassium cyanide, yield on boiling desyl-acetophenone. (Jour. Chem. Soc. LVII, p. 643.)

$$\underset{\textstyle C_6H_5}{C_6H_5—CO—\overset{}{CH}—OH} + CH_3—CO—C_6H_5 =$$

$$\underset{\textstyle C_6H_5}{C_6H_5—CO—CH—CH_2—CO—C_6H_5} + H_2O$$

The interaction is now found to extend to other ketols. From cuminoin and acetophenone, cumino-desylacetophenone was prepared according to the equation—

$$C_{20}H_{24}O_2 + C_8H_8O = C_{28}H_{30}O_2 + H_2O$$

It is a substance melting at 145° C. With phenyl hydrazine it yields an o-diazine derivative and its constitution as a 1:4 diketone was proved by its yielding furfurane and pyrrol derivatives. Piperonoin, furoin, and benzoylcarbinol have also been used, and the interaction seems to hold for them also. The products have not yet been fully investigated.

In all cases a small amount of another, much less soluble, product is formed. The equation for this action seems in the case of benzoin to be—

$$3C_6H_5\cdot COH + C_8H_8O = C_{29}H_{22}O + 2H_2O$$

The examination of these products is in progress.

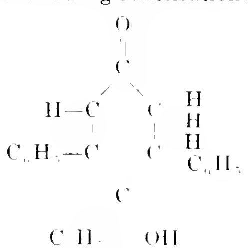
Condensation of Acetone with Benzoin by Means of Dilute Potassium Cyanide. By Alex. Smith.

[Abstract.]

In connection with the work mentioned in the preceding paper, experiments were also made where the ketol was benzoin but acetone was used in place of acetophenone. The main course of the interaction was an entirely different one. A substance melting at 246° C was produced according to the equation—

$$3C_6H_5\cdot COH + C_3H_6O = C_{24}H_{20}O_2 + 2H_2O$$

It appears to possess the following constitution:

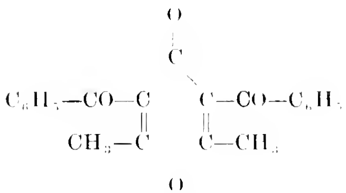


It yields a monoxim and a monophenyl hydrazone. With acetic anhydride it yields the acetate of triphenyl phenol. From this triphenyl phenol itself is obtained by saponification. Distillation over zinc dust yields the hydrocarbon triphenyl benzene and the original substance yields the same product under similar treatment. A substance, found to have almost identical properties, is described by Japp (Chem. Soc. Jour., vol. LVII, p. 783). He had formerly ascribed to it the formula $C_{16}H_{10}O_{1}$. In the later note he points out that the analysis agrees approximately with the formula $C_{24}H_{20}O$. The substance was prepared by Japp's method, namely the action of dilute caustic potash on a mixture of benzoin and acetone in alcoholic solution. It appears to be the same body as that obtained by the action of potassium cyanide, but acetic anhydride acts on it with extreme difficulty only and distillation over zinc dust yields none of the hydrocarbon.

PYRONE AND PYRIDONE DERIVATIVES FROM BENZOYL ACETONE. By ALEX. SMITH.

[ABSTRACT.]

Conrad and Guthzeit's reaction was applied to benzoyl acetone. Cuprobenzoyl acetone was found to yield with phosgene a pyrone derivative possessing the formula—



Dimethyldi-benzoyl pyrone melts at 188° C. With phenyl hydrazine it yields a diphenyl hydrazone and with ammonia the oxygen of the ring is replaced by the group :NH and dibenzoyl-lutidone is formed. Similarly the action of aniline gives dibenzoylphenyl-lutidone. These substances are bases whose hydro-chlorides form double salts with platinum tetrachloride.

CARBON DIOXIDE IN THE URINE. By T. C. VAN NUYS and R. E. LYONS.

From the intense alkalinity of the normal urates, as well as the di and basic phosphates of potassium and sodium, we were led to believe that, ordinarily the urine is not alkaline from the presence of the carbonates of the alkali metals; that in all probability CO_2 is not in combination in normal or moderately alkaline urine.

To determine this, the CO_2 in the total urine of 24 hours was estimated after employing, (1) mixed diet, (2) vegetable diet, (3) after injesting large doses of neutral tartrate of sodium.

(1). Mixed diet—Urine acid in reaction.

First day . . .	0.64 gram. CO_2.	Fourth day . .	0.56 gram. CO_2.
Second day . .	0.49 " "	Fifth day . . .	0.45 " "
Third day . . .	0.60 " "	Sixth day . . .	0.79 " "

Average for each day, 0.588 gram. CO_2.

(2). Vegetable diet—Urine strongly alkaline, but did not effervesce on the addition of an acid.

First day	1.20 gram. CO_2.	Average for each day, 1.09 gram. CO_2.
Second day	1.16 " "	
Third day . . .	0.93 " "	

(3). After injesting neutral tartrate of sodium urine became alkaline, which was in part due to carbonates, as the urine effervesced *slightly* on the addition of acid.

First period 48 hours following "mixed diet":	Gram. $C_4H_4Na_2O_6$ taken in 24 hours:	Gram. CO_2 in the urine of 24 hours:
First day	10	1.42
Second day	10	1.65
Second period 48 hours following "vegetable diet":		
First day	15	1.30
Second day	15–17	2.67

From our investigations we conclude:

1. Combined CO_2 is not ordinarily a constituent of normal urine.

2. When CO_2 does appear in combination, it is owing to the excessive alkalinity of the blood when it combines with the hydrates of potassium and sodium.

3. Alkalinity of normal urine, unless excessive in degree, is caused by di- or tri-basic phosphates, and normal urates of potassium and sodium.

RESULTS OF ESTIMATION OF CHLORINE IN MINERAL WATERS BY VOLHARD'S PLAN. By SHERMAN DAVIS.

In "Die Untersuchung des Wassers," by Drs. Tierman and Gärtner, page 132, we find directions for the estimation of chlorine in mineral waters. The method given is essentially that of Volhard. It is the object of this paper to call attention to two points in this process: First, though it has been remarked by previous observers that there is a reaction between the *silver chloride* formed and the ammonium sulphocyanide, is not this reaction sufficient to produce an appreciable error? We here give some observations made, with this point in view.

WITH DISTILLED WATER.

No.	Time	Filtered.	$\frac{1}{10}$ N. Na Cl.	$\frac{1}{10}$ N. $Ag.NO_3$	$\frac{1}{10}$ N Am. Sulph.	Ferric Alum.	HNO_3 (1.2)
	Min.						
1 .	5	no	4	1.62	3	3	3
2 . .	5	"	"	5½	1.85	"	"
3 . .	3	"	"	"	1.70	"	"
4 . .	2	"	"	"	1.70	"	"
5 . .	3	"	"	"	1.75	"	"
6 .	2	"	"	"	1.65	"	"
7 . .	1½	"	"	"	1.70	"	"
8 . .	2	"	"	"	1.80	"	"

These data seem to indicate that even though the time be reduced to a minimum, the results are inconsistent and misleading. Now these variations may be eliminated by a process of *filtering*. Introduce a quantity of sodium chloride, say 4cc from a $\frac{1}{10}$ normal solution, into a 200cc graduated flask, add 4cc nitric acid (1.2 sp. gr.), free from *nitrous acid*, and with distilled water at 15° C fill to mark. Mix well. When the silver chloride has been separated, filter off 100cc of the fluid through a *dry filter*. Introduce the filtrate into a titrating flask, add 2—3cc sat. sol. ferric alum and titrate with the $\frac{1}{10}$ nor. sol. am. sulphocyanide, till the addition of one drop causes a light brown color to appear. This color once produced will be permanent. The results of such a device are shown by the following data:

No.	Time	Filtered.	$\frac{1}{10}$ N Na Cl.	$\frac{1}{10}$ N Ag. NO_3	$\frac{1}{10}$ N Am. Sulph.	Ferric Alum.	HNO_3 (1.2)
1 . .	. . .	yes	4cc	7cc	1.55	3	3
2 . .	. . .	"	"	"	1.50	"	"
3 . .	. . .	"	"	"	"	"	"
4 . .	. . .	"	"	"	"	"	"
5 . .	. . .	"	"	"	"	"	"
6 . .	. . .	"	"	"	"	"	"
7 . .	. . .	"	"	"	"	"	"
8 . .	. . .	"	"	"	"	"	"

These results agree with the quantities introduced and are constant. This device was employed in estimating the chlorine in the waters from West

Baden, French Lick, Mt. Aris, Indian and Trinity Springs. The results were *constant* and *accurate*. It also holds in waters containing much mineral matter and organic matter to 350 parts in 100,000.

Second. Will there, without filtering, be an appreciable error? We produce the following data:

WITH DISTILLED WATER.

No.	Time.	$\frac{1}{10}$ N Na Cl.	$\frac{1}{10}$ N Ag. NO_3	$\frac{1}{10}$ Am. Sulph.	Ferric Alum	HNO_3 (1.2)
1 . . .	1	3cc	3.5cc	.78cc	3	3
2 . . .	5	5	3.5	.75	"	"
3 . .	10	3	3.5	.75	"	"
4 . . .	12	"	"	.82	"	"
5 . . .	10	"	"	.75	"	"
6 . . .	10	6	6.5	1.00	"	"
7 . . .	10	6	6.5	.88	"	"
8 . .	10	"	"	1.00	"	"

We differed from the authors in this—that the solution was *gently* agitated until the color no longer disappeared. With such a standard the error may reach 1.77 pts. in 100,000 pts. as shown by the eighth titration. The observations justify the following inferences:

First. There is an appreciable reaction between the silver chloride and the ammonium sulphocyanide.

Second. The error varies directly with the quantity of chlorine present, and the time employed.

Third. When the reaction of chlorine upon silver nitrate is effected in the presence of ammonium sulphocyanide, the results are inconstant.

Fourth. That it is necessary to filter off the silver chloride, before adding the ferric salt.

Fifth. That by filtering the results are *very* accurate.

Sixth. That if the solution, unfiltered, be allowed to stand ten minutes, the reactions which take place, will produce very appreciable errors.

SOME SUGGESTIONS TO TEACHERS OF SCIENCE OR MATHEMATICS IN HIGH SCHOOLS.

By THOS. C. VAN NUYS.

It is the purpose of the writer to endeavor to indicate, as briefly as practicable, the spirit which should influence teachers of science or mathematics in high schools.

It is needless to state in this connection that the spirit, in which a teacher performs his duty, arises from his conception of what education is, consequently, correct views of education in general, are of very great importance to teachers. No system of education can exist, without grave defects, unless there is in the system a certain degree of uniformity in the curriculum of study. Classes of studies for periods of time should be so grouped, that by the pursuit of them, the pupil is led to the highest degree of discipline and culture. Fortunately, the course of study in the public schools of this country is pretty well formulated, but, unfortunately, the course is better adapted for preparing pupils for technical or business education than for scholarship or the learned professions. This defect, however, may, in part, be remedied by the efficiency of teachers.

In order that the teacher of elementary science or mathematics in a high school may become proficient in his work he should first determine what benefit are the pupils to derive from a course of instruction in mathematics and elementary science. Notwithstanding, the tendency of the age is in favor of technical education, the fact is, no class of studies can take the place of the inflected languages, history and literature for a high degree of discipline and culture, and, that full benefit should be derived from linguistic studies, they should be introduced, early in the course, as training in them is easier at an early age.

The study of the humanities, if pursued early in life, when the emotional faculties are springing into existence, results in refining, cultivating the tastes and engendering a broad philanthropy. This is readily understood when it is taken into consideration that through the study of the ancient languages, the pupil becomes acquainted with different phases of human thought, and, because different from modern thought, they are not the less human.

With thorough training in these studies, early in life, the pupil becomes disciplined and refined, disciplined, by long continued mental drill, necessary in acquiring knowledge of the inflected languages, and refined, by sympathy for mankind acquired by a knowledge of the vicissitudes through which the human race has passed. This comes from the study of the humanities being subjective as well as objective. On the other hand, the study of science and mathematics is objective. In these pursuits, the emotions may be dormant, while reason is called into activity. If this be true, it is readily understood why the study of languages, history and literature should precede the study of the sciences and higher mathematics.

To reach the highest results in education the tastes, the moral faculties and the sensibilities should be developed as well as the intellectual; otherwise, the development is not symmetrical.

The teacher should not encourage the popular opinion that the education which does not enable a person to superintend a factory, make shoes, or build a bridge, is worthless.

In this materialistic age we are apt to employ our educational forces so as to intensify the mad strife we have about us, to make prominent those studies, by a knowledge of which, wealth is acquired and to neglect those studies which tend to refine, temper and balance the mind.

The word discipline is perhaps the most difficult term in pedagogical science to define. No attempt will be made to offer a definition here, further than to state, that by discipline, the pupil has power of self-control, that by it, undivided attention can be concentrated to the subject under consideration. By discipline, there is economy in mental work. The mind is disciplined when it possesses the art of thinking. To many it would seem absurd that it requires many years of systematic study, under good instruction to read a book, or study a subject with profit and, therefore, with understanding, and yet, it is true. While it is claimed that the study of the inflected languages, history and literature, pursued early in life, is imperative for discipline, culture and scholarship, yet if the study of higher mathematics and science be not subsequently pursued (and it might be added in proper spirit), the work of preparation is incomplete.

It is a recognized fact that the body soon becomes accustomed to certain movements which are, with sufficient practice, made almost unconsciously, so the mind, with practice, soon becomes accustomed to certain processes of reasoning.

Although the study of the humanities presents many aspects of thought, yet the mind of the classical student runs in grooves. For him the study of higher mathematics opens up a new field of thought as the processes of reasoning are essentially different from those employed in the study of the humanities.

Method and system in the processes of reasoning are characteristic of the mathematical mind.

The study of chemistry is of importance as a means of cultivation of the powers of observation, but, perhaps, the greatest value of the study of chemistry, is the knowledge of the constitution of matter and the changes it undergoes, producing new bodies. The cultured pupil reads here a wonderful story. His mind dwells on the growth and consequent changes of living languages, so rapid are these changes that a language is scarcely the same each decade. Every period of history is stamped with changes. Nations grow like plants, remain in the developed state a time, then they decline and upon their ruins other nations spring up, likewise to perish. The student reads in chemical science a similar story told in symbolic language. Hitherto he knew but little of the laws of matter, he now learns that matter and its laws form the basis of all. Were it not for the facts on which the atomic theory is based and were it not that forces are evolved by the reduction of organic matter there could be no mental process, in fact no brain, no muscle. Now, while this expresses a phase of materialistic philosophy yet the pupil who has a thorough training in the studies of the humanities is not easily thrown off his balance. By his long continued training he recognizes the fact that the moral sense or sentiment is a potent factor in nature, that man is not a selfish animal seeking to survive that he may enjoy his sensuous pleasures. Although the age is becoming more rationalistic, yet there never was a time when society was subject to so much vaccillation, frivolity and extremes. The craze for something new or sensational precludes sober thought. We may as a nation excel all others in inventions and conveniences and yet we may become a nation of artisans and tradesmen. The pupil who is educated in the humanities, and therefore has a disciplined mind, does not seek for wild theories, even if founded on the results of modern research. Too many men, who represent the results of the new education are without convictions. The character of too many is reflected by current of popular opinion. The greatest need of this age is a generation of men, cultured and disciplined, who have convictions and therefore are not moved by the great waves of thought which often sweep over the country like an epidemic.

The teacher of science, or higher mathematics, in a preparatory school, should consider himself employed to build over, or bridge a chasm at the end of a long line. He should consider his work a necessity to fill out, and round up the intellectual and moral character of the pupils, under his charge.

However different his work may appear from the work of his colleague who teaches the Greek language, or his colleague who studies, with his classes, Shakspeare, Dante or Milton, his work is along the same line. The teacher of science will benefit his pupils much more by confining his instruction to general principles, whether he teaches elementary chemistry, botany or zoology.

After having spent years of persistent study of languages, literature and history, acquiring a knowledge of the inflections of verbs, memorizing the definition of words and becoming familiar with the outline of all forms of speech, with the political divisions of countries of the remote past—in short, with the life of a world in its childhood and now to be introduced into the world of the present, constitutes the most interesting period in the life of the pupil. The teacher guides with watchful care the mental processes awakened by the study of nature. He witnesses a wonderful mental development, wonderful because it springs from a rich store-house of knowledge and because the mental processes are new.

After all, the ultimate object of education is utilitarian in character. The educated man or woman, who is a useful member of society, who is of value to the state, must be of the world. He must be brought in intimate relationship with the affairs of the present, and, for this purpose, the study of science and mathematics is well adapted. A full degree of utilitarianism is not wholly technical in kind. To become useful in any of the learned professions all of the discipline afforded by classical and scientific training, in addition to the training in the professional studies proper, is required.

If education is to be the safeguard of the nation, if it is to prevent the enactment of extreme measures, if it is to act as the balance wheel in the machinery of the social state, it must result in the development of all the resources of the intellect as well as the sense of justice and love of humanity.

THE SUGAR BEET IN INDIANA. By H. A. HUSTON.

FORMS OF NITROGEN FOR WHEAT. By H. A. HUSTON.

A COPPER AMMONIUM OXIDE. By P. S. BAKER.

Di benzyl carbinamine. By W. A. Noyes.

[ABSTRACT.]

[Published in the American Chemical Journal, 14, 225.]

Di-benzyl carbinamine was prepared by the reduction of the oxim of di-benzyl-ketone by means of sodium and absolute alcohol.

The new base melts at 47° and boils at 330°. The chloride, $C_{15}H_{15}NH_2$. HCl, separates in compact crystals which melt at 205°. The chloro-platinate, the nitrite and the di-benzyl carbinamine sulphocarbamimate of di-benzyl carbinamine, $\genfrac{}{}{0pt}{}{C_{15}H_{15}NH}{C_{15}H_{15}NH_2HS} > CS$, were also prepared.

Especial interest attaches to the nitrite which is stable at ordinary temperatures, and a dilute solution of which can be boiled with very slight decomposition. In these respects the base is intermediate in its properties between the "alicyclic" bases of Bamberger and the ordinary aliphatic amines.—[Rose Polytechnic Institute, Dec. 1891.

The character of well waters in a thickly populated area. By W. A. Noyes.

[ABSTRACT.]

A table was shown giving the results of the analysis of a number of well-waters taken from wells in various parts of the city of Terre Haute. The amounts of free and of "albuminoid" ammonia in these well waters is usually very low, but the amounts of chlorine and of nitrates, and especially the latter, when compared with the amounts of the same substances found in a well water in the country east of the city show that the waters of the city wells are seriously contaminated with surface drainage. The fact that a large proportion of the cases of typhoid fever and of dysentery (477 cases out of 500 cases investigated) occur in families where well water and not hydrant water is used for drinking purposes justifies the condemnation of such well waters, even where the amount of organic matter in the water is very small.—[Rose Polytechnic Institute, Dec. 1891.

LABORATORY AND FIELD WORK ON THE PHOSPHATE OF ALUMINA. By H. A. HUSTON.

RECENT METHODS FOR THE DETERMINATION OF PHOSPHORIC ACID. By H. A. HUSTON.

THE DIGESTIBILITY OF THE PENTOSE CARBOHYDRATES. By W. E. STONE.

THE ACTION OF PHENYL-HYDRAZIN ON FURFUROL. By W. E. STONE.

A GRAPHICAL SOLUTION FOR EQUATIONS OF HIGHER DEGREE, FOR BOTH REAL AND IMAGINARY ROOTS. By A. S. HATHAWAY.

*1. Preliminary on imaginary numbers.

The usual idea of imaginary numbers, as presented in our text books of algebra, is that they are symbols introduced for the sake of making the laws of algebra formally complete. It is implied in the name given to these numbers that they have no actual meaning. This is a mistake. The failure to mean anything in ordinary cases is not the fault of the numbers, but results from the nature of the concrete quantities with which they are generally used. Like difficulties are experienced with real numbers under similar circumstances. Let us go briefly over the list of numbers and emphasize this point.

First, the numbers 1, 2, 3, 4, that denote repetitions of a concrete quantity. If the quantity be incapable of the indicated repetition the result is imaginary. Thus: Three spaces of four dimensions. This may be comprehensible to a different order of beings, but not to us.

Second, the numbers $\frac{1}{2}$, $\frac{1}{3}$, $\frac{1}{4}$, that denote partitions of a concrete quantity. Nevertheless, a space of $\frac{1}{2}$ a dimension, a school of $\frac{1}{4}$ a student, are impossibilities.

Third, the number -1. This number must be used with quantities of two kinds such that two of equal magnitude and different kinds give, when

*NOTE.—This preliminary on the graphic representation of imaginary numbers was not presented to the Academy. It is a simple and direct presentation of the subject without the use of analytical geometry, and on that account may be interesting to mathematicians; at the same time, it places the whole article upon an elementary basis, and makes it available to a larger circle of readers.

combined, zero result; e. g., assets and liabilities. In this case -1 reverses quality without altering magnitude, so that $1 + (-1) = 0$. But what is a farm of -80 acres? Imagine a farm that put with an 80 acre farm gives no land at all.

Fourth, the incommensurable numbers, e. g., the ratio of a diagonal to a side of a square. These require continuous quantity, and their use with quantity whose partitions are limited is impossible. What is a space of $\sqrt{2}$ dimensions, a country with $\sqrt{2}$ presidents, a man with $\sqrt{2}$ dollars in his pockets?

We recognize a number by what it can do with appropriate quantity to operate upon, not by what it can not do with inappropriate quantity. The interpretation of imaginary number requires quantity that has magnitude and different qualities. These quantities, whether geometrical or physical, may be represented by certain geometrical quantities called by Clifford steps.

The step from a position A in space to another position B has length and direction. Two steps are equal that have the same length, and the same direction; i. e., the opposite sides of a parallelogram taken in the same direction are equal steps. The sum of any number of successive steps in various directions is the step from the first point of departure to the last point reached: e. g., $AB + BC + CD = AD$. In particular the sum of two successive steps along the sides of a parallelogram is equal to the step along the diagonal. As the remaining sides in the parallelogram form equal steps added in reverse order, we learn that the order of successive steps in a sum may be changed without altering the sum.

Positive numbers operating on steps change lengths but not directions: -1 reverses direction without altering length; e. g., $-1\ AB = BA$. If x be any real number we see by similar triangles that $x\,(AB + BC) = x\,AB + x\,BC$.

A valuable analysis may be developed by the use of steps and real numbers only. From its simplicity, and its value in physical applications, it ought to displace ordinary analytical geometry, in technical schools at least. The main difficulty is the lack of a suitable text book.

Let us confine ourselves, now, to steps in the plane of the paper, and consider the nature of the number that multiplying O A produces O B. It must alter the length of O A into the length of O B; this is the tensor factor, an ordinary positive number. It must turn O A thus lengthened into O B; this is the versor factor; the angle of this turn, reckoned as positive when it is counter clockwise, is the angle of the number. Thus, let $(2, 30°)$ denote a number that doubles length and turns 30° counter clockwise. Its tensor is 2, its versor is $(1, 30°)$, and its angle is 30°.

After multiplying a step by $(2, 30°)$ multiply the result by $(3, 20°)$. Plainly the final step is $(6, 50°)$ times the first step. This example of a product enables us to see at once that:

The tensor of a product equals the product of the tensors of the factors: and the angle of a product equals the sum of the angles of the factors. Hence the factors may be combined in any order without altering their product.

The definition of a sum of two numbers p and q is that $(p + q) O B = p O B + q O B$.* Replacing O B by r O A we have that $(p + q) r = p r + q r$; and since the factors of a product have been shown to be interchangeable, therefore $r (p + q) = (p + q) r = r p + r q$.

We thus find that these versi-tensors follow the ordinary laws of algebraic combination. To identify them with imaginaries, notice that $(1, 90°)^2 = (1, 180°) = -1 = (1, -90°)^2$. These two square roots of −1 are negatives of each other, for $-1 (1, -90°) = (1, 180°) (1, -90°) = (1, 90°)$. So −1 has three cube roots, −1 and $(1, \pm 60°)$; and so on.

It is convenient to represent versi-tensors by steps. Some step O A is taken to represent unity; and then any other step represents its ratio to the unit step O A. Thus, if O B, O B¹ are steps of the same length as O A, and make angles of 60° and −60° respectively with O A, they represent the imaginary cube roots of −1. We may use geometry to put these roots in the standard form $x + y i$, where x and y are real numbers and $i = (1, 90°)$. Let B B¹ meet O A in C; then O C represents, or say =, ½, and $C B = \frac{1}{2}\sqrt{3}\, i = - C B^1$; and from $O B = O C + C B$, $O B^1 = O C + C B^1$, we have $(1, \pm 60°) = \frac{1}{2} \pm \frac{1}{2}\sqrt{3}\, i$.

This example just given makes it plain that any imaginary number may be put in the form $x + y i$, in one and only one way; and from the right triangle involved, we also see that the tensor of $x + y i$ is $\sqrt{x^2 + y^2}$, the so-called modulus in imaginaries. It is easy to show by geometry how it is that every equation with real or imaginary co-efficients has at least one root, and therefore just as many roots as its degree and no more, or even to show the whole directly.* In fact, all the fundamental properties of imag-

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*To see that this does define the sum, try it for the case of $p = (2, 30°)$, $q = (2, 150°)$, which gives $p + q = (2, 90°)$. Also compare with the verification that 2+3=5.

inaries may be made visible realities rather than symbolic results based upon certain assumptions.

When dealing with steps not limited to the plane of the paper, then (O A, n°) may be taken as the symbol of a number that turns any step that is perpendicular to O A, n° round O A as axis, counter clockwise to an observer at A, and lengthens in the ratio of the length of O A to the unit length. This is a quaternion. Quaternions whose angles are o° or 180° are ordinary positive and negative numbers, and are called scalars. Quaternions whose angles are 90° are called vectors. The square of a vector is a negative scalar. The ordinary rules of algebra hold except that factors are not interchangeable without altering the product. A quaternion, also, cannot multiply a step that is not perpendicular to its axis. It can be geometrically represented only by two steps. A vector (O A, 90°) or briefly (O A) may be represented by the step O A. The value of this representation is expressed by the equations:

$$(O B) + (O A) = (O B + O A)$$
$$(O B) : (O A) = O B : O A.$$

The calculus of quaternions is superior for all purposes of investigation to analytical geometry, and as its results can be immediately turned into analytical formulas, it is likely to be very much used and developed in the future. It is especially valuable in mathematical physics. An account of the system by Sir Wm. Rowan Hamilton, the inventor, was first presented to the Royal Irish Academy in 1843. The first book upon the subject, "Hamilton's Lectures," appeared in 1853.

II.

Let $a x^3 + b x^2 + c x + d = o$ be an equation with general imaginary co-efficients. Divide this by $x - r$: the quotient is $a x^2 + (a r + b) x + (a r^2 + b r + c)$ and the remainder is $a r^3 + b r^2 + c r + d$. The co-efficients of the quotient, and final remainder are best found by synthetic division, which shows the general method of forming each co-efficient by multiplying the last by r and adding the next co-efficient of the original equation. The process is identical with the reduction of the compound number (a, b, c, d) whose radix is r. The test of a root is that the remainder should be zero.

The steps that represent these numbers may be constructed as follows:

Take in the plane of the paper steps O A, A B, B C, C D, representing the numbers a, b, c, d. Take any point A′, and let A′ A : O A be the r we are to try in the equation for x. To find the result of the trial, construct the triangle A′ B′ B similar to O A′ A, and then the triangle B′ C′ C, also similar to O A′ A. We have O A = a, A′ A = a r, and hence A′ B = A′ A + A B = a r + b; also by similar triangles, B′ B = r A′ B = a r^2 + b r, and hence B′ C = B′ B + B C = a r^2 + b r + c. Again by similar triangles, C′ C = r (a r^2 + b r + c) = a r^3 + b r^2 + c r and hence C′ D = C′ C + C D = a r^3 + b r^2 + c r + d, the remainder sought; moreover, the co-efficients of the quotient are represented by O A, A′ B, B′ C. The problem is to so choose the first point A′ that the last vertex C′ of the series of similar triangles O A′ A, A′ B′ B, B′ C′ C, shall coincide with D: then A′ A : O A is a root of the given equation. With the ability to construct a series of similar triangles with ease, a position for A′ may be approximated to without much difficulty. Observe that O A′, A′ B′, B′ C′ are equi-multiples of O A, A′ B, B′ C. This follows from the similar triangles O A′ A, A′ B′ B, B′ C′ C, which give O A′ : O A = A′ B′ : A′ B = B′ C′ : B′ C both as to tensor and angle parts. Hence the circuit O A′ B′ C′ represents the quotient on the new scale in which O A′ instead of O A represents the first co-efficient a.

If the co-efficients of the given equation are all real numbers and only the real roots are sought, the method fails, since A′ must be taken on O A produced giving no triangle O A′ A. In such a case, put x = $\frac{z}{m}$ where m is a given versor, say (1, 60°), or (1, 90°); the equation becomes:

$$a z^3 + m b z^2 + m^2 c z + m^3 d = o.$$

The figure O, A, B, C, D that represents the co-efficients of this equation will have equal angles at A, B, C, viz.: the supplement of the angle of m (since a, b, c, d are real numbers, their angles are 0 or 180°). We are to seek for roots of this equation whose angles are, angle of m or angle of m+180°. (Since z = m x, therefore angle z = angle m + angle x.) Thus A′ must be taken on A B produced; and since the angles at A, B, C, are equal, it follows that the similar triangles required will have their vertices B′, C′ on B C, C D, produced, so that the construction of these triangles is simplified, e. g., to find B′, draw from A′ a line making with O A′ an angle equal to the angle A; that line meets B C in B′. The broken line O A′ B′ C′ has its angles A′, B′ equal to the angles A, B, and its vertices A′, B′, C′ in the sides A B, B C, C D; trials of this construction must be made until C′ co-incides with D, when A′ A : m O A is the real root of the equation in x.

Taking m = (1, 90°), this is Lill's construction for the real roots of an equation with real co-efficients. Lill has devised an instrument for facilitating his construction, which is described as follows (Cremona Graph. Statics (Beare), p. 76):

"The apparatus consists of a perfectly plane circular disc, which may be made of wood; upon it is pasted a piece of paper ruled in squares. In the center of the disc, which should remain fixed, stands a pin, around which as a spindle another disc of ground glass of equal diameter can turn. Since the glass is transparent, we can with the help of the ruled paper underneath, immediately draw upon it the circuit corresponding to the given equation. If we now turn the glass plate, the ruled paper assists the eye in finding the circuit which determines a root. A division upon the circumference of the ruled disc enables us by means of the deviation of the first side of the first circuit from the first side of the second, to immediately determine the magnitude of the root. For this purpose the first side of the circuit corresponding to the equation must be directed to the zero point of the graduation."

Linkages might be found to perform mechanically what must be done by successive approximations in the method above, viz.: to bring the last vertex C′ into co-incidence with D. Kempe has given some linkages for a different construction. [See Messenger of Mathematics, Vol. 4, 1875, p. 124.]

III.

The following constructions are given as illustrations:

(a.) Roots of $2x^2 + 4x + 1 = o$. [Fig. I.]

As the co-efficients are all real it is preferable, and for real roots necessary, to transform the equation by putting $x = \frac{z}{m}$, $m = (1, 90°)$. The equation becomes $2z^2 + 4mz + m^2 = 0$, and O A = 2, A B = 4 m, B C = $m^2 = -1$. If A′ A : O A is a root of this equation then, dividing by m, we find A′ A : m O A as a root of the original equation. If this is real A′ must lie on A B, produced if necessary. Remember that A′ is such that O A′ A, A′ C B are similar triangles and we see that the angle O A′ C is a right angle when A′ lies on A B. Hence the circle on O C as diameter cuts A B in the sought points A′, A″. From the figure the roots A′ A : m O A, A″ A : m O A are approximately —.3 and —1.7.

(b.) Roots of $2x^2 + 2x + 4 = 0$. [Fig. II.]

Here O A = 2, A B = 2 m, B C = $4m^2 = -4$. The circle on O C as diameter does not cut A B and the roots are imaginary. Since O A′ A, A′ C B are similar, therefore A′ is equally distant from A and B, and that distance is mean proportional between O A and C B. A circle with this mean proportional as radius and center at A or B will therefore cut the perpendicular erected at the middle point (M) of A B in the sought points A′, A″. The circle with center at M and cutting the circle on O C as diameter at right angles also passes through these points. Conceiving the step m. O A drawn from A′ we see that M A and A′ M, A″ M are the real and imaginary components of the roots. The roots given by A′ and A″ are by the figure $-\frac{1}{2}-1.3m$ and $-\frac{1}{2}-1.3m$.

(c.) Real root of $2x^3+4x^2-8-4=0$.

We have O A = 2, A C = 4 m, B C = $8m^2=-8$, C D = $4m^3=-4m$. The circuit O A′ B′ D was drawn by aid of transparent paper turned round a pin with cross section paper underneath, after the manner of Lill's wooden and ground glass discs. The root, A′ A : m O A = tan A′ O A, may be read off from the cross section paper to several decimal places. It is here $-.64\ldots$.

O A′ B′ D is the circuit for the quadratic equation that gives the remaining pair of roots of the cubic. The circle on O D as diameter will not cut A′ B′ so that these roots are imaginary.

ON SOME THEOREMS OF INTEGRATIONS IN QUATERNIONS. By A. S. HATHAWAY.

There are certain identities among volume, surface and line integrals of a quaternion function q = f(h) that include as special cases the well known theorems of Green and Stokes, that are so often employed in mathematical physics. These indentities were first demonstrated by Prof. Tait by the aid of the physical principles usually employed in forming the so-called "Equation of Continuity." [See Tait's Quatermous, third ed., ch. XII J.]

If dh d_1h, d_2h be non-coplanar differentials of the vector h, the theorems may be written:

(1) $-\int\int\int S dh d_1h d_2h \cdot \nabla q = \int\int \mathbf{V} dh d_1h . q$

(The surface integral extends over the boundary of the volume integral and $\mathbf{V} dh d_1h$ is an outward facing element of the surface.)

(2) $\int\int \mathbf{V}(\mathbf{V} dh d_1h . \nabla).q = \int dh q$

(The line integral extends over the boundary of the surface integral in the positive direction as given by the vector areas $\mathbf{V}$ $dh d_1h$.)

These theorems are analogous to the elementary theorem,

(3) $\int_A^B dq = q_B - q_A$ or in quaternion notation,

$-\int S dh \nabla . q = q$

It has not been noticed, so far as I am aware that these identities are equivalent to simpler identities pertaining to the operator ∇, as follows:

(1)′ $Sdhd_1hd_2h.\nabla = Vd_1hd_2hSdh\nabla + Vd_2hdhSd_1h\nabla + Vdhd_1hSd_2h\nabla$

(2)′ $V(Vdhd_1h.\nabla) = dhSd_1h\nabla - d_1hSdh\nabla$

In fact (1) and (2) become these (into q) when applied to the elements of volume and surface just as (3) becomes $Sdh\nabla = d_1$ (into q) when applied to the element of length.

To identify (1) and (1)′, let h be the vector of the mean point of the parallelopiped whose edges are dh, d_1h, d_2h. The outward vector areas of the two faces parallel to d_1h, d_2h are $-Vd_1hd_2h, Vd_1hd_2h$, and the corresponding values of q are $q+\frac{1}{2}Sdh.\nabla.q$, $q-\frac{1}{2}Sdh\nabla.q$; so that sum of the vector areas into q is $-Vd_1hd_2hSdh\nabla.q$. Similarly for the other faces.

So to identify (2) and (2)′, the line elements bounding the parallelogram dh, d_1h are $dh, d_1h, -dh, -d_1h$, and the corresponding values of q are $q+\frac{1}{2}Sd_1h\nabla.q$, $q-\frac{1}{2}Sdh\nabla.q$, $q-\frac{1}{2}Sd_1h\nabla.q$, $q-\frac{1}{2}Sdh\nabla.q$ and the sum dbq is $dhSd_1h\nabla.q - d_1hSdh\nabla.q$.

To obtain (1) from (1)′ divide the given volume into infinitesimal parallelopipeds by any three systems of surfaces, one of which includes the boundary of the volume. In summing the terms (1)′ the introduced interior surfaces between adjacent elements of volume are gone over twice with the vector areas oppositely directed. These surfaces balance one another, therefore, and may be dropped from the summation, leaving the volume integral equal to the surface integral over the boundary of the volume integral.

We see also that if any discontinuity in q or its derivatives exists within the given volume that the proper way to overcome this is to surround the discontinuity by surfaces and so exclude the discontinuity. Usually this alters only the surface over which the surface integral extends without affecting the volume integral.

Similarly (2) is obtained from summation of (2)′ and, as every student of integral calculus is aware, (3) is obtained from dq in a similar manner.

THE SECTIONS OF THE ANCHOR RING. By W. V. BROWN.

Note on the early history of the potential functions. By A. S. Hathaway.

This is to call attention to an injustice that has been done by Todhunter in his "History of the Theory of Attractions" in assigning to Laplace instead of Lagrange the honor of the introduction of the potential function into dynamics. This injustice has been perpetuated by various encyclopedias, notably the Encyclopedia Britannica, and by leading text books, such as Thompson and Tait's Natural Philosophy, and Maxwell's Electricity and Magnetism. In an article in Vol. 1 No. 3 of the Bulletin of the New York Mathematical Society (Dec. 1891) I have shown conclusively that Lagrange anticipated Laplace by at least ten years in investigations on the potential. Laplace's first announcement is fixed by Todhunter as between 1783 and 1785, and this was merely through the paper of another, Legendre. Lagrange on the other hand, wrote distinctly upon that subject in 1773, 1777 and 1780; and in the last paper the notation is the same as that used by Laplace three or four years later. There is also evidence that Lagrange had begun to develop the idea of the potential as early as 1763, in connection with his celebrated generalized equations of motion.

Some geometrical propositions. By C. A. Waldo.

Notes on numerical radices. By C. A. Waldo.

Some suggested changes in notation. By R. L. Green.

An adjustment for the control magnet on a mirror galvanometer. By J. P. Naylor.

A combined Wheatstone's bridge and potentiometer. By J. P. Naylor.

Histeresis curves for mitis and other cast iron. By J. E. Moore and E. M. Tingley.

Heating of a dielectric in a condenser—Preliminary note. By Albert P. Carman.

Preliminary notes on the geology of Dearborn county. By A. J. Bigney.

The geological formations in Dearborn county are the lower silurian which is found in almost every part of the county, the upper silurian occupying only a small area in the northwest part of the county and the glacial deposit of the post-tertiary times. Blue limestone is the characteristic rock. The rock is abundantly supplied with fossils, much of it being composed almost entirely of brachiopods, corals and other closely related fossils. On this account they are of little value for building purposes, the chief use being for foundation stones. Some of the hardest will weather very perceptibly in only a few years. Along the railroad at Moore's Hill, the rocks are so easily disintegrated that the cliffs appear more like immense shell banks than true rocks.

In the northern part of the county, near the upper silurian outcrop, the rock is much harder and is quarried in considerable quantities, and is regarded as a very fine quality of stone. It, however, is not equal to that which is found in Ripley and Decatur counties. Where there is no drift the soil is marly—that is, composed of lime, clay, sand, etc. In the greater part of the county and especially in the western section there is much clay; on the flats this is very tenacious. In the eastern part of the county along the Ohio drift deposits are very prominent. There is some drift at Newtown, near Lawrenceburgh, but the most important deposits are just outside the county, in Ohio county, and where it is about fifty feet thick and three miles below Aurora on the Kentucky side, above and below Wolper creek. About five miles further to the south in Boone county, Ky., still more drift is to be found. This last deposit is about on a level with the highest part of the cliff, that is, 1,000 feet. The drift at the mouth of Wolper creek, called Split-rock, is an immense mass of conglomerate fully 100 feet thick and nearly 400 feet lower than that five miles to the south. There is one perpendicular cliff that measures 73 feet high, and above this there is a rise of about 20 feet more, and how deep it extends no one has investigated. About one-fourth mile to the south, on the opposite side of a small creek, is still more deposit and one cliff is even higher than the one just described.

In the lower part of this drift, which is finer than the upper drift, gold has been found, more particularly, however, on the Indiana side.

The fossil remains in the county are rich, and a fuller report may be given at some future time. Only a few can receive our attention in this paper. Near Aurora and Lawrenceburgh numerous bones of the mastodon and mammoth have been found. The bones of a sloth and the skull of a black bear have also been found, and a few other mammals. Brachiopods, crinoids, trilobites, mollusks, bryozoa, corals, etc., are found in great abundance. The trilobites are not so numerous as they used to be, for most of the specimens have been collected—that is, the surface specimens. While exploring a mound four miles north of Moore's Hill several large specimens of the coral, tetradium fibratum were found. One of them required four men to place it in the wagon. One little ravine seemed to be literally filled with it. Prof. Gorby pronounced these the finest specimens of the kind in the state. They are now in the museum at Moore's Hill College.

THE CYSTIDIANS OF JEFFERSON COUNTY, IND.—By GEO. C. HUBBARD.

These fossils form an order of the crinoids, and are most abundant in the Niagara group. About thirty species, up to this time, have been found in Jefferson county, which proves it to be the richest locality in this respect in North America, if not in the world. Fifteen new species will be described and figured in the 17th report of the Geological Survey of Indiana, most of which, if not all, were collected by Mr. John Hammel. Those found belong to the genera holocystites, caryocrinus and allocystites. These fossils are uniformly found in shale or soft limestone, near the bottom of the Niagara group. Near Madison few have been found and these are in poor condition; but along Big creek, in the northern part of the county, they are more numerous and are well preserved. On two or three occasions I had the pleasure of accompanying Mr. Hammel to Big creek. Numerous other fossils were found, but few cystidians. If an experienced collector finds two or three good specimens in a day's search he may consider himself fortunate. A few are found in the debris at the base of the low cliffs or in the bed of the creek; more are obtained, however, by moving along on hands and knees and closely examining the various strata known to contain them, as well as the bottom of the projecting rocks above, for they are often found adhering to the lower surface of certain strata.

Hudson river fossils of Jefferson county, Indiana. By Geo. C. Hubbard.

In the Geological Report of Indiana for 1874, there appeared a list of Hudson River fossils prepared by Dr. W. J. S. Cornett, containing the names of seventy-six species and varieties. They were classified as *plantæ, encrinites, parasitic corals, univalves, orthis* and *trilobites*. Among the "orthis" were modiolopsis modiolaris, a lamellibranch, and streptelasma corniculum, a cup coral. Tetradium fibratum, a columnar coral, was placed under "univalves." Young and old of the same species were sometimes classed as two species. Strophomena nutans, which has never been found in Indiana, was included in the list. These and similar errors, together with the incompleteness of the list, call for a second attempt.

The species included in this second list have been collected chiefly by myself in the vicinity of Madison. Most of the crinoids, however, were named from Mr. Jno. Hammel's extensive collection.

The list, which is too long for an abstract, contains:

Plantæ	8	species.
Porifera	6	"
Anthozoa	25	"
Crinoidea	28	"
Stellerida	6	"
Bryozoa	14	"
Brachiopoda	32	"
Pteropoda	3	"
Gasteropoda	20	"
Cephalopoda	18	"
Lamellibranchiata	26	"
Annelida	4	"
Crustacea	8	"
Total	198	

Among these some ten or twelve are believed to be undescribed species.

The upper limit of the lower silurian at Madison, Ind.—By George C. Hubbard.

The upper strata of the bluffs along the Ohio river belong to the Niagara group, and the lower to the Hudson river or Cincinnati group; but the exact line of demarcation between them has long been an unsettled question. The importance of this parting is recognized when we remember that it exists wherever the silurian rocks are exposed, and that here in an altitude of more than 20,000 feet of the earth's crust, representing a period of untold ages, the greatest break in animal life occurred; but one-fourth of the genera represented in the lower silurian being found in the upper silurian, while the species are almost entirely new.

In Ripley county, along Graham creek, this parting is easily determined by means of the abundant and well preserved fossils, but at Madison this is not the case. Fossils are easily found from the level of the river to a height of 300 feet, where the favistella stillata bed outcrops. Above this for seventy-five feet the strata are nearly non-fossiliferous. At three hundred seventy-five feet above the Ohio the "cliff rock" outcrops, which contains characteristic Niagara fossils.

In 1859 Prof. Richard Owen, after a hasty examination, stated the favistella reef to be the limit. A few years later Prof. Eaton discovered tetradium fibratum, a Hudson river fossil, six feet higher. Subsequently, Dr. W. J. S. Cornett claimed that he had discovered a 10 inch stratum about fifty feet above the favistella reef containing orthis occidentalis and other Hudson river fossils, and announced this stratum as the last of the lower silurian.

In 1889 I commenced collecting fossils, being unacquainted with what has been stated just above. Occasionally at the head of ravines I found fossils in fallen rocks which were undescribed in any of my books on palæontology. Some were sent to S. A. Miller, of Cincinnati, who returned them, saying they were new species. This made me eager to ascertain the position from which the rock bearing them came. Mr. John Hammel and I commenced an investigation and discovered that it is situated near the summit of the precipices forming the various falls west of Madison. Immediately above we found a hard, durable salmon-colored stone which, on account of its greater resistance to decomposition, shielded and concealed the stratum beneath. The upper stratum was found to contain certain Niagara fossils, and later investigation has shown that there is an abrupt palæontological break between the two strata, corresponding to the cycles of time when the lower silurian rocks were elevated above the surface of the ocean and subjected to the disintegrating action of the elements.

By comparing the upper stratum, according to our determination, with that selected by Dr. Cornett at the stone quarry near his residence, they were found to be identical. Hence, to this gentleman belongs the honor of the discovery, our labors simply confirming his conclusion.

The only facts which militate against the validity of the limit assigned are that a survey of the two strata up and down the river for several miles shows them to be conformable; but as stated above, in Ripley county the fifty feet of non-fossiliferous rock is absent, proving non-conformability, and that the fossils, with few exceptions, are unlike others found in the Hudson river group.

THE KANKAKEE RIVER AND PURE WATER FOR NORTHWESTERN INDIANA AND CHICAGO—By J. L. CAMPBELL.

The Kankakee river is the unsolved engineering problem of Indiana.

How to secure the proper drainage of the vast basin known as the Kankakee marshes is a question which has not had a practical answer—chiefly on account of the expense necessary to carry out any of the proposed plans. A new interest in this question may be developed in connection with the problem of an adequate supply of pure water for the new cities in northwestern Indiana and of Chicago, beyond our borders.

The fact exists, although vigorously denied by citizens of Chicago, that pure water has not been obtained by the tunnel system into Lake Michigan, and it is more than probable that further extension of the system will fail to furnish pure water, and after the most costly experiments or repeated disappointments the city will seek its water supply from other sources.

The effort to keep the lake water pure by artificial drainage of the city into the Illinois river may be partially successful—but even this is doubtful—and at best changes will be enormously expensive,—literally an up-hill business.

It will not be denied that a vast territory around Chicago cannot be included in the artificial drainage system, and this territory will continue to be drained into Lake Michigan.

The mouth of the tunnel, whether located two or ten miles from the shore, is the source of an artificial stream toward which currents must tend from all directions. Into these currents the impure drainage of the city will be carried, and the water supply will be contaminated.

The extension of the tunnels doubtless will furnish less impure water, but certainly not the pure supply necessary for the health of a great city.

The practical questions connected with the question of the water supply of a great city are:—

(1) Purity of water.

(2) Adequacy of supply.

(3) Elevation.

(4) Cost of construction.

The purpose of this paper is to show that the Kankakee river furnishes a satisfactory answer to these questions.

The river takes its rise in the marsh land near South Bend, in St. Joseph county, Indiana, at an elevation of seven hundred and twenty feet above sea level, and by an extremely crooked course through Indiana, enters Illinois a few miles east of Momence. The length of the river in Indiana is nearly two hundred and fifty miles.

According to a survey made by the author of this paper for the State of Indiana in 1882 this channel could be reduced for better drainage to less than one hundred miles.

The chief tributary of the Kankakee is Yellow river, which rises in the eastern part of Marshall county.

The country adjacent to the river is a broad plain, varying in width from one to twenty miles, along the borders of which are sand ridges which give to the region the designation of the Kankakee Valley, and which have produced the erroneous impression that the marsh is a low irreclaimable swamp, whereas the fact is that it is an elevated plateau with a mean level of ninety feet above Lake Michigan and six hundred and seventy feet above the ocean.

The plateau has a slope westward of one foot per mile.

The water of the Kankakee is remarkably pure and clear, and is regarded by all who have used it as exceptionally healthful.

Iron is found in solution, which doubtless adds value to the water for general purposes.

The bed of the Kankakee and of its tributaries generally is fine sand and gravel, and the underlying strata throughout the valley are fine sand increasing to coarse gravel. Clay beds are rare and there is no stone along the stream throughout Indiana. The overlying loam varies in thickness from a few inches to several feet, and the surface generally is an unreclaimed marsh in which coarse grass, wild rice and weeds grow in the greatest luxuriance.

The crookedness of the stream is readily explained by the instability of the sandy strata through which it flows—the twelve inches of surface slope being reduced to four inches, measured in the channel of the stream.

The sandy substratum makes the entire valley a vast filtering basin—a great lake filled with sand and gravel, whence issues the pure and limpid water of the Kankakee river.

This is a satisfactory answer to the first and most important question concerning a city water supply.

The second question is the adequacy of supply.

The most convenient point on the Kankakee for starting a pipe line to Chicago or any of the new cities in the northwestern part of Indiana is in township 33 north, range 6 west, not far from the boundary line between Porter and Lake counties.

The drainage area of the basin above this point is about twelve hundred square miles, which is four times the area of the Croton basin whence is derived the water supply of New York.

The sluggish flow of the river, due to the fall of only four inches to the mile, substantially makes this basin of over a thousand square miles a reservoir more than sufficient for the greatest demands, and satisfactorily answers the second general question concerning a city supply.

In answer to the third and fourth general questions, the state survey of 1882 shows that the elevation of the initial point already designated as the proper beginning place for a pipe line is seventy-three (73) feet above lake Michigan, or sixty-nine feet above the Illinois Central depot on the lake front of Chicago, or fifty-one feet above the railway station at Toleston.

The distance from the initial point to Chicago is less than fifty miles and to Toleston twenty-five miles.

The sand ridge on the north side of the Kankakee has a probable altitude of fifty feet, and in the absence of a survey it cannot be stated whether it would be better to excavate through this ridge for the pipe line or to pump the water to the summit. If it is found feasible to excavate for the line a a flow of water by gravity alone can be secured from the Kankakee to the lake front in Chicago, with a fall of one foot per mile, into the receiving reservoir twenty-three feet above the level of the street. The first Croton aqueduct has a fall of forty-seven feet in thirty-eight miles.

If it is found more expedient to pump the water to the summit it is possible that an open channel along the surface of the ridge could be constructed so as to reduce the closed pipe line to twenty-five miles and to deliver the water in Chicago with a standpipe pressure of from fifty to seventy-five feet.

These questions cannot be satisfactorily answered until after a careful survey has been made.

The importance of this enterprise cannot easily be overestimated, and the cost of the work, even if it should reach millions, will be insignificant in comparison with the results to be obtained.

Explorations of Mt. Orizaba. By J. T. Scovell.

Variations in the dynamical conditions during the deposit of the rock beds at Richmond, Ind. By Joseph Moore.

The relation of the keokuk groups of Montgomery county with the typical locality. By C. S. Beachler.

Comments on the descriptions of species. By C. S. Beachler.

On a deposit of vertebrate fossils in Colorado. By Amos W. Butler.

Topographical evidence of a great and sudden diminution of the ancient water supply of the Wabash river. By J. T. Campbell.

Source of supply to medial morains probably from the bottom of the glacial channel. By J. T. Campbell.

Notes on a Kansas species of buckeye. By W. A. Kellerman.

Photographing certain natural objects without a camera. By W. A. Kellerman.

On the occurrence of certain western plants at Columbus, Ohio. By Aug. D. Selby.

[Abstract].

It is my purpose in this paper to point out two features of the flora in the vicinity of Columbus, Ohio, which combine to present in it a representation of western plants; as a result of the one, we find in that locality the beginning of western species, and by the other are to note the comparatively recent introduction of a good many far-western and southwestern plants, some of which appear there, perhaps, for the first time east of the Mississippi river.

In Central Ohio there is a marked blending of eastern and western species of plants; east and southeast of Columbus but a short distance will bring one into the typical Appalachian flora, while to the westward the entire half of the state is underlain by the great limestone formations and with the outcrop of the corniferous limestone, the first to be met with traveling westward, plants of a well-marked western range begin to appear. This feature was referred to by Prof. J. S. Newberry* in 1859. He points out a peculiar facies due (in part) to the presence of a number of the prairie plants of the west here on the eastern limits of their range.

The following species may be cited as illustrating this fact, all occurring near Columbus:

Erysimum asperum, Trifolium stoloniferum, Cornus asperifolia.

Aster azureus, Aster Shortii, Helianthus doronicoides.

Camassia Fraseri, Bouteloua racemosa.

But it is to the presence of a number of distinctly western and southwestern plants introduced by wholesale, as it were, that more particular attention is directed.

Columbus, in common with all railroad centers through which shipment

* Ohio Agricultural Report, 1859, p. 240.

of products from the west regularly occurs, is in a position to receive the plants thus dropped. Artemisia biennis and Verbena stricta have been received by this means; the latter is especially abundant around the railroad intersections. In addition to this opportunity, an exceptional one, as it would appear, is presented by the permanent quarters of a circus and menagerie (Sells Brothers').

On the grounds about these winter quarters near Columbus, about twenty species of plants have been introduced and more than half of them have not appeared elsewhere in the vicinity. The range and distribution of the plants found is such as to increase the interest attaching to their appearance. The seeds were evidently brought upon the return at the close of the season, carried in cars, cages, wagons, or preserved in the intestines of animals. The litter of cars and cages seems to the writer the most likely vehicle for the seeds of the larger number of plants found.

Below are the species found on the circus grounds and appearing by some agency connected therewith; those introduced independently at other points in the county are marked with an asterisk; accompanying certain ones the range of the species is copied from the Manual or Synoptical Flora:

Callirrhoe involucrata, Gray. Minnesota to Texas.

Erodium cicutarium, L'Her.

Clarkia pulchella, Pursh. Western Montana and westward.

Amphiachyris dracunculoides, Nutt. Plains, Kansas and southward.

Aster pauciflorus, Nutt. Kansas and west (?).

Artemisia annua L.

Dysodia chrysanthemoides, Lag.*

Gutierrezia Texana, Torr & Gray. Sterile plains throughout Texas.

Helenium microcephalum, DC. Southern Texas and adjacent Mexico.

Helenium nudiflorum, Nutt.

Helenium tenuifolium, Nutt. West of Mississippi river.

Parthenium Hysterophorus, L. Throughout Eastern and Central Texas, also east of Mississippi river.

Solanum rostratum, Dunal. Plains of Nebraska to Texas, spreading eastward.

Verbena angustifolia, Michx.

Monarda citriodora, Cerv. Nebraska to Texas.

Plantago Patagonica, Jacq., var aristata, Gray.*

Amarantus spinosus, L.

Chenopodium ambrosioides, L. var. anthelminticum, Gray.

Croton capitatus, Michx.

Avena fatua, L.

Of those here much beyond their assigned limits, three show decidedly weedy tendencies. They are Solamum rostratum, Dysodia chrysanthemoides and Parthenium Hysterophorus. The two last named promise to become permanent additions to our flora, undesirable though they may be.

The circus is at present in Australia and we shall watch with interest to secure anything that may be brought from there.

BIOLOGICAL SURVEYS. By JOHN M. COULTER.

SOME STRANGE DEVELOPMENTS OF STOMATA UPON CARYA ALBA CAUSED BY PHYLLOXERA. By D. A. OWEN.

[ABSTRACT].

Upon the upper side of the leaf of Carya alba are found some hemispherical and conical galls produced by the little insect Phylloxera. These galls are the receptacles for the eggs, or nest of these insects.

The stomata in leaves uninjured are all found upon the lower surface. But in those containing galls there are seldom any stomata found in the epidermis just beneath the gall. The upper side is entirely free from stomata with the exception of the gall itself. In no case was any gall examined in which stomata were not found upon the upper surface. And with but one or two exceptions no stomata were found upon the under surface just beneath the gall.

Surrounding and within the opening of the gall upon the under side of the leaf minute hairs were found, all extending outward as if to guard the opening against the entrance of an enemy.

There seems, from the above, to be an intimate relation existing here between the plant and animal.

PRELIMINARY PAPER ON THE FLORA OF HENRY COUNTY, IND. By T. B. REDDING and MRS. ROSA REDDING MIKELS.

A NEW COMPOUND MICROTOME. By GEO. C. HUBBARD.

Wishing to prepare some slides exhibiting the structure of various animal tissues and organs, but having no microtome, I made one of wood chiefly, at a cost of thirty cents and two or three days' labor.

The principle of the machine is to prepare sections by quickly forcing the tissue, supported on a carrier attached to the circumference of a 12-inch wheel, across the edge of a razor, which is brought automatically a slight distance nearer the tissue at each rotation of the wheel.

The base of the machine is a heavy board about thirteen inches long by eight in width. At the middle of each side inflexible standards are erected and adjustable bearings provided, the centre of the opening in each being six and one half inches above the board. In these bearings rests the axis of the 12-inch wheel, which is turned by means of a crank.

The support for the tissue consists of a round brass disc of any convenient size attached at its centre to one end of a short cylindrical rod. This rod fits into a corresponding orifice extending through the middle of a half-cleft sphere, which fits loosely in a corresponding socket in the circumference of the wheel. One side (the one opposite to the automatic feeder) of this socket is made adjustable by removing a round bit of wood and inserting in its stead a concave disc, which is attached to the short end of a straight lever extending down the side of the wheel to near the axis. A screw passing loosely through the lever about an inch from the center of the disc into the wheel serves as a fulcrum. Let this lever be called A. The long arm of A is moved by means of a circular wedge turning upon the round end of the wheel's axis. The thick part of the wedge is allowed to project four or five inches beyond the line of the circumference of the circle, and provided with a knob, thus forming a second lever, B, to which the power is applied. Instead of B and the wedge, a thumb-screw may be screwed through the long end of A, its end turning against the side of the wheel.

When the tissue has been fastened to the brass disc in the usual way, its round support is thrust into the opening of the ball. The carrier is turned and bent in any direction and pushed out or in until tne tissue is in the right position with regard to the razor. A slight force exerted on the knob of B moves B forward thus causing a thicker part of the circular wedge to pass between the wheel and the long arm of A, which forces the concave disc at the other arm against the half-cleft ball, thus causing it to grip firmly the tissue support. If a thumb-screw be used, it must be turned three or four times to produce the same effect.

At one end of the board forming the base of the machine is fastened, by means of two hinges, a perpendicular piece of wood six and one-half inches long, cut so that there are three arms above. Each of two of these has an opening at its upper extremity suitable for receiving the razor, and is provided with a set-screw for clamping the razor.

To the third arm is attached a nut in which work the threads of a bolt, which extends horizontally to near the axis. The head of the bolt is attached to the centre of a wheel some four or five inches in diameter. The bolt now forms the axis of this wheel and must be supported at the wheel by an unyielding bearing. Turning this wheel once in the right direction pulls the razor forward a distance equal to that between the threads, which we shall suppose to be one-sixteenth of an inch.

On the face farthest from the razor of the small wheel, about twenty round brads are inserted near the circumference *at equal distances apart*, and *all the same distance from the centre of the bolt.* If the wheel be rotated the distance between two brads, the razor is drawn forward one three hundred and twentieth of an inch.

A small rectangle of tin or brass about three-fourths of an inch long is bent at right angles, and one edge is cut to form a slightly concave set of twelve vertical teeth of equal size, to turn the 4-inch wheel by pushing against the brads. If ten of the teeth are used, one tooth will move the razor forward one thirty-two hundredth of an inch.

This ratchet is now fastened to the side of a long horizontal lever, which is secured at one end to an upright support. The other arm rests upon an eccentric on the square end of the axis of the 12-inch wheel. Turning this wheel causes an up-and-down motion of the ratchet. The eccentric has a rectangular opening so that it may be slipped upon the axis and made more or less eccentric. It is held in any desired position by a set-screw. A peg, or better a screw with the head removed, projects from the under side of the lever just mentioned into a groove made in the circumference of the eccentric. This groove must be so arranged, that when the ratchet is rising, a tooth catches under a brad; but when it ceases to rise, a short oblique portion of the groove moves the tooth from under the brad. The groove now resumes its straight course so as to prevent the next tooth above from coming in contact with the brad as the ratchet descends. Another short oblique portion of the groove brings this tooth under the brad. As one brad escapes from the top of the ratchet, another enters at the bottom.

To prevent any lost motion, and to push back the razor support when the 4-inch wheel is turned backward, a strong spiral spring may be placed on the bolt so as to extend from the bearing to the nut.

With the above described arrangement of parts, sections can be cut one thirty-two hundredth of an inch thick. By shifting the eccentric so that alternate teeth work, the sections are of double the thickness, etc. But little eccentricity is needed, about one-sixteenth of an inch being sufficient when each tooth of the ratchet is employed.

ON THE ORGANOGENY OF COMPOSITÆ. By G. W. MARTIN.

ON THE DEVELOPMENT OF THE ARCHEGONIUM AND APICAL GROWTH IN THE STEM OF TSUGA CANADENSIS AND PINUS SYLVESTRIS. By D. M. MOTTIER.

[ABSTRACT.]

This work consisted in a study of the development of the archegonium and the meristems of the stem. The results obtained in reference to the archegonium differ from those of Strasburger in that the neck of that organ in Tsuga consisted of two cells in as many cases as where one only was found, and very rarely three. In Pinus the neck of the archegonium was found to be made of two layers of cells, four in each layer, lying one above the other, instead of one layer.

As regards the growth of the stem it is argued that we can not say with certainty that growth proceeds from a single initial cell, as claimed by Duliot for the Gymnosperms.

PRELIMINARY NOTES ON THE GENUS HOFFMANSEGGIA. By E. M. FISHER.

DEVELOPMENT OF THE SPORANGIUM AND APICAL GROWTH OF STEM OF BOTRYCHIUM VIRGINIANUM. By C. L. HOLTZMAN.

The flora of Mt. Orizaba. By Henry E. Seaton.

As botanist of the J. T. Scovell expedition during July and August, 1891, collections were made by the writer on Mt. Orizaba through a range of 3,000 to 14,000 feet.

The first collections of importance on the mountain were made by Frederik Liebmann in 1841. Others who have collected on the mountain, and especially in the valley of Orizaba and Cordoba, are Henri Galeotti, August Ghiesbreght, E. Bourgeau, M. Botteri and Frederick Mueller. The volcano of Orizaba is described by Liebmann as the most interesting mountain in North America. It has a latitude of 18 degrees and lies surrounded by the very fertile country of southern Mexico. It is only ninety miles from the gulf, and having such a situation there is presented upon its eastern slope every phase of vegetation from tropical to alpine.

The region in the vicinity of Cordoba, at an elevation of 3,000 feet and a distance of sixty miles from the coast, has a sub-tropical vegetation. Palms grow in abundance and orange, banana and coffee trees attain a high degree of cultivation. Prominent among the families that make up the shrubby and herbaceous flora are the Malvaceæ, Leguminosæ, Rubiaceæ, Compositæ, Asclepiadaceæ, Convolvulaceæ, Solanaceæ, Euphorbiaceæ and Bromelliaceæ, besides the grasses, sedges and ferns.

The town of Orizaba, 1,000 feet higher up the mountain, has a somewhat less tropical vegetation in the way of cultivated plants. At this altitude the Compositæ have their greatest display. The Helianthoideæ are the forms most abundant, and not only are they characteristic of this particular region but have in Mexico their greatest concentration, amounting, it has been estimated, to thirty-two per cent. of the species and two-fifths of the genera of all the Compositæ of the country. The sub-order Eupatoriaceæ ranks second in numerical strength, the genera Eupatorium and Stevia, however, contributing nearly all the species. The Asteroideæ have but little representation in the forms Aster, Erigeron and Solidago, which are so characteristic of the north. All the other sub-orders of the family are present excepting the Arctotideæ and Calendulaceæ, which are confined principally to southern Africa.

Collections were made at three successively higher stations till the altitude of 9,000 feet was reached, and this zone of 5,000 feet above the town of Orizaba may be considered as the temperate region, and that above 9,000 feet as alpine. Many plants of the sub-tropical region extend their range to the temperate and even to the alpine district, this being especially true of the low growing plants like Oxalis, Stellaria Trifolium and several of the Malvas. The temperate zone is characterized, nevertheless, by many genera and families that are not present or are hardly noticeable in the more tropical regions. The genus Salvia and order Lythraceæ have a strikingly large distribution. Of these latter Cuphea is the most conspicuous element, growing in great abundance under all conditions of soil and moisture. There are many representatives from the Geraniaceæ, Borraginaceæ, Scrophulariaceæ, Verbenaceæ and Acanthaceæ, which take the place in a great measure of the Malvaceæ, Rubiaceæ, Asclepiadaceæ, Solanaceæ and Euphorbiaceæ in the tropics.

Great and rapid changes are experienced in the flora as the slopes are ascended above 9 000 feet, and there are well marked zones for the distribution of plants till the limit of vegetation is reached. Between 9,000 and 10,000 feet, species of Sisymbrium, Lepidium, Geum, Epilobium, Œnothera, Krynitzkia, Mimulus, Castilleia, Verbena, Salvia, Plantago and Chenopodium, are the most characteristic forms of the herbaceous flora. Prominent among the Compositæ are Steria, Avillea, Dahlia and Tagetes, and besides Eupatorium and Baccharis the shrubby flora is represented by Rubus, Symphoricarpos and Buddleia. Prominent among the grasses are Agrostis, Muehlenbergia and Bromus, and the ferns are represented by Adiantum, Cheilanthes, Woodsia and Asplenium.

Between 11,000 and 12,000 feet the forests are entirely of pines and spruce. The greater part of the herbaceous flora at this altitude is composed of Cerastium, Lupinus, Acaena, Eryngium, Arracacia, Halenia, Penstemon, Cnicus and Stenanthium. Penstemon and Stenathium are exceedingly abundant, though possessing a very limited range.

At 13,000 feet the vegetation consists principally of Cerastium, Arenaria, Potentilla, Castelleia and Lithospernum. The pine woods, beginning at 7,000 feet, disappear at 13,000 feet, excepting stunted forms that continue to 14,000 feet. At 13,500 feet the vegetation becomes scantier and the slopes more sandy and beset with masses of sharp pointed rocks. The dry, sandy soil produces species of Draba, Gnaphalium, Senecio, Cnicus, Agrostis, Bromus and Asplenium. Even at 14,000 feet on the higher slopes, just at the snow line, there exists quite a varied vegetation, with species of Draba, Sisymbrium, Gnaphalium, Cnicus, Asplenium and the grasses of the sandy plain below. This was the highest point collections were made, but several species extend their range a hundred feet higher, and Dr. Scovell secured a Draba at 15,000 feet.

The collection numbered 510 species, distributed among 459 Phanerogams and 51 Pteridophytes. In this limited space no mention has been made of species, the object being only to present the general character of the flora of the mountain, as shown by the distribution of certain families and genera. A more complete report will be published later, with notes on species.

An apparatus for determining the periodicity of root pressure. By M. B. Thomas.

[Abstract.]

The paper presented the need of a self-registering apparatus for determining the periodicity of root pressure, and gave an outline of the ones now in use, all of which were seen to need constant attention. An apparatus made in the following manner was suggested. The base of the instrument is about 1′x3″ and is supported by legs about 3″ high. About 10″ from one end and in the center of the base is erected a standard about 2′ high and 4″ in width. On the short end of the base and near the post is fastened a set of strong clock-works. The works are covered with a box and the end of a cylinder 6″ in diameter and 1′ 10″ high is fastened to the hour pinion of the clock by means of a pin passing through a hole in the end of the pinion and fitting in a slot in the end of the cylinder. The top of the cylinder is held in place by a pin passing through a support from the main pillar and a hole in the end of the cylinder. To the large upright pillar is fastened a U tube of about ½′ in diameter; one arm being nearly as high as the pillar and the other but half the height. The tube is filled with mercury to within about an inch of the top of the short arm. The stem of the plant is cut off near the base and placed in position. An inverted U tube is fastened to the stem in the usual way by means of a rubber tube fastened with wire while the other end of the U tube is connected with the larger one in the same way. The small U tube is filled with water through an opening in the top. The cylinder which is made of light tin is blackened by revolving it slowly in the flames of a candle or gas jet. The indicator consists of a light steel wire with a cork at the end somewhat smaller than the diameter of the tube. This rests on the mercury. It is then at the top of the tube bent twice at right angles and allowed to extend to the bottom of the cylinder where it is again bent twice at right angles and the end allowed to rest against the smoked surface of the cylinder. A pin driven in the pillar prevents the wire from turning to one side because of the friction of its end with the cylinder. As the root absorbs water the pressure upon the column of mercury increases, causing it to rise in the tube lifting the cork and indicator with it. The indicator then marks a continuous spiral course on the cylinder. The hourly variation can be studied by observing the distances between the lines. The supply of water given to the plant must be kept constant. An eight day clock should be used and the apparatus need scarcely be touched until the plant is exhausted.

THE DISTRIBUTION OF TROPICAL FERNS IN PENINSULAR FLORIDA. By LUCIEN M. UNDERWOOD.

To one who makes a visit to Florida for the first time, constant surprises appear on every hand; sand, palmetto and spanish moss were expected, but the excess of dry pine lands over hamaks, the multitudinous lakes of every size and shape, the comparative purity of the waters, and the variety of elevation apparent in short distances, formed elements that were not looked for and that serve to modify the botanical features of the country to a considerable extent. The river systems are mostly in a north and south direction, and the rivers are sluggish and often rather deep. Throughout the interior of the state, lakes of all sizes are abundant; twenty-five to thirty lakes in a single township (six miles square) is not unusual. Most of the small lakes are without outlets, and frequently stand in deep hollows. Sometimes you may find two lakes a half mile or so apart with a difference of elevation from 50 to 100 feet. Except for a slight discoloration from roots, the water is remarkably clear and few algæ were seen. With the exception of river borders where clay and black mud are found, there is everywhere the loose gray sand that rolls under foot of man or beast, making progress slow and tedious, that supports no turf and only a scattered vegetation, that absorbs moisture rapidly, and that contains a fine dust that filters through the clothing and renders one black and grimy after even the shortest tramp. Occasional swamps occur where a former pond has given way to a bog, or where a small stream is choked up and thus overflows its usual bounds; here a variety of deciduous trees stand thick together interwoven with the omnipresent and exceedingly spiny

Smilax of many species. Here and there are occasional overflows of larger streams where the cypress flourishes, but pine is the prevailing forest growth. From Gainesville southward through Ocala and on toward the center of the state is found higher ground which, long before the phosphate fiend had bored the rocks for paying phosphate, was pitted with natural sink holes and caves where moisture is ever present and where the frosts rarely penetrate. These extend to Brooksville and beyond, and are found on either side of the Withlacoochee river. Further southward and including the lower fourth of the peninsula are the low everglades with saw grass lakes and scrub-palmetto barrens soaked with water during the spring rains, which is reduced to scattered shallow ponds in the dry season.

Although Florida possesses a larger number of ferns than most of the states of the Union (43), and of these more than half (24) are found in no other state, one who visits the state in the winter season will be impressed with the rarity of ferns unless the state is reached before the usual December frosts have cut down the fronds. Along the rivers and wherever moisture is abundant *Woodwardia Virginica* grows luxuriantly in its season as the most abundant fern. With it appear two of the *Osmundas* though far less abundant than in northern swamps. It seems out of harmony with our preconceived notions to find the fertile fronds of *O. cinnamomea* growing from a circle of *older* sterile ones, but this condition is common even in January. Farther down the state *Blechnum* and *Aspidium unitum* and some other species are occasional, but are rarely abundant, at least in the upper two-thirds of the peninsula. In drier land *Pteris aquilina* grows in a more or less stunted condition, but in the more tropical parts of the state it grows occasionally to an excessive height. Next to *Woodwardia* it is probably the most abundant species. *Polypodium incanum* is everywhere found to a limited extent on tree trunks, but is found in profusion only in the southern third of the state. At Orange Bend we found the *mucronata* form of *Marsilia vestita* in abundance rooting in sand and mud. While this is more or less common from Oregon and Dakota to Southern California and Texas it has never been reported before from east of the Mississippi. Its presence in Central Florida becomes almost as interesting a problem as that of its congener, *M. quadrifolia*, in Northwestern Connecticut. No fruit could be found in January, but in the latter part of March fruit was found in great abundance.

The uncertainty of frosts makes the collecting period difficult to predict. Sometimes the fall frosts hold off until January, and often cease to be troublesome after the middle of February. In other years they appear anywhere from December to April. Often they are local, while again there will be a general freeze that will cut down all tender vegetation. The "great frost" of March, 1886, was sufficiently severe to kill the young fruits of the cocoanut as far south as Lake Worth, and killed out much of the *Vittaria* as far down the gulf side as Manatee. During last winter several frosts appeared in January as far south as the lake region, and on the 8th of April the *Woodwardias* along the St John's from Sanford to Palatka were all drooping from a cutting frost. Of course in secluded places ferns may be found at any season, but only in comparatively frostless winters can they be seen to advantage in the northern half of the state.

The rarer ferns of Florida are tucked away in inaccessible quarters and are not to be found without much searching. Of the ferns peculiarly tropical three groups may be considered: (1.) The swamp species. (2.) The epiphytes. (3.) The lime-rock ferns. Of the swamp species, *Blechnum serrulatum* is perhaps the most common; ordinarily this species grows from two to three feet high, but toward its northern limit along the outlet of Lake Dora we found robust forms six and seven feet high. *Nephrolepis exaltata* we found in profusion at the same place growing on decaying stumps and logs. In fact this seems to be its usual habitat instead of palmetto trunks, as so often stated. *Aspidium unitum* has much the same range. *Polypodium phyllitidis* comes north on the gulf side as far as the Manatee river and we found it not uncommon at Lake Worth. *Acrostichum aureum* frequents the brackish borders of tidal streams occasionally encroaching below high water mark. In the west coast it comes up as far as Tampa, and on the Atlantic coast it is more or less common throughout the Indian river country and comes well up to the coast above Titusville. We did not find *Asplenium serratum* in any part of the state visited, though Garber reported it from Manatee in 1879. It more properly belongs in the really tropical portion of Florida.

Of the epiphytic species *Vittaria* and *Polypodium aureum* come furthest north. We found abundance of the former between lakes Griffin and Harris; the latter may be seen occasionally in the vicinity of Lake Monroe, though it is more common below Titusville on the east and Tampa Bay on the west. *Vittaria* grows pendent on palmetto trunks at every height and in every stage of growth from prothallus to mature plant.* Its northern

*It may be of interest to state that a species of liverwort, *Riccia reticulata*, was based on the prothallus of this fern.

limit as we found it is in Lake county. *Polypodium aureum* usually grows just under the clustered leaves of the cabbage palmetto, often at a height of twenty-five or thirty feet. *Ophioglossum palmatum* comes as far north as Manatee where we found the sterile fronds in February after a weary search, for it grows well up on the palmetto trunks, burying its roots deeply between the old decaying bases of the palmetto leaves. He who attempts to climb the palmetto trunk is not usually anxious for the second trip.

The *Ophioglossum* fruits in April or perhaps the last of March and is the most peculiar member of its order, since most of its congeners are terrestrial in habit. The remaining epiphytes have not been found north of the tropical portions of Florida, which include the Keys and the region of Biscayne Bay.

The rock-loving species have a more extensive distribution as they grow in places beyond the reach of ordinary frosts; in the high hamak region to which allusion has been made, several of the tropical species linger in portions of Florida, too cold even for the successful culture of the Orange. In the various limestone sinks about Ocala may be found *Pteris cretica, Asplenium rhizophyllum, Asplenium firmum, Polypodium pecctinatum, Aspidium patens and Adiantum tenerum.* From this same region the rare *Phegopteris tetragona* was collected, but its discoverer holds the exact locality in secret, and furnishes herbarium specimens at 50 cents apiece. While this method of procedure is not what is expected among botanists, one who knows the difficulty and expense of securing some of the rare Florida ferns can scarcely have the heart to criticise too harshly.

A still more interesting locality for the rock ferns is on the Withlacoochee river, two and a half miles below Istachatta. This town which makes considerable display on the maps, consists of two houses and a store and must be reached from Pemberton the nearest railroad station by boat or private conveyance. As the exact locality has never been defined it was by merest chance that we met Mr. F. M. Townsend, the proprietor of the store at Istachatta, who conducted Donnell Smith to the same location in 1883. The locality, which is on the premises of Mr. George K. Allen, was reached just at nightfall. Here, besides a much greater profusion of the species found at Ocala, are found the rare and variable *Phegopteris reptans* and a great profusion of *Aspidium trifoliatum*. Other stations are found near Brooksville and farther down the river on either side. In these sheltered sink holes, protected from frost and so far removed from sunshine as to retain moisture in the driest season, these relics of a tropical flora still persist, never attracting the attention of either the native "cracker" or the northern migrant, both of whom stare alike at the botanist and his outfit and doubtless wonder what he can want of "fearns." While the higher flora of the tropics does not begin to appear until we reach the Manatee on the west coast and Lake Worth on the Atlantic seaboard, these outliers of the tropical flora extend from two to three degrees farther north, and represent the stragglers in the southern retreat that has marked the southern extension of the peninsula from reef to key and from key to everglade.

With all the information that could be gathered before starting we found that the experience of the winter was necessary to learn the peculiarities of the country and the best localities for exploration and especially how to reach them after they were made known, for of all English speaking countries to learn how to reach a given point Florida is one of the worst in our experience. To point out some of the best localities for future exploration is partly the object of this paper. We would like also to protest against the stupid method of sending out collectors to look simply for the higher vegetation of a new region. Mosses and hepatics, algæ, lichens and fungi form just as much a part of the flora of a country as do the seed plants and ferns and often furnish more valuable information regarding the true character of a region than can be gained from a study of the higher flora alone.

Four distinct regions in Florida suggest themselves as likely to yield not only more interesting tropical ferns than have yet been brought to light, but a rich harvest of new facts and species illustrating the nature and distribution of the tropical flora of the peninsula. This, however, will only be possible when the critical botanist gets away from his dried herbarium fragments and studies the flora face to face in its native fastnesses. Then only can biological surveys prove a success. These regions are:

1. *The river regions of West Florida.*—The Withlacoochee, especially from Pemberton Ferry to the mouth, and including lakes Tsala Apopka and Penasoffkee on either side, the Manatee, the Myakka and the Peace. Explorations along these rivers can best be made in boats* and are likely to well repay the cost, for while nearly all have been somewhat visited by botanists, the country has been *skimmed* rather than explored.

2. *The interior lake region of South Florida.*—This would involve a trip from Kissimmee southward down the chain of lakes to Okeechobee and

*The region of Lake Tsala Apopka and Lake Penasoffkee could best be explored with a horse and wagon, though the development of phosphate beds in Citrus county is likely to extend the public means of conveyance. Railroads in Florida are too slow and uncertain for much dependence for short trips.

and then westward through the drainage canals and the Caloosahatchee river to Punta Rassa. This means from 200 to 250 miles by boat, subjection to considerable hardship, and could only be undertaken by a party.

3. *The Keys.*—Within the triangle whose base is a line running from Key West to Key Largo, and whose apex is at Punta Rassa, there are myriads of small islands, all lying in the tropical portion of Florida, which have never received anything like a thorough botanical exploration. These can only be explored by boat. A small sailing craft can be obtained at Tampa, Manatee, or Key West, for $40 a month furnished with a sailor who will also act as cook. Board is cheap, for game and fish are abundant, while other supplies will have to be obtained at the point of embarkation. The scattering trips that have already been made to this region have yielded some of the rarer ferns, to say nothing of extensive additions to the higher flora of the state, ranging from a new genus of palms down. Unless it be among the algæ not a single specimen of the lower cryptogams has been collected in this region.

4. *The Biscayne Bay region.*—The fairest spot we found in Florida during last winter was Lake Worth. The northern tourist who leaves this out misses the best of the state. Here the climate is that of Southern California, mild and balmy like all Florida, and yet with the invigorating tonic that nearly all the rest of Florida sadly lacks. Here, too, if you are fortunate enough to stop at Oaklawn on the mainland, you will find as we did the first square meal in Florida, served by the genial judge of Dade county, who is also the proprietor of the best hotel on the lake. Here was the first real taste of the tropics. Tropical fruits and cocoanuts in profusion, mangroves without trunks set up on spider-like roots, banyans, and a profusion of strange shrubs and trees. It was only when too late to avail ourselves of the trip that we learned how to reach Biscayne Bay from the Atlantic side. Of course it could be reached from the Gulf side by boat,* but in vain did we try to learn whether there was an overland passage from Miami to Lake Worth. Here we found that a solitary mail carrier tramps the distance (about 60 miles) once a week, thus bringing the two settlements of Dade county within reach of each other. He goes up and down the beach, for there is no other path. Life saving stations are scattered along the coast at intervals of about 25 miles, and the only places where there is real danger is at the inlets, which, during the high seas are difficult to nav-

* Miami may be reached from Tampa by a tri-weekly mail steamer to Key West (fare $10), thence by sailing vessel which carries bi-weekly mail to Miami (fare $4).

igate in the frail barks that serve for ferries, and the inlets are usually infested with both sharks and "'gators." The best collecting ground is usually within 300 yards of the coast line. The ordinary guide books state that "there is nothing of interest below Lake Worth," but one who has seen the country below from a botanical standpoint says "there is nothing above Lake Worth." Botanically this is doubtless the most interesting region of all Florida. The part between Lake Worth and Miami has so far as we know never been trodden by a botanist. Around Miami and on the neighboring Keys have been found most of the remaining tropical ferns of Florida, viz.: *Polypodium Swartzii*, *Asplenium serratum*, *A. dentatum*, *Nephrolepis acuta*, *Pteris longifolia*, *Tænitis lanceolata* and *Aneimia adiantifolia*.

SOME ADDITIONS TO THE STATE FLORA FROM PUTNAM COUNTY. By LUCIEN M. UNDERWOOD.

While the higher flora of Indiana seems to be fairly well known, it is surprising to find so little on record regarding the lower cryptogams of the state. Except a short paper on "The Mildews of Indiana,"* a few bulletins from the experiment station relating to some injurious fungi, a short list of mosses and lichens from Richmond,† and a few scattering notes in the *Botanical Gazette*, nothing has been placed on record, which, however, is far from saying that nothing has been done in this direction. It is a question whether as teachers of botany we have not swung the pendulum too far in training our students to become expert section-cutters and discriminating histologists and have thereby left out of their course that *cultural* feature of botany that comes only from bringing them in direct contact with nature. I plead for considerable field work as an invaluable adjunct to laboratory instruction. In a year's study of botany a student ought to become fairly proficient in the manipulation of the microscope and at the same time learn how and where plants grow (and especially the less conspicuous plants), and where their position is in the system, thus gaining a love for nature as well as a knowledge of the methods of manipulation. Botany ought to be a *cultural* study as well as a purely *technical* one. When we

*J. N. Rose, *Botanical Gazette*, XI, 60–23 (1886).

†Mary P. Haines, 8th, 9th and 10th Ann. Reports, Geol. Survey, 235–239 (1879).

consider the tendency of botanical instruction for the past ten years, it is not surprising that the younger generation of botanists do not know how to collect, and when turned loose in some highly interesting botanical field find, to the sorrow of those who want something of them, that their eyes are trained only for an immersion lens and not at all for learning the richness of the flora about them.

While the season since our advent to the state has been exceedingly dry and therefore unfavorable to the development of fungi, we have in three or four short excursions in the immediate vicinity of Greencastle, secured sufficient material to show a rich cryptogamic flora. A few of the more interesting discoveries will be noted and exhibited:

1. On the sandstone rocks at Fern, a rare moss, *Eustichia Norvegica*, is found in great abundance covering many square rods of the rock wall. It was first reported by Sullivant in 1846 from Lancaster, Ohio, and distributed in his *Musci Alleghanienses* as no. 188. Rau has reported it from Pennsylvania and Mrs. Britton found it in fruit for the first time in the Dalles of the Wisconsin in July, 1883. Its sterile states have been figured by Sullivant* and its fruit by Mrs. Britton†. This Indiana station makes the fourth in the fourth state.

2. On clay banks at Fern we have found a hepatic new to America, *Fossombronia cristata*, Lindb.‡ In Europe it has frequently been confounded with *F. pusilla* and is possibly the plant reported under that name by Sullivant in one of the earlier issues of Gray's Manual. Of the true *pusilla* we have seen no American specimens in fruit, and *Fossombronia* is one of the few genera of the *Jungermaniaceæ* in which the exospore is sufficiently differentiated to furnish satisfactory specific characters. *F. cristata* is easily recognized by the confluent crests of its spores. Its known range hitherto includes Finland, Sweden, Germany, France and England.

3. *Trametes ambigua* (Berk.) Fr. This is not an an uncommon species in the vicinity of Greencastle and Fern. It was first described by Berkley§ from specimens collected by Lea in the vicinity of Cincinnati, and has since been reported from Ohio by Morgan, from Kansas by Cragin, and from Missouri by Demetrio, through whom it was distributed by Ellis in N. A. Fungi under the original name *Dædalia ambigua* (no. 1593.)

4. *Hydnum stratosum* Berk. has been found once under a rotten log near

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*Mem, Amer. Acad. n. s. III, t. I (1846.)

†Bull. Torrey Bot. Club. X, 99 (1883.)

‡Notiser pro Fauna et Flora Fennica, XIII, 388 (1874).

§*Dædalea ambigua* Berk. Decades of Fungi, n. 83 (1846).

Greencastle. It was first reported from the vicinity of Cincinnati by Lea in 1845,* and afterward by Morgan. We found it in 1889 near Syracuse, N. Y. This makes the third station known to us. The species when fully mature is unlike any other species of *Hydnum* in the stratification of the spines.

5. *Cordyceps capitata* Fr. We have found one specimen of this species in rich woods at Fern. It belongs to a group of fungi that are usually parasites either on living animals like the "caterpillar fungus" of New Zealand, or on living pupæ of insects like *C. militaris*, or on truffles like the present species. This species is usually reported as growing in pine woods, but we found it last year at Cambridge, Mass., growing under oaks on *Elaphomyces granulatus* which is the usual host on which it has been reported from North Carolina by Curtis and from New York by Peck. The present specimen seems to be saprophytic, growing from a nidus of decaying matter. It was found of course under deciduous trees.

6. *Phallus Ravenelii* B. & C.† seems to be the common stink-horn of this vicinity. It was originally reported from South Carolina and we found it once at Cambridge, Mass. Under a rotten log at Fern we found its mycelial strands a ramifying network which extended ten feet or more, giving rise to fifteen or twenty fruits in various stages of development. In addition to these fruits there were irregular swellings on the mycelial strands in great abundance; the larger ones were hollow, the smaller solid. They suggest *sclerotia* which so far as we know have never been reported among phalloids. As the specimens were collected in November, it would seem that the plant was making an effort to store up nutriment in these tuber-like bodies for the necessities of the following season.

Besides *Phallus Ravenelii*, which is easily recognized by its rudimentary veil, its thin pileus, and its mild fragrance (?), we have found two other *Phalli* in this vicinity. *P. duplicatus* we have found once. An enormous specimen ten inches in height and with a large bell-like veil fully four inches across is evidently the plant that was referred by Morgan‡ to *P. Dæmonum*. That its odor was diabolical we can fully testify. Although Fischer has combined all the indusiate forms with *Phallus duplicatus* and refers then to the genus *Dictyophora*, we have certainly a distinct species in this specimen; whether it should bear the name *P. Dæmonum* or not is another question to be settled later.

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* *loc. cit.* p. 86.

†Grevilla, II, 33 (1873). Fischer refers it to *Ithyphallus*.

‡Jour. Cin. Soc. Nat. Hist. XI, 145 (1889).

Connecting forms among the polyporoid fungi. By L. M. Underwood.

Unused forest resources. By Stanley Coulter.

Distribution of certain forest trees. By Stanley Coulter.

Cleistogamy in Polygonum. By Stanley Coulter.

The Cactus flora of the southwest. By W. H. Evans.

Diseases of the sugar beet root. By Katherine E. Golden.

In some analyses of sugar beets made at the Purdue Experimenting Station by Prof. Houston, station chemist, the percentage of sugar was so low that an investigation as to the cause was made. Upon a microscopic examination by Dr. Arthur, station botanist, the low per cent. roots were found to have bacteria in them. After that the roots were observed closely, and it was found that individual beets among all the varieties grown were affected, to a greater or less extent, with this bacterial disease.

The roots thus affected do not differ in outward appearance from the healthy roots, but are much lighter in weight. The texture of a healthy root is firm and somewhat brittle, and in color is a clear white, while the diseased root is rather soft and tough and of a yellowish white color. If the diseased root be cut transversely, concentric rings of brownish dots are seen.* These rings are formed by the fibro-vascular bundles, the dots being the separate bundles. The cells of the bundles have a deposition of yellow coloring matter upon their walls, which becomes somewhat darker upon exposure to air.

*Circles of dark dots are found in all sugar beet roots, but in the diseased roots they assume a greater prominence, and thus are very effective in the determination of the disease.

During the early growth of the plants no difference can be seen between the diseased and healthy ones, but as they develop the outer leaves of the diseased plants wither, while the heart leaves curl up much more than the normal, are dull in color, and the under side has a mottled appearance, causing the leaves to resemble somewhat those of the Savoy cabbage. As the season advances the differences between the diseased and healthy plants become more and more accentuated. In the early season the bacteria are found in parts of the plant only, but that may be any part from the leaves to the extreme end of the tap root; on account of this it is difficult to surmise how the plants become diseased. In the late season the bacteria are found permeating every part of the plant.

Examined microscopically the bacteria are found to the greatest extent in the parenchymatous tissue, but the tissue is not broken down by them. They are found imbedded in the substance of the protoplasm as well as being in the cell sap.

In form the beet bacterium is shortly cylindrical, being about twice as long as broad. They occur mainly as isolated cells, though they are sometimes found in pairs. When vegetating rapidly the bacteria are very active, moving in and out among one another with great rapidity. From their arthrosporous character the bacteria of the sugar beet very probably belong to the genus Bacterium.

The pure germ is easily obtained by the ordinary gelatine or agar plate separation method, if a piece of the root that has no contact with the surface be used for inoculation. This gives the disease germ only, free from soil and air contamination.

Very good development of the bacterium has been obtained by test tube cultures of acid and neutral nutrient gelatine. Upon acid gelatine, using spot cultures, the bacterium forms round, irregular-edged, greyish-yellow masses, having beautiful iridescent surfaces. This iridescence is a peculiar characteristic of the organism grown upon solid acid media. The masses retain this iridescence for about two weeks; then the surfaces become crust-like and dry, and the masses decidedly yellow in color. The bacteria liquefy the gelatine, gradually forming hemispherical depressions into which they drop. In neutral gelatine cultures they form, in most respects, the same kind of growth as in acid, but the surface has simply a shiny appearance, and as the masses ages they do not form crust-like surfaces. They liquefy the neutral gelatine much more rapidly than the acid.

A curious feature of this organism is that it causes the gelatine to become distinctly alkaline, even though it be acid before the organism has grown on it. The diseased beet roots give a neutral or very slightly acid reaction.

In a Pasteur sugar culture the bacteria grow well, causing the liquid to become slightly turbid in 24 hours. As growth goes on, the turbidity becomes greater, and again decreases until at the end of nine or ten days, when the growth practically ceases, the liquid becomes clear, the bacteria forming a greyish yellow sediment in the bottom of the tube.

They also develop well in sterilized sugar beet juice, but as contact with the air causes the juice to turn black, they are not readily seen. In juice that had been cleared by filtering through bone black very poor growths were obtained.

Inoculation tests were made upon six apparently healthy roots that were brought from the garden into the greenhouse. Four of these now give indications of having the disease; the leaves are crinkled, the under side being dull and mottled in appearance. Bacteria were found in the leaves and petioles.

Considerable interest attaches to this disease from its reduction of the sugar content of the root, and its prevalence throughout the state. The study of the subject was begun too late to estimate the loss by the disease, but as was already mentioned, diseased plants were found among all the beets grown on the station grounds, which included eight varieties for the past year—Red Top sugar, Silesian sugar, Imperial sugar, Dippe's Vilmorin, Simon LeGrand improved white, Dippe's Kleiwanzleben, Flormond Desprez richest, and Bultean Desprez richest. Roots were sent to the station for analysis from twenty-seven different places in the state and from nineteen of these some of the roots were diseased. This is not a fair estimate of the prevalence of the disease, however, as the tendency is, in sending beets for analysis, to choose the best looking and most nearly perfect ones, and the proportion of infected specimens included is necessarily much short of the actual average.

There were more of the Kleiwanzleben and Vilmorin beets sent than of the other varieties, and these gave respectively 12.9 per cent. and 12.7 per cent. diseased roots. Counting all the varieties there were 434 beets sent, among which were 12.1 per cent. diseased. In analyzing for the sugar content one set gave 13.3 per cent for good beets, 11.9 per cent. for beets showing a trace of the disease; another set gave 10.2 per cent. for good ones, 7 per cent. for diseased ones; while still another set, that Prof. Huston thinks gives the fairest estimate of loss, gave 10.3 per cent. for good beets, and 5.7

per cent. for diseased ones, a loss of nearly 50 per cent. of the sugar content. The per cent. of sugar is expressed in terms of the beet, not of the juice.

Besides the bacterial disease that is general for all parts of the plant, the sugar beet roots are affected with diseases of a local character. These are in the form of surface scabs, discoloration of the tissue, and small masses of tissue different from that surrounding them.

The scabs are of two kinds, one resembling the so-called "deep scab" of potatoes, while the other protrudes from the surface.

The deep scabs are light brown in color when first affecting the root, but as the root is more deeply affected they become dark brown or rusty black. They vary in size from a mere dot to an extent sufficient to nearly cover the whole root, though the latter case is not so often found. The deep scabs are sometimes accompanied by a red discoloration of the tissue that, in some cases, extends fully two inches beneath the surface. Upon exposure to the air the red color changes to magenta. These scabs are not to be confounded with the breaks in the surface of the roots caused by uneven growth.

The raised scab differs essentially from the preceding in outward appearance, as it forms warty elevations on the surface of the roots. It has the same general color as the deep scabs, but has not been found covering so great an extent of surface as they. When found in large quantity, instead of extending itself over the surface, it seems to have a tendency to form bands encircling the root. It is oftenest found near the neck of the beet at or near the surface of the ground. Both forms of scab are found on the same root, sometimes in close proximity, and forms have been found seemingly intermediate between the two. It is probable that the two forms of scab are just different stages of the same disease; the raised scab being the first stage, where the irritated tissue with the corky modifications form elevations on the surface of the root; as the tissue outside the corky layers dies and is gradually eliminated, the depressions are left in the surface. This theory is given further force from the fact that the same organism has been obtained from plate cultures of both forms of scab. The organism has the characteristic of the potato scab germ described by Dr. Thaxter.* There are the same filamentous forms that break up into bacteria-like bodies, and the dark stain given to the culture medium.

The organism itself is perfectly colorless, but it excretes a substance

*Annual Report Conn. Agr. Exp. Sta., 1890, pp. 81-95.

which in the presence of oxygen becomes dark brown. Cultures have been made in the fermentation tubes brought out by Dr. Theobold Smith, which are so constructed that one arm of the tube remains free of all gases. In such a tube the part of the culture in contact with the air becomes a deep brown color and that in the opposite gas-free portion remains uncolored for even a month or more, and its final change to brown, if the culture be continued sufficiently long, is without doubt due to diffusion, both of the gas absorbed from the air and the oxydized substance, by which they pass from the open arm of the tube into the closed arm.

Prof. Bolley* has induced the scab on the sugar beets by inoculating with the organism from potato scab. The scab has also been transmitted to the beet directly from the potato, and also from soil in which pototoes affected with scab had been grown, by experiments made in a cool greenhouse at the Purdue station. In the former case a young potato tuber, just removed from a pot-grown plant and well covered with active scab, was laid in contact with a perfectly healthy root of a young beet. An examination was made eight days later, but with no distinct evidence of results. A further examination thirty-seven days later showed a well defined scab about a quarter of an inch across upon the beet, where the diseased potato touched it, and no trace of scab elsewhere. In the latter case ten healthy beets were transplanted to pots containing soil in which potatoes affected with the scab had been grown. These were examined sixty-four days after being transplanted, and eight of the ten roots were affected with the scab, five of them having the neck entirely surrounded with it.

The scabbing originates without doubt from the soil. How long the organism may maintain itself in the soil as a saprophyte is uncertain, but the data elicited by Professor Bolley and by the Purdue station appears to show that the time may extend over one or two years.

The tissue of the roots is found to be blackened occasionally. This blackening is in the parenchymatous tissues between the rings of fibro-vascular bundles, and is of varying extent. It is sometimes found in roots that are neither affected with the bacterial disease nor scab.

There also occur small spherical or spheroidal masses that differ from the rest of the interior tissue of the roots in having a uniform watery appearance, similar to that of a water-core apple, and may, for the sake of distinction, be called water-core spots. They occur in the parenchymatous tissue, and are sharply defined, not grading into the adjoining tissue.

* Bulletin N. Dakota Exper. Sta., No. 4, December, 1891.

They are colorless, or of a pale yellowish tint, and turn black upon immersion in alcohol, the rest of the beet remaining colorless. The spots are composed entirely of parenchyma tissue, the cells having fine delicate walls. The cells, in the specimens examined, measured .03 to .075 mm. in diameter, while the cells of the adjoining parenchyma measured .15 to .25 mm. in diameter. The measurements were taken in transverse sections of the root. No parasitic organism, either animal or vegetable, was found associated with them, and no explanation of their presence is known.

The scabs, discoloration, and water-core spots do not seem to affect the size of the beets, as they are oftener found in medium and large beets than in smaller ones. The effect of their influence on the sugar content is not known.

PLANT ZONES OF ARIZONA. By D. T. MCDOUGAL.

[ABSTRACT.]

The author, while collecting plants in Arizona during May to October, 1891, for the Botanical Division of the U. S. Department of Agriculture, made a series of observations resulting in additional data on a biological survey of the San Francisco Mountains made by Dr. C. H. Merriam in the previous year.

The feasibility of the correlation of the life forms of this region into the Alpine, Timberline, Hudsonian, Canadian, Pine, Piñon and Desert Zones was recognized. Detailed notes of the occurrence of plants peculiar to each zone were made, and the bounding lines of each were carried southward through the Mogollon, Graham and Chiricahua mountains, and over the edge of the Colorado Plateau into the Verdi Touti, Salt and Gila basins to the Mexican boundary.

RELATION OF AVAILABLE ENZYM IN THE SEED TO GROWTH OF THE PLANT. By J. C. ARTHUR.

THE POTATO TUBER AS A MEANS OF TRANSMITTING ENERGY. By J. C. ARTHUR

SCIENCE AND THE COLUMBIAN EXPOSITION. By J. L. CAMPBELL.

[ABSTRACT.]

In this paper the author discussed the relation of science to the Exposition of 1893, the subject being limited to the *classification* and the *awards*.

The suggestions presented were based chiefly on the writer's knowledge of the subject from his experience as Secretary of the Centennial Exhibition, 1876.

RECENT ARCHÆOLOGICAL DISCOVERIES IN SOUTHERN OHIO. By WARREN K. MOOREHEAD.

METHODS OBSERVED IN ARCHÆOLOGICAL RESEARCH. By WARREN K. MOOREHEAD.

THE PRE-HISTORIC EARTHWORKS OF HENRY COUNTY, IND. By T. B. REDDING.

The mounds and enclosures of this county are not so large as some of those of Madison, Randolph and Wayne counties adjoining us, but are large enough and numerous enough to be of interest. While but very recently reclaimed from the wilderness and from savage life, Henry county has its antiquities; an unwritten history, a history full of human life, human joys and human sufferings; of organized and aggregated labor; of war, battle and bloodshed; of passions and worship. But the joys, the sorrows, the loves, the hates, the struggles and the triumphs of those long centuries past have faded forever out of sight, except so far as preserved in these ancient and rude earth works. Since they lived, thought and acted—

> "Year after year its course has sped:
> Age after age has passed away.
> And generations born and dead
> Have mingled with their kindred clay."
>
> —*Finley.*

So far as my knowledge extends there are twenty artificial mounds and fourteen enclosures within the limits of Henry county. There are also certain mounds or elevations that have much the appearance of artificial mounds, but of which I am not sure, numbering in all twelve to fourteen, and one uncertain enclosure. Of these the strong probability is some are artificial. Doubtless some of the smaller mounds and enclosures have long since been obliterated by cultivation.

I will now give a detailed list of the mounds and enclosures of Henry county, which I have represented upon an outline map. There is a circular earthwork, or enclosure, on E. S. E. Section 1, T. 16, R. 10, in Franklin township, owned by J. P. Nicholson, about sixty rods east of the pike. This has been almost obliterated by long cultivation. It is about 150 feet in diameter. I got my information mainly from Jethro Wickersham, whose father once owned the farm. There is a circular inclosure on the line between the N. E. and N. W. quarters of Sec. 22, T. 17, R. 10, Henry township, 100 rods west, and one and three-eighths of a mile south of the court house, on lands owned by R. M. Chambers and M. L. Bundy. It is still in the woods though mostly cut off. Its diameter (measuring in all cases from the center of the embankments), is 115 feet; the height of embankment, at highest point from bottom of ditch is about three feet. There is an open place, or gateway, on the east side, about twelve feet wide. There is the appearance of a small mound inside of the enclosure toward the west side, about fifteen feet in diameter and eighteen to twenty-four inches high. Width of ditch about eight feet, of embankment about fifteen feet. Large trees have grown, died and decayed within this enclosure and its ditches and upon its embankments since it was built. There is also a small mound in S. W. quarter Sec. 7, T. 16, R. 11 E., nearly obliterated by cultivation, but I have not made a personal inspection of it. There is another enclosure about 250 feet in diameter on the west side of the N. E. quarter of S. W. quarter Sec. 2, T. 17, R. 10, owned by Joseph Dorran. In early times this enclosure was a noted structure. Its banks were five or six feet high, and the ditches were clearly marked, but the northern turnpike runs through the eastern side of it, while the larger part of it has been under cultivation for more than fifty years, and it is gradually being obliterated. Its banks are now not more than one to two feet high. I will say here, that in all the enclosures in this county the ditches are on the inside of the enclosure. On the northeast quarter of this same section, mostly on the southwest quarter of the quarter and less than half a mile to the northeast from the above named enclosure, is the largest group of enclosures and mounds found in the county. They are situated on the eastern part of the farm of John C. Hudleson, and cover an area of ten to twenty acres. There are in the group nine well defined enclosures, and one or two apparent enclosures which have been so completely obliterated by the plow that I cannot be certain about them. I have visited and measured all of these. The largest is situated farthest east, near the line and very near the N. E. corner of the quarter quarter. It is 650 feet in circumference and is an ellipse, longest east and west. Its east and west diameter is 215 feet. The north and south is about 150 feet. Within this enclosure is a large mound, longest east and west and having much the appearance of two mounds joined to each other, the western mound being the highest. The length of the mound, east and west, is 140 feet and it is about 100 feet wide, north and south. The height of the mounds above the general original surface is about ten feet; above the bottom of the ditches about fifteen feet. The ditch varies in depth but is probably six feet in deepest place, and shallows off into three feet at places. It is mostly in the original forest, but has its south embankment in a cultivated field. On each side of the eastern part of the mound there are slight elevations, whether natural or artificial I cannot tell. They give the mound an appearance of an attempt to imitate a cross. I have a map of this whole group, and an elevation showing shape of the large mound. This mound has been dug into in four or five places at different times.

In the fall of 1890 myself and several others made an exploration of parts of this mound. We dug a trench six to eight feet deep from the east side to the center, and one from north to south through the western end of the mound. We found two places in the last, one within eight or ten feet of each end, where the clay had been burned hard, and yet there were no ashes. Betwen these two places about thirty feet apart we found deposits of ashes but no burnt clay, indicating that the ashes had been removed from the places of fire and thrown in heaps at a distance of a few feet. These places of burnt earth were about two by three feet in size and burned to the depth of ten or more inches. One of them had the appearance of having been raised above the surrounding earth seven or more inches. It was longest east and west and had somewhat the appearance of the figure 8. Near the center of the mound in the trench dug from the eastern side we found, at a depth of nearly nine feet, a large bed of ashes some six by seven feet in diameter. The bed was slightly hollowed out and the ashes at deepest place, near the center, were not less than four to five inches in depth. Among these ashes we found much charcoal and many fragments of bones, some of which I have with me. I am not able to say from what animal they are. A little to the northwest of this bed of ashes was another bed of ashes and burnt clay which had been explored at some time by other parties, but I cannot give results. The large bed found by us was burned hard, of a dull red color, to a depth of about eight inches.

At the time of making the explorations of the large mound we discovered another small mound about sixty rods to the northeast of the large one, 100 feet in diameter and about six feet high, situated upon a point of a hill overlooking Blue river valley, and in front of which was formerly a marsh of several acres. The ditch and enclosure around the mound are very distinct, it having only very recently been cleared of timber. The ditch at places is three feet deep and the embankment averages about two and a half feet in height.

To the east of this a few rods, just across a deep ravine on the north edge of a hill, is an embankment of about six feet in height and nearly two hundred feet long. To the south of the ditch behind the embankment, which is not less than forty to fifty feet wide, the hill rises about twenty feet. The excavation behind embankment is longest east and west. It is wholly unlike anything else found in the county, and no one is able to give any account of its origin.

Ten rods west of this large mound and enclosure is another enclosure, partly in the woods but mostly in the cultivated field. The ditch is well preserved in that part in the woods, but is almost wholly obliterated in that part within the field. As near as I could determine this enclosure was about one hundred and fifty feet in diameter. The ditch on the north side is now about two to two and one-half feet in depth. I am inclined to the opinion that there was also a mound probably two or three feet high within its enclosure, but if so it is nearly levelled. One hundred feet to the northwest of the last is another enclosure, all in the woods, ninety-four feet in diameter and with shallow inside ditches at present one to three feet deep, and having a gateway on east, opening toward the large mound already described. Near the gateway, on the south, is the appearance of a small mound about twelve feet in diameter and twelve to eighteen inches high. It has been dug into recently and seems to be a mass of gravel. I am in doubt whether it is natural or artificial. One hundred feet from the last is an artificial mound forty feet in diameter and about six feet high. The south edge is in the cultivated field but the main body of the mound is in the woods. It has been recently dug into by Joshua Holland, of North Carolina, and Mr. Reynolds, of the Smithsonian Institute, but work was not completed and nothing of importance was found. This is the only clearly identified mound in the whole group not within a circular enclosure. About one hundred and fifty feet south of this little mound, within the cultivated field, are the remains of a large circular enclosure with a gateway facing the east and the large enclosure already described. It is two hundred and fifty feet in diameter and the ditches are from three to five feet or more in depth, notwithstanding years of cultivation under the plow. There is the appearance of a mound in the western part of this enclosure, about forty feet in diameter and about two feet high.

One hundred feet south of the above is another enclosure one hundred and fifty feet in diameter, with ditches two or three feet in depth. It has also an opening to the east, but not so well marked as the others. This enclosure is almost immediately east of the house on said tract and just east of the old orchard. A long period of cultivation has doubtless much lowered its walls. There is a slight indication of a mound near by, but if it is one the plow has so completely obscured the evidences that it is not safe to call it one. About two hundred and fifty feet to the southeast, in the edge of the grove, is another enclosure one hundred feet in diameter, with ditch on inside two to two and one-half feet in depth. It has also a gate or opening on the east facing the large enclosed mound. Sixty feet to the southeast of the above is another enclosure ninety feet in diameter, with inside ditch eighteen to twenty-four inches in depth, and having an opening to the northeast facing the large enclosure and mound. There is also a small mound in the center of this enclosure.

Going another hundred feet to the southeast we find another enclosure one hundred and twenty feet in diameter, with a mound in the center from three to five feet high. The ditch is from two to three feet deep. There is an opening on the northeast facing the large enclosure and mound. East, slightly north of the above and adjoining it is another enclosure one hun-hundred feet in diameter. The ditch is shallow, not more than eighteen to twenty-four inches in depth. The embankment on the west and adjoining the preceding seems to be common to both enclosures. The space between the ditches of the two is about twenty to twenty-five feet. To the northeast is a low, wet place. The opening is not very clearly marked in this last enclosure but it seems to be to the east. North of this last, about three hundred feet in the cultivated field, are very strong evidences of another enclosure, but it has been so disfigured by the plow and long cultivation that I do not feel safe in saying positively that it is an artificial enclosure, but it is very suggestive of one, and is about one hundred and sixty feet in diameter.

There are three or four other little hillocks in the neighborhood of these enclosures that look much like small mounds. On the west side of the pike, about sixty or seventy rods west of the large mound, is a gravel bank in which a number of human skeletons have been found. There was found in this bank, recently, the skeleton of a dog, about six feet below the surface. Skeletons have been found both in a horizontal and in an erect posture. In it are also found pieces of charcoal; also shafts of earth and clay. These are round and from five to eight feet deep and two or three feet in diameter, as if a grave had been dug and then filled with earth. It is probable that there was a mound on this bank, but it has been so long worked and so much of it removed that it cannot be verified. It was at least a burial ground. The skeletons mostly crumble on being exposed.

Across the river, about a mile to the west, on the N half of Sec. 3, T. 17, R. 10, belonging, also, to Mr. Hudleson, is another large circular enclosure in cultivated ground. It is probably 150 feet in diameter, and before the land was cleared was enclosed by embankments five to six feet high,—but a long period of cultivation has nearly obliterated the embankments. I do not know whether it enclosed a mound or not, but probably did. There was, until recently, a mound on S. W. S. E. quarter Sec. 1, T. 17, R. 10, owned by Joseph Smith, about thirty rods west of his house. It was about fifty feet in diameter, and eight to ten feet high, before cultivation. During the last year Mr. Smith plowed it down and used the earth to make an embankment along the creek near by. He tells me that he came to a bed of ashes and charcoal in the center of the mound, about six feet square but did not examine to ascertain the depth. He did not notice any fragments of bones or other articles.

There is also a mound on the E. S. E. quarter Sec. 24, T. 16, R. 10, in Franklin township, now owned by John Gilbert. It is small, probably forty feet in diameter, and three or four feet high. There is another mound in the same township on S. W. S. W. quarter Sec. 15, T. 16, R. 10, owned by Charles Stubbs. It is about three feet high and fifty feet in diameter. It has been dug into and ashes and coals found. Another mound, in this township, is found on S. W. S. E. quarter Sec. 28, T. 16, R. 11, owned by D. H. Fenstamaker, about thirty rods south of the Central railroad, about six feet high and seventy-five across, before plowed down. There is a small hillock, or mound, in the southeast corner of the county, about ten feet high and fifty in diameter, on the top of which formerly grew a large beech tree. It is supposed, by some, to be artificial, but others think it natural. I have not examined it. It is in the N. E quarter Sec. 31, T. 16, R. 12. There is a small mound, now almost obliterated, on the N. W. S. E. quarter Sec. 14, T. 16, R. 9, owned by Daniel Jackson. Was probably twenty-five feet in diameter and four feet high. Was dug into and ashes and coals found. About a mile southwest of the above, on the S. W. quarter Sec. 3, T. 16, R. 9, owned by John Small, is another small mound of about the same size of the one just described.

On Charles McDormain's farm near the S. E. cor. of Sec. 20, T. 17, R. 10, is a mound about fifty feet in diameter and three feet high. It has been under cultivation for more than fifty years, and was, originally, probably over six feet high. It has been dug into. Flints, ashes and coals were found. On the Hoover place, west of the barn, in the N. E. quarter Sec. 5, T. 16, R. 10, is a small mound, now about fifty feet in diameter and two feet high. It has been plowed over fifty years or more. There is a small mound on the farm of Jonathan K. Bond, on the N. W. S. W., quarter Sec. 24, T. 17, R. 9, probably forty feet in diameter and four feet high. This, and the one on McDorman's farm, and the large circular enclosure on the west part of Hudleson's farm and a small mound on Benj. Wilhoit's farm are the only artificial earthworks of which I have any information, which are located on the west side of Blue River, in this county. There is a small mound on S. E. N. E. quarter Sec. 28, T. 16, R. 10, in Spiceland township, on the farm owned by Hinshaw's heirs. It is represented as about fifty feet across and three or four high. It was dug into, a few years ago, and ashes and coals found.

One of the largest and best preserved mounds is found on N. E. S. E. quarter Sec. 26, T. 17, R. 10, owned by John R. Peed, about two and a half miles southeast of New Castle. Until recently it was in a forest, but has been cleared, and, the embankments plowed down and the ditches partly filled. It is sixty-five feet in diameter, and at least six feet high. The ditches were formerly about three feet deep. I first saw this mound when I was a small boy, it being near the farm on which I was brought up, and was often visited by me. When I first saw it, there was growing on its top a large red oak three feet in diameter. The mound has been dug into several times. Ashes, coals, bones and fragments of pottery were found, but they have been scattered and carried off, and I cannot find any of them to examine. I have recently visited the mound. It is surrounded by an enclosure

130 feet in diameter from the crest of the embankment on one side to that on the other. The mound is situated in western part of the enclosure, fifty feet west of the eastern side. There is a gate, or opening in the eastern wall. The mound is at least six feet high above the general level of country, and was about nine feet above bottom of the ditches when I first saw it. The old red oak has blown down, but the stump is still lying on the mound. At the ground it is about five feet through, and, as near as I could calculate from the annual rings of growth, it was at least 280 years old. There is, also, a small mound on the S. N. W. quarter Sec. 18, T. 16, R. 12, owned by J. V. Huffman and now occupied as a cemetery. It is about seventy feet in diameter and was formerly eight to ten feet high, and is now about six feet in height. It was dug into a number of years ago and ashes, coals and burned stones were found. Near by, about 150 feet to the Northwest is a pit from which the earth was probably taken to build the mound.

Daniel Harvey informs me that there are three small mounds on N. W. N. W. quarter Sec. 36, T. 18, R. 10, now owned by Thomas Graham, arranged in a crescent shape. The large mound occupies the center and two small mounds the ends. The center mound was dug into about thirty years ago by Mr. Harvey and others, but found no skeletons nor remains. The central mound is about ten feet high and sixty feet in diameter, and the outside mounds are about thirty feet in diameter and four or five feet high, so Daniel Harvey tells me. H. B. Hernly informs me that there is a large mound on W. N. W. quarter Sec. 25, T. 18, R. 10, owned by him. It has not been explored and may or may not be artificial. I have had no opportunity to examine it. There is a mound five or six feet high and twenty five to forty feet in diameter on the N. E. N. E. quarter Sec. 27, T. 18, R. 10, now owned by Benj. Wilhoit. It has been dug into and shells, etc., found.

The graves of a departed race are found in a great many of the gravel banks of the country. I have the skulls and some of the other bones, and a lot of beads, pendants, gorgets, and other articles, taken from some of these graves upon John Hosea's farm, formerly owned by my father, near this city. These pendants, gorgets and beads are mostly made from the shell of a kind of Conch, called *Busycon perversum*, found along the Atlantic coast from Massachusetts south to the Gulf of Mexico. Some are from other kinds of shells found along the same coast. Whether these are the remains of the Mound-builders, or of a later race, is unknown. They are very similar to many of the articles found in the mounds in such position as to lead to the supposition that they were placed there by the builders of the mounds.

On LeConte's terrapins, Emys concinna and E. floridana. By O. P. Hay.

On the breeding habits, eggs, and young of certain snakes. By O. P. Hay.

Notwithstanding the deep impression which serpents have made on the human mind, as shown in literature and in popular conversation, it is surprising how little accurate information has been accumulated concerning some of their habits. The densest ignorance, the result of inattention and general lack of interest, prevails with regard to some of the most interesting matters connected with the life-history of snakes: while on the other hand, many of the popular notions about the powers of these animals are either wholly false or are gross exaggerations of the truth. The breeding habits of our snakes, even of the most common species, belong among the things about which little is known. Even our biologists have given but little attention to this subject, while unscientific people simply recognize the fact that nests of snake eggs are occasionally met with. For instance, who would not suppose that all the essential facts are known concerning the reproduction of the common black-racer, *Bascanion constrictor?* Nevertheless, where have we been told when it lays its eggs, how many there are of them, how they are concealed, and when they hatch?

Some snakes are known to lay eggs which after a period produce young. Other snakes are known to retain the eggs within the body until the young have attained sufficient size and strength to care for themselves after birth. Still other species are supposed sometimes to lay eggs, at other times to bring forth living young,* or to produce some eggs and some living young at the same time.† There are, indeed, oviparous snakes and snakes which are ovoviviparous, and there is a conspicuous difference in their eggs. The eggs of the oviparous species are furnished with a thick, tough, flexible covering, or "shell," while the eggs of the species which produce living

* Proc. A. A. A. S., 1873, p. 185.

† Proc. Phil. Acad. Sci., 1887, p. 121.

young have coverings which are very thin and delicate. Now, should such eggs as the latter be laid any considerable period before the young are ready to be excluded, the thin envelopes would surely be torn during the writhings of the embryo. That some of the eggs may be only partially developed at the time when the embryos of other eggs are ready to be ushered into the world, and that all may be expelled together, is possible: but this is not the normal course of things and may not be well for the immature young. Normally the coverings of such eggs are ruptured before birth or immediately afterwards. On the other hand, it is quite probable that the eggs of the oviparous species are laid a considerable period before they are hatched. The tough coverings of such eggs protect them from attacks and injuries from without, and at the same time resist the movements of the young snake within. So far as we know, these eggs are deposited in the earth, in piles of decaying vegetable matter, and similar places.

A very curious structure deserves mention here. This is the "egg-tooth," a small tooth fixed to the united premaxillary bones and projecting forward slightly beyond the edge of the upper lip. It is present only in the embryo, and is shed very shortly after the escape of the young snake from the egg. In the ovoviviparous species, the tooth may apparently be shed before the young are born. The tooth is employed by the little snake in ripping open the tough egg-covering in its efforts to escape from its prison. It would appear to be of little service to the young which are mature when born, since the egg-coverings are so very tender; nevertheless, I have found the tooth present in all of the ovoviviparous species whose young I have had opportunity to study. This tooth, as found in the black-racer, was described as long ago as 1857, by Dr. Weinland;* but Müller had observed it even earlier.

The Crotalidæ, including the rattlesnake, the copperhead, and the water-moccasin, all, so far as I am able to discover, bring forth living young. The number produced at each birth is small as compared with the number of young sent into the world by some other species.

As to the breeding habits of the copperhead, *Agkistrodon contortrix*, we have the statement of Dr. J. A. Allen † that in Massachusetts five out of seven females caught in the latter part of July contained slightly developed embryos, while of six killed in September, the oviducts of each contained from seven to nine young, each of which had a length of six inches. As to

* Proc. Essex Institute, Vol. II, p. 28, pl. I.

† Proc. Bost. Soc. Nat. Hist., 1868, Vol. XII, p. 179.

the time of the pairing of the sexes, I have knowledge of only one observation. My friend, Rev. A. M. Hall, brought me from Western Pennsylvania two specimens of this species, which he took while pairing, on the 28th of August. Unfortunately, the female was disposed of before my investigation of this subject was begun. This observation and those of Dr. Allen, when considered together, seem to indicate a period of gestation of nearly a year.

The breeding habits of the water-moccasin, *Agkistrodon piscivorus*, are no doubt much like those of the copperhead. A female 26 inches long (U. S. Nat. Mus., No. 17968), which was taken on the Arkansas bank of the Mississippi river, just opposite Memphis, in the latter days of June, contains seven eggs, four of which are in the left oviduct. Usually the larger number of eggs in snakes is found in the right oviduct. The eggs of this specimen are about the size of the yolk of a hen's egg. In each is an embryo not larger than a common pea.

The breeding habits of *Crotalus* do not appear to be well known. Prof. Putnam* dissected a female which he says contained in the oviducts eight fully formed eggs, besides a number of smaller ones, which he supposed belonged to a later brood. It is more probable that all the eggs were really in the ovaries. A female rattlesnake, 39 inches long (U. S. Nat. Mus., No. 17959), was brought to me from Western Pennsylvania by Mr. Hall. In this I find nine eggs, four of which are in the left oviduct. The eggs will average nearly an inch and a half in long, and an inch in short, diameter. In one of them I find an embryo about 3 inches long. The egg-coverings are extremely thin. The mother snake was captured some time in August, probably before the 15th. At what time of year the sexes unite I find nothing on record. Prof. S. W. Williston, who has had abundant opportunities for making observations on *C. confluentus*, states† that the sexes pair in May. Nor do I know how large the young are at the time of their birth. M. Palisot Beauvois, as quoted by Dr. Goode,‡ says that he saw five young run into the mouth of a mother snake, and that these young were about the size of a goose quill. The young are undoubtedly much larger than this statement makes them. There is apparently as strong a tendency in observers to minify the size of the young of snakes as there is to magnify the size of the adults.

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* Amer. Nat., Vol. II, p. 133.

† Amer. Nat., Vol. XII, p. 207.

‡ Proc. A. A. A. S., 1873, p. 183.

I have been enabled to make some observations on *Sistrurus catenatus* Raf. (*Crotalus tergeminus* Say.). In the American Naturalist for March, 1887, pp. 211–218, I published some notes on the breeding habits and young of this species. About September 1, two females, which had been kept in confinement, brought forth young, one six, the other seven. The young were not seen by myself at the time of birth, but on the 1st of January they were at least 10 inches long. From a female sent me from Paris, Ill., I have taken an almost fully developed embryo (U. S. Nat. Mus., No. 17947). It measures 7½ inches in length, and this is probably nearly the length which it would have been when born. A considerable amount of the yolk was still spread over and among the coils of the little snake; but, when its body was opened, a large mass of the yolk was seen to have been received within its walls. This would be sufficient to maintain life and growth until the little reptile could provide for its own necessities. The fang is developed, and the egg-tooth is present, although it does not seem to be directed so much forward as in other species. In the oviduct, lying alongside of the embryo just described, was another egg which contained an embryo only about 4 inches in length. It was so deeply immersed in the yolk that its presence was not suspected until the yolk was cut partially away. Nevertheless this immature little snake exhibits quite distinctly the pattern of coloration found in the adults. In contact with this egg was another in which no indications of an embryo were to be found. The more immature young were probably lying farther forward in the animal, but of this I am not now certain. Should all these eggs be expelled from the mother's body at the same time, it would seem that the least developed young must perish. A female (U. S. Nat. Mus., No. 17950) of this species taken in Hamilton county, Ind., contained eight eggs, and these had not yet left the ovaries. Three of the eggs were in the left ovary. The eggs were an inch long by half an inch in the short diameter. Prof. Putnam mentions* a specimen of *Sistrurus miliarius* which contained fourteen eggs. This appears to be a larger number than is usually found in the Crotalidæ.

The species of the genus *Eutainia* are probably all ovoviviparous. Dr. Goode, as already cited, says that there is some reason to believe that some of them are in some instances oviparous, in others ovoviviparous. Dr. C. C. Abbott † says that the eggs of the garter-snake, *E. sirtalis*, and of the rib-

* Amer. Nat., Vol. II, p. 134.

† Rambles, &c., p. 295.

bon snake, *E. saurita*, are deposited in the loose sandy soil of the recently plowed fields. He has found none earlier than May 9; and once he found a complement of seventeen within a day or two of hatching. He farther states that he has never come across a young snake less than four inches in length, except in the case of the hog-nosed snake *Heterodon platirhinos*. I am convinced that there is some error of observation here. I shall present evidence that the species of *Eutainia* bring forth living young, and that too rather late in the summer and in autumn. It seems improbable that a snake should usually be ovoviviparous, and again, at rare times, should lay eggs furnished with coverings suitable for protecting the developing embryos. If, notwithstanding all this, the *Eutainias* do lay spring eggs, I shall be extremely glad to receive a batch of them.

Dr. H. C. Bumpus, in his interesting account of the snakes,* says that the eggs of *Eutainia sirtalis* and of *E. saurita* are sometimes found about outbuildings, and in hatching give birth to little fellows having enormous eyes and a spotted body, the longitudinal bands of the adults only being gained after several sloughings of the skin. The source of the information here detailed is not given; but almost certainly the eggs of some other species have been mistaken for those of *Eutainia*. Young of both the species, especially those of *saurita*, taken by myself from the oviducts of the female and with a considerable portion of the yolk still unabsorbed, have the stripes perfectly distinct.

As to *E. sirtalis*, Prof. F. W. Putnam † states that a female taken July 22, contained forty-two nearly developed young. Each of these was $5\frac{1}{2}$ inches long. The mother snake was 35 inches long. Dr. J. Schneck, of Mt. Carmel, Ill., writes ‡ that seventy-eight were taken from a female. He implies that he saw this done. C. Few Seiss says§ that the sexes of this species copulate in early spring and produce from thirteen to eighty young. That he has seen the latter number from a single snake he does not say. Drs. Coues and Yarrow refer ‖ to the habits of *Eutainia sirtalis parietalis*, as observed by them in Montana during the month of August. "At this season all the female individuals observed were gravid with nearly matured embryos. Like others of the genus, this species is ovoviviparous, the young being some 6 inches in length when born." In a specimen of *E.*

* Riverside Natural History, Vol. III, p. 371.
† Amer. Nat., Vol. II, p. 134.
‡ Amer. Nat., Vol. XVI, p. 1008.
§ Scientific Amer., Vol. LXIII, p. 105.
‖ Bulletins U. S. Geol. & Geo. Survey, Vol. IV, p. 277.

sirtalis (U. S. Nat. Mus., No. 17960), captured near the city of Indianapolis by Dr. Alex. Jameson about August 1, I find thirty-nine partially developed young. Of these, twenty-five are in the right uterus. The young measure 6 inches in length. There is a considerable amount of yolk still remaining attached to these young, a fact which indicates that they will increase in size before birth. An examination of the mouth of some of these little snakes shows that the egg-tooth is present. The membrane which surrounds each egg is quite thin. The female bearing this lot of young is 33 inches in length. Another female (U. S. Nat. Mus., No. 17961), from Paris, Ill., of nearly the same size, contained about thirty-five young snakes, these being packed together so densely in the mother's body that it was difficult to determine the number accurately without removing them. They are each 7 inches long, and are evidently just ready to be expelled. An examination of about half a dozen of them failed to reveal the presence of the egg-tooth, which has therefore been shed. Nor could I determine with certainty that any egg-covering was present. The yolk of the egg, also, is wholly consumed. On opening these young snakes I find little or none of the yolk within the body. In this respect they contrast strongly with the young of the rattlesnakes. The young garter-snakes must from the first depend on their own activities for support. This accords well with the report of Mr. C. Few Seiss, that the young of a female kept in confinement began to feed shortly after birth, struggling vigorously with one another for the earthworms thrown them. At what time during the summer the Paris, Ill., specimen was captured I do not know. Seiss' statement that the sexes of *E. sirtalis* pair in the early spring has already been mentioned. Drs. Coues and Yarrow (*op. cit.*, p. 278) tell us that the females of the closely related species, *E. radix*, are pregnant in July and August, bringing forth as many as thirty to forty young; and that they are found *in coitu* in September and October. Can it be that snakes copulate twice in the year, as Agassiz says* some turtles do, and as Gage has recently found† to be the habit of the newt, *Diemyctylus?* Observations on this point are to be desired.

The ribbon-snake, *E. saurita*, appears to be wholly similar in its breeding habits to its relative just considered, although it probably does not bring forth so many young at each birth. Prof. Putnam informs‡ us that a female, taken in Massachusetts on July 13, had nine eggs, each three-

* Contributions, Vol. II, p. 491.
† Amer. Nat., Vol. XXV, p. 1091.
‡ Amer. Nat., Vol. II, p. 134.

fourths inch long and containing an embryo 2½ inches in length. Another, taken July 31, contained but four eggs, and these are ready to be burst by the young. The eggs containing the coiled embryos were then an inch and a quarter long, while the extended young had a length of 5½ inches. Dr. Goode has quoted* a note from Herman Strecker, of Reading, Pa., who states that some years previously he had found and caged a female of this species which soon produced thirty or more young ones. He supposed that the little snakes had been hidden in the mother's stomach. There is possibly some confusion here with *E. sirtalis*, judging merely from the number of the young. Prof. S. I. Smith, of the Sheffield Scientific School, is quoted† by Dr. Goode as having seen two young snakes, each 3 or 4 inches long, run down the mother's throat. The statement is no doubt incorrect, so far as regards the size of the young.

In a female (U. S. Nat. Mus., No. 17965) of the variety *faireyi*, taken probably in Mississippi, I find nine eggs, the hindermost three of which are in the left oviduct. The eggs are about three quarters of an inch long and a third of an inch in the short diameter. The development of the embryo had just begun. In a female (U. S. Nat. Mus., No. 17952) of *faireyi*, 28 inches long, taken at Veedersburg, Ind., are twelve ovarian eggs of the same size as those just mentioned. The hinder four are in the left ovary. At what time of the year the two specimens last described were killed, I do not know. In a specimen of *faireyi*, 40 inches long (U. S. Nat. Mus., No. 17958), captured at Vicksburg, Miss., about the 4th of July, there are twenty young snakes, each close to 9 inches in length. The hindermost nine of these are in the left oviduct. All were evidently ready to be expelled. They did not appear to be contained in any egg-covering, and the egg tooth was not found in any of the three which were examined. Not only is this date not so early as that given by Dr. Abbott for the finding of the eggs of this species in New Jersey, we must take into account the difference in the climate, and especially the difference in the size of the young snakes.

The species of the related genus *Tropidonotus* are also ovoviviparous. *T. sipedon*, our water-snake, is the commonest species of the genus in the eastern United States. It is extremely variable and reaches a large size. Prof. Putnam has a note regarding the breeding habits of this species.‡ He states that twenty two of the young belonging to one family were

*Proc. A. A. A. S., 1873, p. 18.
† Proc. A. A. A. S., 1873, p. —.
‡ Amer Nat., Vol. II, p. 134.

found. Each of them was 8 inches long. Dr. Heilprin mentions* a large specimen from which thirty-three young were taken. These were in different stages of development. Some of the larger ones had absorbed all the yolk, while to others a considerable mass of this was attached. In a specimen (U. S. Nat. Mus., No. 17962) from some point in northern Indiana I find sixteen eggs, eight in each oviduct. The young are 7½ inches long, and each is provided with a well-developed egg-tooth. This is curved upward like a short horn, and tapers gradually to near the point, where it rounds off rapidly. The egg-membranes are thin. I have some reasons for believing that the larger specimens of this species will be found to produce a considerably larger number of young than the above observations indicate.

I have met with no statements regarding the breeding habits of either *Tropidonotus grahamii* or *T. leberis*, except that made by Miss Hopley,† to the effect that a specimen of the last-mentioned species in the Zoölogical Gardens produced in August five young and at the same time some eggs. What the state of development of these eggs was, and what became of them, we are not informed. I have a female specimen (No. 26) taken somewhere in Indiana, and in this I find eight eggs, of which three are in the left oviduct. There are no signs of beginning development. A gravid female (U. S. Nat. Mus., No. 17970), captured on July 15, and sent me by Mr. W. O. Wallace, of Wabash, Ind., is 24 inches long. There are eight eggs, two of which are in the left oviduct. The eggs are of different shapes, on account of pressure. A considerable amount of yolk is still present, an indication that the embryos are not yet completely developed. A measurement of one of these shows it to be 6½ inches long. The longitudinal bands of the upper surface are sufficiently well displayed to enable one easily to determine the species, but the longitudinal brown ventral bands are not seen. I find no indications of the presence of the egg-tooth, although it is probably present.

Some years ago I killed a specimen of a female of *T. grahamii* in Bureau County, Ill. Of the specimen the skin and a few eggs (U. S. Nat. Mus., No. 17954) were preserved. The time of capture was about the middle of July or later. The mother snake was of such a rusty color that the species to which she belonged could not then be determined. One of the eggs measures an inch and a half in long diameter by three-quarters trans-

* Proc. Phil. Acad. Sci., 1887, p. 121.

† Snakes, etc., Miss C. C. Hopley, p. 437.

versely. A considerable mass of yolk is present, into one side of which an embryo snake is sunken. This embryo is 7 inches long; and, although thus immature, has its scales and its colors so perfect that there is no difficulty in assigning it to the proper species. The embryo is surrounded by a very thin egg-covering. No indications of the presence of the egg-tooth were seen until a series of sections through the snout were examined, when it appeared.

Tropidonotus kirtlandi is a rather common snake in central Indiana. One specimen (U. S. Nat. Mus., No. 17957) taken at Irvington contains three eggs in each ovary. Each egg is a little less than half an inch in length. Another specimen (U. S. Nat. Mus., No. 17953) from Winchester, Randolph county, has eight eggs in the ovaries. Each egg is seven-sixteenths of an inch in length. This species is in all probability ovoviviparous.

The species of *Storeria* are stated by Dr. Goode* to be oviparous; but Prof. Cope† regards them as ovoviviparous, and he is quite certainly correct in his conclusion. One female of *Storeria dekayi* sent me from Winchester, Ind., contains thirteen eggs, five of which are in the left ovary, the remainder in the right. The eggs have apparently not attained their full ovarian size. Another specimen (U. S. Nat. Mus., No. 17966) of this species, taken by Dr. D. S. Jordan, at Cumberland Gap, Tenn., about midsummer, is a foot long, and has in it eleven eggs, the hindermost three of which are in the left oviduct. Each egg is about three-eighths of an inch in length by one-quarter in short diameter. Another specimen (U. S. Nat. Mus., No. 17967), which was taken at Irvington, contains eight eggs in the oviducts, each including a very immature embryo an inch and a half in length. The eggs are about half an inch long. The membranes are extremely thin.

I find a few notes on the breeding habits of *Heterodon platirhinos*, the hog-nosed snake, viper, or spreading adder, as it is popularly known. Some of these contain statements which, to me, appear exaggerated. Dr. J. Schneck, of Mount Carmel, Ill., reports‡ that eighty-seven "young spotted spreading adders" were taken from the body of a wounded female. The author of the note did not see this done, but got his information from persons who did see it. I am strongly inclined to believe that the reptile was a *Tropidonotus sipedon*. Another writer§ in Pennsylvania gives an account of over one hundred young snakes issuing from a wound in the side of a female

*Proc. A. A. A. S., 1873, p. 184.
†Proc. Phila. Acad. Sci., 1874, p. 116.
‡Amer. Nat., Vol. XVI, p. 1008.
§Amer. Nat., Vol. III, p. 555.

spreading adder. These young were each from 6 to 8 inches in length, and all were active and blowing vigorously. Neither did the author of this note see the escape of the snakes, although he did see sixty-three of the young in alcohol. There may easily have been an error in the determination of the species to which these young snakes belonged. One who has examined the eggs of this species can not easily believe that so many young snakes could, with such readiness, escape from a wound in the mother's side. Moreover, these snakes deposit their eggs in the earth some time before the young are ready to lead an independent existence.

Dr. Bumpus (*op. cit.*, p. 364) states that a female *Heterodon* in the National Museum brought forth one hundred and eleven young; but Dr. Bumpus kindly informs me that he did not himself observe this.

Prof. F. W. Cragin reports* the finding, on September 10, of twenty-two eggs of this species. They were buried in the sand at East Hampton, Long Island. Two of the eggs, which he had in his possession, hatched four days afterwards. Troost appears to have dissected a black specimen, in which he found twenty-five eggs. Dr. C. C. Abbott says† that he has frequently in May found the eggs of the hog-nosed snake in considerable numbers, a few inches below the surface of the ground; and in early July he once found a family of 17 very small, and apparently just hatched, young. These resented all interference, snapped, hissed, and flattened their heads precisely as an older snake would do. The size of the young is not given, but in another place (*op. cit.* p. p. 295) he implies that they were less than 4 inches in length. I think that this species, like most other species, produce their young rather later in the season; but I see no reason for not believing that some individuals may bear their eggs over the winter and lay them in the spring.

A female (U. S. Nat. Mus., No. 17951), sent me from Veedersburg, Fountain county, Ind., contained fifteen eggs, the posterior four of which lay in the left oviduct. I could discover no signs of embryos. Each egg was covered by a thick, tough, yellowish coat, inside of which was a thinner and more delicate membrane.

Through the kindness of Dr. L. Stejneger, curator of the department of reptiles in the National Museum, I have been enabled to make some observations on the eggs and living young of this *Heterodon*. On the 31st day of last August, there were brought into the laboratory of the Department, from

*Amer. Nat., Vol. XIII, p. 710.
†Rambles, etc., p. 289.

some point in Maryland not far from Washington, a lot of twenty-seven eggs, which the finder said were the eggs of the copperhead. It was reported that the eggs were thrown up out of the ground by the plow, and that the mother snake was near by and had resented the disturbing of her treasures. She had been killed, but had not been sent along with the eggs. Since it was supposed that the copperhead produces living young, the occupants of the laboratory were anxious to learn if this opinion were erroneous. Accordingly one of the eggs was opened, and in it was found a young hog nosed snake, fully developed, and ready to assist himself on the stage of action. This *Heterodon* quite closely resembles the copperhead, and most people are not accustomed to make nice distinctions among snakes. This close resemblance may account for some of the statements of the large number of young produced by the copperheads.*

The eggs referred to were between an inch and a quarter and an inch and a half long, and about seven-eighths inch in short diameter. The egg covering was thick, tough, and flexible, resembling a piece of parchment. There is little if any deposit of lime in it. Of these eggs, some were found to have hatched during the night of September 6. Others, which were buried somewhat deeper in some clay, escaped from the eggs later; but all were out by the afternoon of the 8th. The length of such as were measured varied between 7 and 8 inches. From the moment of escape from the egg all were quite active, and manifested many of the characteristics of the adults. Some of the little fellows were quite saucy, and would make a pretense of striking at the approaching finger; but their efforts in that line were rather feeble. A faint hiss was sometimes uttered, but that may not have been voluntary. One would sometimes flatten its head and body and rear up with the anterior third of its length free from the ground. If one did not know well their inoffensive natures, one would be excused for fearing to handle them. An extremely singular habit possessed by the adults is that of feigning death. On being struck or teased they will roll over and over, as if in the intensest agony, and then throw themselves on the back and lie there as if dead. Out of some fifteen of the young experimented with, I succeeded in getting only two or three to go through with this performance, but these did it to perfection. On being lightly struck a few times, they would turn over on the back, writhe about a while, and then lie perfectly still. If turned right side up, they would again turn on the back. If left undisturbed for a little while they would turn over and

* Amer. Nat., Vol. XVII, p. 1235.

creep slyly away. The others of the young would not act in this way, however much they were teased. It would be interesting to know whether all the adults possess this odd habit, or only a portion of them.

The cuticle of the young *Heterodons* is shed very shortly after their escape from the egg-coverings. Within a few minutes after one had left its prison the skin was observed to be broken about the head. It had left the egg at half-past 1 and by 4 o'clock the skin was pushed back half the length of the body. The next morning the skin was wholly shed, revealing the brighter colors of the new skin. While getting rid of the cuticle the little reptile kept crawling over the clay and among the roots of grass.

The opportunity was embraced to observe the use which is made of the egg-tooth. The tooth itself is easily seen in the just-hatched snake. Its lateral borders are more nearly parallel than those of the tooth of *Bascanion* figured by Weinland. Seen from the side, the anterior or upper outline is concave, the posterior outline convex. Thus, the tooth projects forward and is turned slightly up. The anterior face is also concave from side to side, so that there is, on each side, a distinct cutting edge. The tip is cut off square. The tooth appears to have a ligamentous attachment, and may be lifted a little, but not much depressed. It seems quite evident that the tooth is first engaged in the egg-covering and then made to do its work by a forward push of the head. An examination of the covering, after the snake has left it, gives ample proof that it has been cut and not merely torn. The edges are as smooth as if they had been slashed with a razor. A long slit is sometimes made as if by a single effort. In other cases, several attempts appear to have been made before the covering has been open enough for the snake to get out. In one or two cases, a tooth has not been inserted deeply enough, and the only result was a scratch on the inside of the covering. The egg tooth having performed its office becomes loose and drops out. This occurs usually within twenty-four hours.

When the slit has been successfully made, the little snake may sometimes be seen pushing its head carefully out as if to survey the surroundings. Should there be any movement, the head will be quickly withdrawn.

I have been able to collect some facts concerning the pairing of the sexes of *Heterodon platirhinos.* Prof. U. O. Cox, of Mankato, Minn., informs me that he found two individuals uniting some time in May. A second male was entwined with the two other snakes. The latter were separated with difficulty. The male intromittent organs are described as being of an oval form, an inch long and over a half inch thick.

Two observers have seen black specimens, formerly called *H. niger*, pairing with the spotted individuals. Prof. W. S. Blatchley* found a black and a spotted one copulating on April 19. He speaks in a letter to me of the intermittent organs as being as large as a walnut, and covered with spines. Mr. E. R. Quick, of Brookville, Ind., an accurate observer of nature, writes me that he once found a black viper pairing with a spotted one. The time, he thinks, was late in June. The time of gestation of this species is not known. It may continue from spring until autumn. Possibly the late-pairing individuals may retain their eggs until the next spring. Nor do we know how long the eggs are laid before they are ready to hatch. These matters are known concerning very few of our snakes, and a wide field is offered for work and observation.

Of the *Colubers*, I have been able to make observations on *C. obsoletus* alone. It is likely that others have observed and written on the subject, but I have not met with their statements. Dr. G. B. Goode reckons† this species among those which are ovoviviparous, but I am inclined to question this. My son, W. P. Hay, captured two of these snakes, near Indianapolis, while they were in sexual union. This was on June 19. The male (U. S. Nat. Mus., No. 17948) was 5 feet 5 inches long, the female (U. S. Nat. Mus., No. 17949) 6 feet 3 inches. When they were separated, the intromittent organs of the male were everted some 3 inches. A dissection shows that the hollow portion of the organ extends behind the vent 3 inches, while the retractor muscles form a cord which extends back nearly to the tip of the tail. At the base of the evertible portion, near the vent, the inner surface, which when the organ is everted becomes the outer surface, is furnished with numerous plications. Near the middle of the organ are found many hooked papillæ, some of them large and horny. The remainder of the organ has the surface raised up into numerous anastomozing folds, so that under the microscope it reminds one of the reticulum of the ox's stomach. On opening the female I find in her sixteen eggs. Of these eggs, four lie about the middle of the animal's body, while the other twelve occupy a much more anterior position; the one farthest forward being within 8 inches of the tip of the snake's snout, the hindermost one only 9 inches farther back. Several of these eggs are lying apparently loose in the body cavity. It might be supposed that they had just left the ovary and were about to enter the oviduct; but they are surrounded each

*Jour. Cincinnati Soc. Nat. Hist., 1891, p. 33.
†Proc. A. A. A. S. 1873, p. 185.

with a covering nearly as thick and tough as that of the egg of the *Heterodon*. Could these eggs have have been in the oviducts and then squeezed out into the body cavity during the time of being entwined with the male? The thickness of the egg covering makes it appear to me highly probable that the eggs are destined to be laid before the young will be mature enough for independent existence.* †

Some years ago, in midsummer, I found a number of the eggs of the house snake which had been deposited in a pile of stable manure. This was in Bureau county, Ill. No record was kept of the number of the eggs, but a few of them (U. S. Nat. Mus., No. 17955) were preserved in alcohol. When found, the eggs were glued together into one mass. Each egg is 2 inches long and nearly an inch and a quarter in the short diameter. On the outside is found a thick, leathery, yellow covering, beneath which is a much thinner coat. From one of these eggs I have taken a young snake which measures 10¾ inches in length. Attached to this embryo is a considerable mass of yolk, a condition which indicates that the embryo is not ready for hatching. Nevertheless, all the generic and specific characters are well shown. There is a well-developed egg-tooth. The intromittent organs are everted in the specimen examined. Each consists of a rather slender and twisted basal stalk, at the end of which is the swollen glans. This is acorn-shaped at the base, but terminates, at the distal end, in two blunt lobes. The base of the glans is densely spinose, the remainder reticulately papilose. The seminal groove winds around the basal stalk and terminates at the tip of one of the terminal lobes, the larger one.

Concerning the breeding habits of the black-racer, *Bascanion constrictor*, I find little in print. It is well known that the young differ markedly from the adults, being decidedly spotted. Dr. Weinland, as already stated,

* Since the above has gone to press, I have had the opportunity, April 29, of dissecting a recently captured female, the length of which was 4 feet 4 inches. The ovaries lie in the region situated about two thirds the distance from the head to the vent. Each oviduct ends close to the corresponding ovary. It seems evident, therefore, that at least some of the eggs of the specimen described above are really lying loose in the body cavity. In the specimen dissected, the ovarian eggs are very immature, none of them exceeding about a quarter of an inch in length. It may be of some interest to add that this female had the anterior three-fourths of the body ornamented with blotches of a decided red color, the red occupying both the surfaces of the scales and the skin between them. The blotches were separated by scales which were partly yellow. Soon after death a great part of the red disappeared. The stomach contained eight wild mice, six of them young.

† I am able to state that *Coluber obsoletus* is oviparous. Mr. Thomas Marron, of the National Museum, early in April, 1889, collected a number of snake eggs in a hollow stump near the Potomac river. They were opened and found to contain fully developed young of this species, (U. S. Nat. Mus., No. 15334).—Leonhard Stejneger.

described the egg-tooth. In one female, taken near Indianapolis, I find nineteen eggs, seven of which lie in the left ovary. These eggs are quite immature.

Some alcoholic eggs (U. S. Nat. Mus., No. 17956) of this species from an unknown locality furnish some points. They are of the usual elongated oval form, an inch and a half long and close to an inch in short diameter. The outer covering is thick and tough, and it is furnished with numerous hard points, as if of deposits of lime salts. Within the egg is a young racer $10\frac{1}{2}$ inches long and evidently nearly ready to come forth. The intromittent organs of this specimen are somewhat flattened, broad at the extremity, and with prominent terminal angles. The organ begins to expand from its base. It is furnished plentifully with spines. When the sexes unite, when the eggs are laid, how concealed, and when they hatch, are some of the things which we need to learn.

I have examined a specimen (U. S. Nat. Mus., No. 17969) of *Haldea striatula* from some point in Arkansas. It is $9\frac{1}{2}$ inches long and contains five eggs, each with a young *Haldea* in it. Only the hindermost egg is in the left oviduct. This is a little over an inch long, but the others are only a little more than three-quarters. The short diameter of the egg is about a quarter of an inch. The embryos are far from mature, being only $2\frac{3}{4}$ inches long when extended. They have a considerable mass of yolk still attached to them. The egg-coverings are very thin. This circumstance causes me to conclude that the young are brought forth alive. A series of sections through the snout of an embryo reveals the presence of the usual egg-tooth.

Some Observations on the Turtles of the Genus Malaclemys. By O. P. Hay.

Of the turtles belonging to the genus *Malaclemys* there are now recognized five species, two new ones having been described within recent years by Dr. G. Baur. The genus is a very distinct one, and is distinguished from *Chrysemys* especially by the extremely broad and flat crushing surfaces of both upper and lower jaws. As a result of the provision made for the support of these wide, horny, masticatory plates, the internal nares are thrown far back, so as to lie behind the level of the eyes. In the Catalogue of the Chelonians in the British Museum, 1889, Dr. G. A. Boulenger says that the "plastron is extensively united to the carapace by suture, with feeble axillary and inguinal peduncles, the latter ankylosed to the fifth costal plate." Sometime ago I macerated a large specimen, *M. geographica*, until the whole plastron fell away from the carapace, thus showing that there was no ankylosis of the parts.

The Map tortoise, *M. geographica*, was described by the naturalist Le Sueur, in the Journal of the Philadelphia Academy for 1817. In the Mémoires du Muséum de Paris for 1827, Le Sueur presented the description of another species of this genus from specimens which he had taken in the Wabash river, at New Harmony, Ind. Neither figure nor systematic name accompanied the description, although he appears to have had a name in manuscript, *pseudogeographica*. It is evident that Le Sueur had in mind the terrapin, which has for the most part gone by that name since then, although the description is in some respects erroneous. The first mention that I find of this manuscript name of Le Sueur is found in connection with the *Emys lesueurii*, described by Dr. J. E. Gray in his Synopsis Reptilium, 1831. It is also given by Duméril and Bibron in Erpétologie Générale, vol. II, p. 256, as a synonym of *Emys geographica*, with the remark, "jeune age." In his work, Herpetology of North America, published in 1842, Dr. Holbrook recognized the fact that this terrapin is distinct from the earlier described *geographica*, and gave to it the name that Le Sueur had bestowed on it in his manuscripts. He also accompanied the description with a colored plate. It is from this date, 1842, that we must reckon in determining the tenability of the name *pseudogeographica*.

In 1831 Dr. J. E. Gray, in his Synopsis Reptilium, p. 31, published a description of a species which he called *Emys lesueurii*. This supposed new species was founded on either a specimen of *geographica* or on one of what Holbrook afterwards called *pseudogeographica*. Dr. Gray himself, in all his subsequent publications, wrote down the name *lesueurii* as a synonym of *geographica*, although previously to the publication of his Catalogue of the Shield Reptiles he did not recognize Le Sueur's *pseudogeographica* as being distinct from the earlier described *geographica*.

In 1857 Louis Agassiz, in his Natural History of the United States, arranged both the species referred to under the genus *Graptemys*. Of his *Graptemys lesueurii* he say: "This species is commonly called *Emys pseudogeographica*, but the specific name *Le Sueurii* is older. It is evident from his reference that Gray at first applied the name of *Emys Le Sueurii* to this species, and not to *Gr. geographica*: now Gray calls it also *Emys pseudo-geographica*." Since that time Prof. E. D. Cope, in his Check List of 1875, employed the name used by Holbrook, but Mr. F. W. True, in Dr. Yarrow's Check List of 1882, adopted Agassiz's suggestion and called the species *Malacoclemys lesueurii*.

Since now the name by which we are to know the species called by Le Sueur and Holbrook *pseudogeographica* depends on what Gray had before him when he described his *Emys lesueurii* it becomes necessary, if possible, to determine that matter. More certainly depends on that than on Gray's references to any previous writings.

Among other differences existing between the two species of *Malaclemys* referred to here, is one which enables us in all cases to distinguish them. This is found in the form of the yellow spot which lies on the side of the head just behind the eye. In *M. geographica* this spot is broad, rather triangular, and elongated in the direction of the head. In the other species the spot is a transverse streak, running behind the eye and sometimes curving forward below it. Now, in his description of *Emys lesueurii*, Gray has this language: "Temporibus macula triangulari notatis." At the end of his description he further says: "*Emys geographica* of Le Sueur agrees with the museum specimen, except in that the first vertebral plate is not urn-shaped, and Le Sueur does not notice the triangular temporal spot." In that remark we have evidence that Gray had before him but a single specimen and that that specimen had the "ear-mark" of *geographica*. We further learn why he described it as different from Le Sueur's species. That Gray was at this time aware of the existence of Le Sueur's manuscript name appears from the following words at the end of the description:

"β, Scutello vertebrali primo urceolato." *Emys geographica*. Lesueur. Jour. Acad. N. S. Phil. t. *Emys pseudogeographica*, Lesueur Mss. (Mus. Paris).

This is probably the reference that Agassiz alludes to, and it is hard to see why Gray introduces it here; but it no more proves that he had Le Sueur's *pseudogeographica* in mind than the other species. Indeed, he regarded them as both the same thing. Furthermore, in his Catalogue of the Shield Reptiles, he refers this β to *pseudogeographica*, while his *lesueurii* is referred to *geographica*. It is evident that he regarded what he placed under β as different from the species he was describing. I make the suggestion that the quotation marks were put in front of the β through an error of writing or printing. As to the characters assigned to *lesueurii*, I submit that they apply much better to *M. geographica* than to *pseudogeographica*.

The subsequent history of these two species, so far as Dr. Gray is concerned, is as follows: In the Catalogue of Tortoises, published in 1844, he regards both *pseudogeographica* and *lesueurii* as synonyms of *geographica*. He does not appear at this time to have seen Dr. Holbrook's work of 1842. In his description of the *geographica* of the Catalogue of Tortoises, Dr. Gray says of the head-spot only that it is "a yellow streak on the temple." In making this description he had before him two specimens, which according to his plan, he designates as *a* and *b*. Was either of these the one on which he had in 1831 based the species *lesueurii*? This is of some importance and will presently be considered.

By the time of the publication of the Catalogue of Shield Reptiles, in 1855, Dr. Gray had undergone another change of mind. He now recognized the existence of two entirely distinct species, and these he designates as *Emys geographica* and *E. pseudogeographica*. Of the latter species there were then in the British Museum seven specimens, five of which had certainly been received since 1844. The other two are distinctly stated to be the ones which had been recorded as *a* and *b* under *Emys geographica* in the work of 1844. Of *Emys geographica*, on the other hand, there was in 1855 only a single specimen in the Museum and that is expressly said to be the one which furnished the description of *E. lesueurii* in 1831. Even then Gray seemed to be a little doubtful about its being the same as Le Sueur's *geographica*, but his description of it removes all doubt. He contrasts it sharply with the specimens of *pseudogeographica*.

All these facts indicate that in 1844, when Gray wrote the Catalogue of Tortoises, the type of *E. lesueurii* was not in his hands. It had probably been misplaced and for the time being lost. The descriptions of that work had been drawn from two specimens of *pseudogeographica*. When the Catalogue of Shield Reptiles was written, the specimen had been recovered, and Gray was enabled to compare it with specimens of the other species and with Holbrook's descriptions and figures. It is spoken of as "animal dry from spirits," "the Museum specimen is in a bad state." Something concerning its history may be inferred from these remarks.

Dr. Boulenger, in his Catalogue of Chelonians, 1889, accepts the specific name *lesueurii*, instead of *pseudogeographica*. No mention is made of the specimen which served Dr. Gray as the type of *lesueurii*.

With the evidence before us, we must, it seems to me, accept the name *pseudogeographica* for the species under consideration. To reject it will be to ignore Gray's statements, repeatedly made, that his *lesueurii* is a synonym of *geographica*, as well as the plain language of his descriptions. It may be a very objectionable name, but the laws of priority must be rigidly observed.

The masticatory surfaces of *M. geographica* are much broader than those of *M. pseudogeographica*, and we might infer therefrom that the food of the two species is not the same. In Volume XXII of the Bulletins of the Essex Institute, Prof. Harry Garman has made the observation that the broad surfaces of *M. geographica* are employed in crushing the shells of mollusks, the remains of which he found in their stomachs. In the stomachs of *M. pseudogeographica*, on the other hand, he found the remains of a species of sedge, as well some animal matter. During the month of May, 1891, at a meeting of the Indiana Academy of Sciences at Lake Maxinkuckee, in northern Indiana, three or four of us, within a few hours captured about thirty specimens of *M. geographica*. These specimens were almost invariably taken in the water near the shores of the lake where the bottom was covered with the shells, living and dead, of *Vivipara contectoides*. Seven of the terrapins were taken home and kept some days in a washtub partially filled with water. When they were taken out, there were found on the bottom of the tub large numbers of the opercula of that water snail. In the alimentary canal of one terrapin were found these opercula, as well as the remains of crayfishes, and what appeared to be the cases of some species of caddis-worm. The masticatory surfaces of the older specimens were found to be much worn. The crushing surfaces of Dr. Baur's recently described *M. oculifera* are rather narrow, while the cutting edges of the jaw are very sharp. The indications are that the food does not consist of mollusks, but rather of some soft vegetable and animal substances.

Most, if not all, the species of this genus are extremely variable in the size of the head. In the paper referred to above, Prof. Garman attempts to give us the characters that distinguish *geographica* from *pseudogeographica*, and among such differential characters is the size of the head relative to length of the carapace. *Geographica* is stated to have a large head; *pseudogeographica* a much smaller head. He also presents measurements that appear to prove his position. Dr. Holbrook long ago described a specimen of *geographica* under the name of *Emys megacephala*, the name being suggested by the massive head. Some years ago Dr. Gray suggested that the large head might be a sexual character, but he did not state which have the big heads, the males or females. Through the kindness of Dr. Stejneger, I have been permitted to examine all the specimens of both species that are in the National Museum, and I have also examined a number of specimens of both the species in my own collection. I find that the size of the head is not a specific, but a sexual, character, and that it is the females which have the large heads. The heads of the males are much smaller and also more pointed. I believe that the same statements are true regarding the salt-water terrapin, *Malaclemys terrapin*, although I have not been able to examine a sufficient number of specimens to be certain about it. With regard to the other two species referred to I am quite certain that no appreciable differences will be found between them, when we compare specimens of the same size and sex.

Another interesting matter pertaining to most, if not all, the species of this genus is the size of the male as compared with that of the female. Le Conte is the only author who has, so far as I am aware, made the observation that the male of the salt-water terrapin is small. Of the seven specimens of *M. geographica* taken by myself at Lake Maxinkuckee, three had the carapace $3\frac{3}{4}$ inches long, while the other four had a length of carapace ranging from $6\frac{3}{4}$ to 9 inches. Dissections proved that all the small specimens were males and the large ones females. The same statements are true of such specimens of *M. pseudogeographica* as I have examined. All the specimens of *M. oculifera* Baur in the National Museum are, judging from the form of the shell, females; and they are all large specimens. Both Agassiz and Baur have observed that the males of *Trionyx spiniferus* are smaller than the females. On the other hand, the largest specimen of *Chelydra serpentina* that I have ever seen was a male, and I believe that the males of the various species of the genus *Chrysemys*, as defined by Boulenger, exceed the females in size.

It is quite characteristic of the species of the genus *Malaclemys* to have a prominent keel along the middle of the carapace, and this is often nodose. In *M. pseudogeographica* the keel is nodose all through life. However, all the species, so far as we know, have these elevations along the keel when young. In some of the young of the salt water terrapin I found that the nodosities were especially large and globular. They resembled greatly a row of medium-sized peas, four or five in number, lying along the back. The species *M. geographica*, having such a nodose keel while young, but losing it as age advances, must be regarded as attaining a higher stage of development than *pseudogeographica*, which retains this embryonic character throughout life. The young of *M. oculifera* will undoubtedly be found to have a distinct and nodose keel.

Agassiz (*loc. cit.* p. 260) discusses the various ways in which the different kinds of turtles get rid of the older layers of the epidermis. He mentions certain species of fresh-water turtles, among them *M. pseudogeographica* in which he observed in the spring the uppermost layer of the dermal plates to be cast off at once as one continuous, thin, mica-like scale all over the plate. In a number of very young specimens of *M. geographica* taken at Lake Maxinkuckee, the outer layer of the epidermis was lifted up from the underlying layers by a quantity of fluid. This was preparatory, no doubt, to the casting off of the epidermal layer.

THE GRYLLIDÆ OF INDIANA. By W. S. BLATCHLEY, A. M., Terre Haute, Ind.

The *Gryllidæ* or crickets are, in the main, distinguished from other *Orthopterous* insects, by having the wing covers flat above and bent abruptly downward at the sides; the antennæ long, slender, and many jointed: the tarsi, or feet, three jointed, without pads between the claws; the ear situated on the tibia of the fore leg; and the abdomen bearing a pair of jointed cerci or stylets at the end.

The ovipositor of the female, when present, is long, usually spear-shaped, and consists, apparently, of two pieces. Each of these halves, however, when closely examined, is seen to be made up of two pieces so united as to form a groove on the inner side, so that when the two halves are fitted together, a tube is produced, down which the eggs pass to the repository in the earth or twig, fitted to receive them.

The inner wings are, for the most part, short, weak, and comparatively useless as flying organs, though, sometimes, they are nearly twice as long as the outer pair. Like their nearest relatives, the grasshoppers and katydids, crickets travel mostly by leaps and, in the course of time, their hind femora have thus become greatly enlarged.

The chirps or love calls of the different species of crickets make up the greater part of that ceaseless thrill which fills the air, usually at night, from mid-August until after frost. These sounds are made only by the males, and are not vocal, as most persons suppose; but are produced by rubbing the veins in the middle of one wing cover upon those of the other. The peculiar structure of this stridulating organ of the male, as well as the high specialization of the ovipositor in the female, have led entomologists to classify the *Gryllidæ* as the highest family of the ORTHOPTERA.

Representatives of nine genera and sixteen species of these interesting insects from Indiana are in the writer's collection, several of which are exceedingly abundant throughout the state.

A belief that a brief and popular description of the leading characters of each of these species, together with some account of their habits, as noted during a number of years of observation, would prove acceptable to persons interested in the study of such creatures, has prompted the preparation of this paper. In order to render it as complete as possible for reference purposes, and thereby aid the younger entomologists of the state, a synonymy of each species has been compiled from such works as were accessible and appended to the name of that species. The following is a full list of the authors and publications to which reference is made in the synonymy given:

Comstock, J. H.—An Introduction to Entomology, I, 1888.

Fernald, C. H.—The Orthoptera of New England, 1888.

Fitch, Dr. Asa.—Third Report on the Noxious Insects of New York, 1856.

Glover, Townsend.—Report of U. S. Entomologist in the U. S. Agricultural Report for 1874.

Harris, Dr. T. W.—Treatise on Some Insects Injurious to Vegetation. Third edition, 1862.

McNeill, Jerome.—A List of the Orthoptera of Illinois, Psyche, VI, 1891.

Packard, A. S., Jun.—Guide to the Study of Insects. Eighth edition, 1883. Fifth report U. S. Entomological Commission, 1890.

Rathvon, S. S.—In the U. S. Agricultural Report, 1862.

Riley, Dr. C. V.—Orthoptera in the Standard Natural History, II, 1884.

Say, Thomas.—The Entomolgy of North America. LeConte edition, 1859.

Scudder, Samuel H.—Materials for a Monograph of the N. A. Orthoptera, in the Boston Journal of Natural History, VII, 1862. Catalogue of the Orthoptera of N. A., 1867. The Distribution of Insects in New Hampshire, in the first volume of Final Report upon the Geology of New Hampshire 1874.

Thomas, Cyrus H.—Insects Injurious to Vegetation in Illinois, in the Transactions of the Illinois State Agricultural Society, V, 1865.

Uhler, Philip R.—Orthopterological Contributions in the Proceedings of the Entomological Society of Philadelphia, II, 1864.

Walsh, B. D.—In the Practical Entomologist, vols. I and II, 1867.

Various Authors.—Insect Life, vol. II, 1889. Canadian Entomologist, XXIV, 1892.

The following artificial key will enable the student to more readily distinguish the different genera of *Gryllidæ* found in Indiana.

a. Fore tibiæ broad, fitted for digging.

b. Length of body more than one-half of an inch. . . II. GRYLLOTALPA.

bb. Length of body less than one-half of an inch. . . . I. TRIDACTYLUS.

aa. Fore tibiæ slender.

c. Hind femora slender. . . . . IX. ŒCANTHUS.

cc. Hind femora robust.

d. Last segment of the maxillary palpus very nearly of the same length as the one preceding.

e. Head as broad as or broader than the posterior margin of the pronotum; color black or dark brown. . . . . III. GRYLLUS.

ee. Head narrower than the posterior margin of the pronotum; color light brown or dark yellow. . . . . VII. OROCHARIS.

dd. Last segment of the maxillary palpus, very nearly, or fully, double the length of the one preceding.

f. Last segment of the maxillary palpus broadly flattened . . . . VI. PHYLLOSCIRTUS.

ff. Last segment of the maxillary palpus club-shaped but not flattened.

g. Ovipositor much compressed, curved strongly upwards. . . . . V. ANAXIPHUS

gg. Ovipositor of the normal form (cylindrical) curved but slightly upwards.

h. Head as broad as, or broader, than the posterior margin of pronotum. . . . . . IV. NEMOBIUS.

hh. Head narrower than the posterior margin of pronotum. . . . . VIII. APITHES.

FAMILY. GRYLLIDÆ.—The Crickets.

I. TRIDACTYLUS, Olivier (1789.)

To this genus belong some of the smallest of the Gryllidæ, no one of the three species found in the United States being more than 10 mm., or two-fifths of an inch, in length. The generic name, Tridactylus, is based upon the peculiar structure of the anterior tibiæ which are much dilated and armed at the end with three strong and slightly curved spurs. The outer wings, or tegmina, are horny and opaque and do not reach the end of the abdomen, while the inner wings are longer and folded lengthwise like a fan. The hind femora are enlarged and the insects are active leapers. But one species has as yet been taken in Indiana, though another one doubtless occurs in the northern half of the state.

1. TRIDACTYLUS APICALIS, Say.

Tridactylus apicalis, Say, Ent. N. A., (Ed. Le Conte), II, 239.
Scudder, Bost. Jour. Nat. Hist., VII, 1862, 425.
Packard, Guide Stud. Ins., 1883, 563.
Riley. Stand. Nat. Hist., II, 1884, 180.
McNeill, Psyche, VI, 1891, 3.

This is the largest of the three species occurring in the U. S., its length being 8 or 9 mm.* The body is deep black, the head and thorax with some white markings, and the tegmina with their outer edge and a spot behind the middle white. The hind femora are whitish, with three faint, dark cross bars. The wings of the male extend three mm. beyond the tip of the abdomen.

Apicalis, is stated by most of the authorities cited above, to be a southern species, but has been taken as far north as Quincy, Illinois. In Indiana it has, so far as known, been noted only in Vigo county, where a few specimens were discovered along the banks of a small stream during the latter part of October, 1891. They evidently dwell in little pits or burrows in the soft sand or mud, as numerous openings of such places were found, from one or two of which specimens emerged and leaped into the water on which they floated for an instant and then sprang back onto the bank. The most of the inhabitants of the pits had, no doubt, been killed by the frost before the species was discovered, and another season will have to arrive before anything distinctive of their habits can be learned.

II. GRYLLOTALPA, Latreille (1807). The Mole Crickets.

Among the Gryllids found in Indiana the burrowing or mole crickets rank first in size and singularity of structure. When full grown they measure from an inch and a fourth to an inch and a half in length; are light brown in color and have the body covered with very short hairs, giving to it

*The measurements in this paper are usually given in millimetres. An inch is equal to very nearly 25 mm.

a soft, velvety appearance. The females have no visible ovipositor, and, externally, may be separated from the males only by the difference in the veining of the uppermost of the wing covers. By their habit of burrowing beneath the soil in search of such food as the tender roots of plants, earth worms and the larvæ of various insects, the anterior tibiæ of these crickets have, in the course of ages, become so modified in structure as to closely resemble the front feet of the common mole, whence the generic name, *Gryllotalpa*, from "*gryllus*," a cricket, and "*talpa*," a mole. Moreover, the compound eyes have become very much aborted, being not more than one-eighth the size of those of the common field cricket, *Gryllus abbreviatus*, Serv., and, as the insect crawls rather than leaps, the hind femora are but little enlarged. Two species occur in Indiana.

2. GRYLLOTALPA BOREALIS, Burmeister. The Northern Mole Cricket.

Gryllotalpa borealis, Scudder, Bost. Journ. Nat. Hist., VII, 1862, 426.
Id., Dist. Ins. in N. H., 1874, 363, pl. A, fig. 7.
Id., Amer.Nat.,X,1876, 97,(The chirp of set to music).
Thomas, Trans. Ill. St. Ag. Soc., V, 1865, 441.
Glover, U. S. Ag. Rep. 1874, 143, fig. 17.
Packard, Guide to Stu. Ins., 1883, 563.
Fernald, Orth. N. Eng., 1888, 14, fig. 6.
Comstock, Int. to Entom., I, 1888, 120, fig. 121.
NcNeill, Psyche, VI, 1891, 3.
Fletcher, Can. Entom. XXIV, 1892, 23, fig. 1.
Doran, Can. Entom., XXIV, 270, (Life history of).

Gryllotalpa brevipennis, Harris, Ins. Inj. to Veg., 1862, 149, fig. 68.
Rathvon, U. S. Ag. Rep., 1862, 378, fig. 12.

The northern mole cricket may be known by the shortness of its outer wings which are less than half the length of the abdomen, while the inner wings extend only about one-sixth of an inch beyond them.

In the moist mud and sand along the margins of the smaller streams and ponds their runs or burrows, exactly like those of a mole though much smaller, can in late summer and early autumn be seen by those interested enough to search for them. These runs usually end beneath a stone or small stick, but the insects themselves are very seldom seen, as they are nocturnal, forming their burrows by night, and scarcely ever emerging from beneath the ground.

The note of the male is a sharp disyllabic chirp, continuously repeated and loud enough to be heard several rods away. It is usually attributed, by those who have given little attention to insect sounds, to the field cricket or to some of the smaller frogs. They are very difficult to locate by this note, and the writer has on several occasions approached cautiously, on hands and knees, a certain spot and has remained silent for minutes while the chirping went on apparently beneath his very eyes; yet, when the supposed exact position of the chirper was determined and a quick movement was made to unearth him he could not be found. Indeed it is only by chance, as by the sudden turning over of a log in a soft, mucky place, that a person can happen upon one of them unawares. Even then quick movement is necessary to capture him before he scrambles into the open mouth of one of the deep burrows which he has ever in readiness.

The eggs of the northern mole cricket are laid in underground chambers in masses of from forty to sixty, and the young are about three years in reaching maturity. On this account, where they exist in numbers, they are very destructive, feeding, as they do during that time, mainly upon the tender roots of various plants. It is therefore fortunate that with us the species is not more common than it is. It has been noted in Wabash, Tippecanoe, Vigo, Putnam and Monroe counties, and is probably found throughout the state, though nowhere abundant.

Average measurements, of twelve specimens: Length of body, 33, mm.; of wing covers, 10 mm.; of wings, 14 mm.

3. GRYLLOTALPA COLUMBIANA, Scudder.—The Long-winged Mole Cricket.

Gryllotalpa longipennis, Scudder, Bost. Jour., Nat. Hist. VII, 1862, 426.
Packard, Guide to Stud. Ins., 1883, 563.

Gryllotalpa columbiana, Fernald, Orth. N. Eng., 1888, 14.
McNeill, Psyche, VI, 1891, 3.

This cricket was first described by Mr. Scudder, *loc. cit.*, under the specific name of *longipennis* which he afterwards changed to *columbia*, the former name being pre-occupied by an East India species of this genus.

It appears to be very rare in Indiana, a single male specimen captured in Clinton county, being the only one known from the state. Packard, *loc. cit.*, says that it is a southern species, but it has since been recorded from Illinois, Iowa and Kansas.

In size and general appearance it closely resembles *G. borealis*, but it may be known from that species by the much greater length of the wings which extend, in the specimen mentioned, 10 mm. beyond the tip of the abdomen; and by the longer and more slender teeth of the anterior tibiæ. Nothing of its habits is known to the writer, but they are probably nearly or quite the same as those of the preceding species.

Length of body, 28 mm.; of wing covers, 12 mm.; of wings, 24 mm.

III. GRYLLUS, Linnæus (1758). The Field and House Crickets.

To this genus belong those dark colored, thick-bodied crickets, mature specimens of which are so abundant from late summer till after heavy frosts, beneath logs, boards, stones, and, especially, beneath rails in the corners of the old-fashioned and rapidly disappearing Virginia rail fences. Three species of *Gryllus* are known to occur in the state.

4. GRYLLUS ABBREVIATUS, Serville. The Short-winged Field Cricket.

Acheta abbreviata, Harris, Ins. Inj. Veg., 1862, 152, fig. 69.
Rathvon, U. S. Agr. Rep., 1862, 380, fig. 15.
Thomas, Trans. Ill. St. Ag. Soc., V, 1865, 442.
Walsh, Practical Entomologist, I, 1866, 126.

Gryllus abbreviatus Scudder, Bost. Jour. Nat. Hist., VII, 1862, 427.
Packard, Guide to Stud. Ins., 1883, 564.
Fernald, Orth. N. Eng., 1888, 15.
Comstock, Intr. to Entom, I, 1888, 121, fig. 108 a.
McNeill, Psyche, VI, 1891, 5.

This is the most common and familiar species of the genus occurring in the state. The males have the wing covers usually reaching to the end of the abdomen, but those of the females are much shortened and reach but little beyond its middle. The wings are sometimes wanting but are usually present and much shorter than the wing covers. The ovipositor is almost as long as the body, and the hind femora are exceedingly thick and have a brick red spot at the base on the under side.

Each of the authorities cited above, who says anything of the life history of this cricket states that the eggs are laid in the ground in autumn and hatch the following summer, but the writer has, many times, taken the half grown young from beneath logs in late autumn and in mid winter. On such occasions they are usually found in a dormant condition, each one at the bottom of a cone shaped cavity which it has formed for itself, and which is very similar to the pits made in loose sand by the larva of the ant lion, *Myrmeleon obsoletus*, Say. Many specimens which had evidently moulted twice were taken thus on February 8th, 1890, and during the three months just passed, (Oct., Nov., and Dec., 1891), the young have been noted in numbers each time the woods were visited, though no mature specimens have been seen since October 20th. The young seen in winter are not numerous enough to develop into the mature specimens of the succeeding autumn, and, in my opinion, those eggs which are laid in early fall hatch and the insects hibernate in the burrows mentioned above: while the greater number of eggs, deposited later, do not hatch till the following season.

The short-winged field cricket is nocturnal, omnivorous, and a cannibal. Avoiding the light of day, he ventures forth, as soon as darkness has fallen, in search of food, and all appears to be fish which comes to his net. Of fruit, vegetables, grass and carrion, he seems equally fond and does not hesitate to prey upon a weaker brother when opportunity offers. I have often surprised them feasting on the bodies of their companions, and of about forty imprisoned together in a box, at the end of a week but six were living. The heads, wings, and legs of their dead companions were all that remained to show that the weaker had succumbed to the stronger—that the fittest, and in this case the fattest, had survived in the deadly struggle for existence.

Average measurements: Females—Length of body, 24 mm.; of posterior femora, 15 mm.; of wing covers, 11 mm.; of ovipositor, 22 mm. Male—Length of body 21 mm.; of posterior femora, 14 mm.; of wing covers, 11 mm.

5. GRYLLUS LUCTUOSUS, Serville. The Long-winged Cricket. The House Cricket.

Gryllus luctuosus, Scudder, Bost. Jour. Nat. Hist., VII, 1862, 427.
Id., Distribt. of Ins. in N. Hamp., 1874, 363.
Thomas, Geol. Surv. Terr., 1871, 433, pl. I, figs. 10, 11.
Packard, Guide to Stud. Ins., 1883, 564.
Fernald, Orth. N. E., 1888, 15.
Comstock, Intro. to Ent., 1888, 121.
McNeill, Psyche. VI, 1891, 4.

This is a species of wide range, occurring throughout the entire United States, but it appears to be somewhat rare in Indiana, having been taken only in Vigo and Parke counties. From the preceding species, which it

*Since verified by a letter received from Dr. C. V. Riley, in which he states that "the periods are very irregular and the egg laying undoubtedly continues for a considerable space of time."

almost equals in size, it is readily distinguished by the shorter ovipositor of the female, and by the greater length of the inner wings which, in both sexes, extend about 7 mm. beyond the tip of the abdomen.

Mature specimens have been taken as early as June 1, so that it, also, must winter in the larval state. It seems to be more fond of the society of man than any other species, and is the one which was usually heard chirping about the hearths of the large, old-fashioned fire-places. It is often found about houses and barns in towns and cities, and a number of specimens have been secured by the writer from beneath electric lights.

All the measurements of both this and *G. abbreviatus*, exceed those given by Mr. Scudder, in his paper in the Boston Journal, *loc. cit.*, yet, otherwise, Indiana specimens fully agree with the descriptions.

Measurements: Male and female—Length of body, 21 mm.; of posterior femora, 13 mm.; of ovipositor of female, 14 mm.

6. GRYLLUS PENNSYLVANICUS, Burmeister.

Gryllus pennsylvanicus, Scudder, Bost. Jour. Nat. Hist., VII, 1862, 429.
Thomas, Trans. Ill. St. Agr. Soc., V, 1865, 443.
McNeill, Psyche, VI, 1891, 4.

Several females of a short, broad-bodied cricket have been taken in Vigo county, which are evidently distinct from either of the above members of this genus, and are referred with some doubt to this species. The wing covers reach to the end of the abdomen while the posterior femora and ovipositor are much shorter than those of the two preceding species. The body in the longest specimen measured but 15 mm., and the wings of all were very much abbreviated or absent. They were taken in September from beneath logs.

Average measurements: Length of body, 14 mm.; of wing covers, 10 mm.; of posterior femora, 8 mm.; of ovipositor 7 mm.

IV. NEMOBIUS, Serville (1839). The Striped Ground Crickets.

Of all the Gryllidæ which occur in the Northern states, the little brown ground crickets are the most numerous and the most social. Unlike their larger cousins, the field crickets, they do not wait for darkness before seeking their food, but wherever the grass has been cropped short, whether on shaded hillside, or in the full glare of the noonday sun along the beaten roadway, mature specimens may be seen by hundreds during the days of early autumn. They are all of small size, being never more than half an inch in length. The color is a dark brown, and the bodies and legs are sparsely clothed with brown hairs. The head is broad, the ovipositor of normal shape, and the last segment of the maxillary palpus is twice the length of the one preceding it, whereas in the species of Gryllus the two segments are of equal length. Three species of Nemobius occur in Indiana.

7. Nemobius vittatus, Harris. The Wingless Striped Cricket.

Acheta vittata, Harris, Ins. Inj. to Veg., 1862, 152, fig. 70.
Rathvon, U. S. Agr. Rep., 1862, 380, fig. 16.

Nemobius vittatus, Scudder, Bost. Jour. Nat. Hist., VII, 1862, 430.
Id. Dist. of Ins. N. H., 1874, 364, (Chirp set to music).
Thomas, Trans. Ill. St. Ag. Soc., V, 1865, 443.
Scudder, Am. Naturalist, II, 1868, 115, (Song of).
Packard, Guide Stud. Ins., 1883, 564.
Fernald, Orth. N. Eng., 1888, 16.
Comstock, Int. to Ent., I, 1888, 121.

In both sexes of this, our most abundant species, the inner wings are wholly wanting. In the female the wing covers are dark brown, about half the length of the abdomen, and have many rather coarse, whitish, parallel veins; whereas in the male they are light brown, reach to the end of the abdomen and have but few reticulated veins. There are usually three narrow, blackish lines on top of the head and one along each side of the prothorax, but all of these are sometimes very dim or wholly wanting.

These small crickets are omnivorous, feeding upon all kinds of decaying animal matter as well as upon living vegetation, freshly dropped cow dung being also especially attractive to them. When disturbed they are very difficult to capture, making enormous leaps with their stout hind legs, no sooner striking the ground than they are up again, even if not pursued, until they find a leaf or other shelter beneath which to take refuge.

From their enormous numbers, as well as from the fact that they are constant, greedy feeders from the time the eggs hatch in spring until laid low by the hoar frost of autumn, it follows that they must be classed among our most injurious orthoptera, but as yet no effective means for their destruction have been discovered.

Mr. S. H. Scudder, in an article entitled the "Songs of the Grasshoppers," has given the following pleasing account of the sounds made by this species: "The chirping of the striped cricket is very similar to that of the black field cricket; and may be expressed by *r-r-r-u*, pronounced as though it were a

French word. The note is trilled forcibly, and lasts a variable length of time. One of these insects was once observed while singing to its mate. At first the song was mild and frequently broken; afterwards it grew impetuous, forcible and more prolonged; then it decreased in volume and extent until it became quite soft and feeble. At this point the male began to approach the female, uttering a series of twittering chirps; the female ran away, and the male, after a short chase, returned to his old haunt, singing with the same vigor but with more frequent pauses. At length finding all persuasions unavailing, he brought his serenade to a close."

Average measurements: Length of body of male, 9 mm.; of female, 12 mm.; of hind femora, 9 mm.; of ovipositor, 9 mm.

8. NEMOBIUS EXIGUUS, Scudder. The Lesser Striped Ground Cricket.

Nemobius exiguus, Scudder, Boston Jour. Nat. Hist., VII, 1862, 429, (Not *Acheta exigua*, Say.).

Nemobius fasciatus exiguus, Fernald, Orth. N. Eng., 1888, 16.

Also a very common species and found in company with the preceding, the habits of the two being essentially the same. From *vittatus* it may be known by its *much smaller* size, lighter color, and by the last two segments of the maxillary palpus being white. Moreover the ovipositor is much shorter, being only one-half to two-thirds the length of the hind femur, whereas in *vittatus* it is fully as long as that segment. A careful examination of a large number of specimens leads me to believe that these differences are constant, with no intermediate forms, hence the two species should be separated.

Length of body, male, 7 mm.; of female, 8 mm.; of hind femora, 6 mm.; of ovipositor, 3 to 4 mm.

9. NEMOBIUS FASCIATUS, DeGeer. The Long-winged Striped Cricket.

Nemobius fasciatus, Scudder, Bost. Jour. Nat. Hist., VII, 1862, 436.
Fernald, Orth. N. Eng., 1888, 16.
McNeill, Psyche, VI, 1891, 6.

This species has not been seen by the writer within the boundaries of the state; but Scudder, *loc. cit.*, says that it has been taken at Delphi, Indiana. From the two preceding species it may be known by the presence of the inner wings, which extend beyond the end of the ovipositor. McNeil, *loc. cit.*, records it as being common about the electric lights at Rock Island, Illinois.

V. Anaxiphus, Saussure (1874).

Our native species of this genus are very small crickets resembling those of *Nemobius* in form of body, breadth of head, etc.; but having the ovipositor very much compressed and curved strongly upwards as in many of the common species of *Locustidæ* or katydids.

10. Anaxiphus pulicarius, Saussure.

Anaxipha pulicaria, McNeill, Psyche VI, 1891, 6.

Head and pronotum brick red in color, sparsely clothed with long hairs; wing covers and legs very light brown; abdomen and ovipositor darker. Both sexes are wingless, but the wing covers of the male are well developed, fully covering the abdomen, while those of the female reach but little beyond its middle. The cerci are exceedingly long, tapering, and covered with fine yellow hairs. The hind femora of the males are proportionally much longer than those of the females as will be seen by the following measurements:

Length of body—male, 6.5 mm., female, 8 mm.; length of posterior femora—male, 6.5 mm., female, 6 mm.; length of ovipositor, 3.5 mm.; of antennæ of male, 32 mm.

This handsome little cricket was first taken in the state on Aug. 26, 1891, at Kewanna, Fulton county, where it occurred in small numbers among the sphagnum mosses growing in a tamarack swamp. On Sept. 6, it was found in Vigo county, 135 miles farther south, about the borders of a large pond. Here it was abundant in isolated spots on the leaves and stems of the arrow alum, *Peltandra undulata*, Raf. It is very active and difficult to capture, and, on account of its small size, is doubtless overlooked in many localities where it occurs in abundance. It is not described in any of the works to which I had access, and specimens were sent to Prof. Lawrence Bruner, Lincoln, Neb., who kindly identified them for me.

VI. Phylloscirtus, Guerin. (1846).

The members of this genus are small crickets which have the head broader than the prothorax. They may be readily known from all other Gryllids by having the apical joint of the maxillary palpus flattened, oval, and much longer than the preceding joint which is triangular. The ovipositor is somewhat compressed and curved upwards.

11. Phylloscirtus pulchellus, Uhler. The Handsome Cricket.

Phyllopalpus pulchellus, Uhler, Proc. Ent. Soc. Phil., II, 1864, 544.

Phylloscirtus pulchellus, Riley, Stand. Nat. Hist., II, 1884, 183.

McNeill, Psyche, VI, 1891, 6.

This is the only species of the genus known to occur in the eastern United States, and is the most brightly colored of all our native crickets. In the living specimen the head and thorax are crimson, the wing covers a shining pitch black, while the thick hind femora are almost transparent but become white in alcohol. The wing covers reach the end of the abdomen, and the wings are almost as long. A single female specimen was taken on September 6th, from a leaf of the button bush, *Cephalanthus occidentalis*, L., near the border of a large pond in Vigo county. When discovered it was motionless, but was vibrating its large maxillary palpi in a very rapid and curious manner. It is a southern species but has been recorded from New York and Illinois, and probably occurs in low wet woods throughout the southern half of this state. According to Uhler, it is found most frequently "amongst the grass and low bushes near ditches where it jumps about with great rapidity."

Measurements: Length of body, 8.5 mm.; of ovipositor, 3.5 mm.; of posterior femora, 6 mm.; of antennæ, 18 mm.

VII. Orocharis, Uhler (1864).

The members of this genus have the head slightly narrower than the base of the pronotum; the maxillary palpi with the third segment longest, cylindrical; the apical one a little longer than the one preceding, enlarged gradually from the base, obliquely truncate. Both wing covers and wings are longer than the abdomen. The posterior femora are less thickened and the body less robust, longer, and flatter, than in the preceding or the following genus.

12. Orocharis saltator, Uhler.

Orocharis saltator, Uhler, Proc. Ent. Sec. Phil., II., 1864, 545.
Riley, Stand. Nat. Hist., II, 1884, 182.
Apithes McNeilli, Blatchley, Canadian Entomologist, XXIV, 1892, 27.

General color, after immersion in alcohol, dull brownish yellow, the male the lighter. A dark brown stripe reaches from the eye along the side of head and prothorax to posterior border of pronotum. The wing covers each with a small brown spot at base: those of the female with many cross veinlets which are darker than those running lengthwise, giving the dorsal field a checkered appearance. In the male the vein separating the dorsal field of the wing cover from the lateral is yellow; in the female the yellow is broken by a number of oblong dark spots. All the femora are rather thickly marked with small, dark spots; those on the posterior pair being arranged in regular rows. The wings extend 2.5 mm. beyond the tip of wing covers. Measurements: Female, length of body. 16 mm.; of wing covers, 14.5 mm.; of posterior femora, 9 mm.; of ovipositor, 12 mm. Male, length of body, 14 mm.; of wing covers, 12.5 mm.; of posterior femora 7.5 mm.

A single pair have been taken in Vigo county. The female was secured Oct. 21, 1891, from the lower leaves of a golden rod, *Solidago latifolia*, L., which grew in a thick, upland woods. The male was taken just a year later from the under surface of a leaf of prickly ash, *Xanthoxylum americanum*, Mill. It *flew* from one leaf to another and, before its capture, was thought to be a species of *Blattidæ*, so flat did its body appear.

Not having Mr. Uhler's paper when the female was taken it was sent to Mr. S. H. Scudder, of Cambridge, Mass., for identification. He returned it with the statement that it was, in his opinion, "an undescribed species of *Apithes*, allied to *A. azteca*, Sauss, and very different from *A. quadrata*, Scudder." On the strength of his statement, and prematurely on my part, it was described as new in the Canadian Entomologist, *loc. cit.* Having since secured Mr. Uhler's paper diagnosing the two genera, *Apithes* and *Orocharis*, a careful comparison with the descriptions therein proves it to belong to the latter genus; and, although differing somewhat in the details of color and measurement from Uhler's description of *saltator*, yet the differences are not sufficient, in my opinion, to make of it a distinct species. It has heretofore, been recorded, as far as I can ascertain, only from the southeastern United States.

VIII. Apithes—(Hapithus), Uhler (1864).

Thick bodied crickets resembling in general form the members of the genus *Gryllus* but having the head narrower than the posterior margin of the pronotum. The maxillary palpi with the apical segment as long as the 2d and 3d together. The wing covers do not reach the base of the abdomen and the wings are much shorter.

13. Apithes agitator, Uhler.

Hapithus agitator, Uhler, Proc. Ent. Soc. Phil., II, 1864, 546.
Riley, Stand. Nat. Hist., II, 1884, 183, fig. 258.

A short, heavy-bodied cricket; dull reddish brown in color, with the vein, separating the dorsal field of the wing cover from the lateral, a yellowish white. The top of head and pronotum, and the surface of all the femora densely covered with brownish-yellow hairs. Measurements: Female, length of body, 11 mm.; of wing covers, 7.5 mm.; of posterior femora, 9 mm.; of ovipositor, 8 mm. Male, length of body, 10 mm.; of posterior femora, 8 mm.

A large number of specimens of this cricket were taken in two localities in Vigo county, Indiana, during the last half of September. The first ones discovered were on the slender twigs of some prickly ash shrubs which grew in a damp upland woods. The place was visited a number of times and the crickets were always found, perfectly motionless, and immediately above or below one of the thorns or prickles jutting forth from the twigs. The tips of the hind femora were raised so as to project above the body thus causing them to resemble the thorns; and the color of the insects corresponding closely to that of the bark, made them very difficult to discover even when in especial search of them. On every clump of prickly ash in the woods mentioned a number of specimens were secured but they could be found no where else thereabouts. The second locality where they were discovered was about the roots of a scarlet oak, *Quercus coccinea*, Wang, which grew on a sandy hillside. Here they were plentiful, and resting motionless in the depressions of the bark or beneath the leaves in the cavities formed by the roots of the tree.

Of all the males taken, over thirty in number, there was not one with perfect wing covers, and, in almost every instance, the wing covers as well as the rudimentary wings were wholly absent; while every female had both pairs unharmed. I at first ascribed this wing mutilation to the males fighting among themselves, but finally discovered a female in the act of devouring the wings of a male. Why this curious habit on the part of the one sex? Possibly the females require a wing diet to requite them for their bestowed affections, or, perchance, they are a jealous set, and, having once gained the affections of a male, devour his wing covers to keep him from calling other females about him. *Quien sabe!*

Agitator is said to be common in the middle and southeastern states. The eggs of the female are there deposited in twigs of the white elm, *Ulmus Americana*, L., and the insects are very active at night, running and jumping about on the trunks of various trees.

IX. Œcanthus, Serville (1831).

From the other *Gryllidæ* of the state the members of this genus may be known by their slender hind femora, their narrow, elongated prothorax, and their whitish or greenish-white color. The wing covers of the females are wrapped closely about the body, while those of the male are much firmer in texture, broadly spread out, and very transparent; causing such a difference of appearance between the two sexes that tyro collectors often take them for widely different insects. Three species have, so far, been collected in the state, and two others very likely occur, but have not yet been taken.

14. ŒCANTHUS NIVEUS, DeGeer. The White Climbing Cricket.

Œcanthus niveus, Harris, Ins. Inj. Veg., 1862, 153, figs. 71, 72, (In part).
Fitch, Third Rep. Nox. Ins., N. Y., 1856, 86.
Scudder, Bost. Journ. Nat. Hist., VII, 1862, 431.
Rathvon, U. S. Agr. Rep., 1862, 381, figs. 17, 18.
Thomas, Trans. Ill. St. Ag. Soc., V, 1865, 444.
Walsh, Prac. Entom., I, 1866, 126; II, 1867, 54, 94.
Scudder, Dist. Ins. in N. H., 1874, 365, (Note of, set to music).
Glover, U. S. Ag. Rep., 1874, 143, fig. 16.
Packard, Guide Stud. Ins., 1883, 564, figs. 561, 562.
Id., Rep U. S. Ent. Conn., V, 1890, 230, 591, figs. 75, 76.
Fernald, Orth. N. Eng., 1888, 17, figs. 7, 8, 9.
Comstock, Intr. Ent., I, 1888, 122, figs. 109, 110
Murtfeldt, Insect Life, II, 1889, 130, (Carnivorous habits of).
McNeill, Psyche, VI, 1891, 6.

Both sexes of this species are in color ivory white, more or less tinged with a delicate green, especially in the female. The top of head and basal joint of antennæ are usually suffused with ochre yellow, while on the lower face of each of the two basal joints of the antennæ is a small black spot. The ovipositor of the female is short, perfectly straight and usually tipped with black. The maxillary palpi are longer in this than in any other species of the genus and the wing covers of the male are broader in proportion to their length than in any other except *O. latipennis*, Riley.

Measurements: Male, length of body, 13 mm.; of wing covers, 13.5 mm.; width of wing covers, 6.5 mm. Female, length of body, 14.5 mm.; of wing covers, 14 mm.; of ovipositor, 5.5 mm.

The white climbing cricket is very common throughout the state, and mature specimens are to be found in numbers about grape vines, shrubbery, etc., from August 1st till November. In my experience the females appear more plentiful than the males, the latter being more often heard than seen.

During the day they keep themselves hidden among the foliage and flowers of various plants, but as night approaches they come forth and the male begins his incessant, shrill, chirping note, which he continues with little or no intermission till the approach of morning warns him to desist. Prof. McNeill, in Psyche, *loc. cit.*, has given an excellent description of the songs of the different species of Oecanthus. "That of *niveus*," he says, "is the well known *t-r-r—r-e-e* : *t-r-r—r-e-e*, repeated without pause or variation about seventy times in a minute. It is heard only at night and occasionally on cloudy days, but in the latter case it is only an isolated song, and never the full chorus of the night-song produced by many wings whose vibrations in exact unison produces that characteristic 'rhythmic beat,' as Burroughs has happily phrased it."

The females of *niveus* do much harm by ovipositing in the tender canes or shoots of various plants, as the raspberry, grape, plum, peach, etc.; no less than 321 eggs, by actual count, having been found in a raspberry cane 22 inches in length. The eggs are laid in autumn and at first the injury is shown only by a slight roughness of the bark, but afterwards the cane or branch frequently dies above the puncture, or is so much injured as to be broken off by the first high wind. If the injured and broken canes containing the eggs be collected and burned in early spring the number of insects for that season will be materially lessened.

Niveus, however, in part if not wholly, offsets this injurious habit by its carnivorous propensities, as the young, which are hatched in June, feed for some time upon the various species of aphides or plant lice which infest the shrubbery they frequent. Mr. B. D. Walsh, in the Practical Entomologist, *loc. cit.*, was the first entomologist to call attention to this carnivorous habit, but it seems little attention was given to the matter. Recently, however, it has come up again, and in Insect Life, for November, 1891, Miss Mary E. Murtfeldt, of St. Louis, Mo., has given a most interesting account of some experiments and observations concerning it which were made by her. From this article the following extract is taken: "Some leaves of plum infested with a delicate species of yellow aphis were put into a jar with the young of *Oecanthus niveus*, but attracted no immediate attention. As twilight deepened, however, the crickets awakened to greater activity. By holding the jar against the light of the window, or bringing it suddenly into the lamp light, the little nocturnal hunters might be seen hurrying with a furtive, darting movement over the leaves and stems, the head bent down, the antennæ stretched forward, and every sense apparently on the alert. Then the aphides provided for their food would be caught up one after another with eagerness and devoured with violent action of the mouth parts, the antennæ meanwhile playing up and down in evident expression of satisfaction. Unless I had provided very liberally not an aphis would be found in the jar the next morning and the sluggish crickets would have every appearance of plethora."

15. ŒCANTHUS FASCIATUS, Fitch. The Striped Tree Cricket.

Œcanthus fasciatus, Fitch, Third Rep. Nox. Ins., N. Y., 1856, 96.
McNeill, Psyche, VI, 1891, 6.
Œcanthus niveus, Harris, Ins. Inj. to Veg., 1862, 154, (In part).
Rathvon, U. S. Ag. Rep., 1862, 381.

In its general form this insect resembles the preceding, but it is always darker in color, varying from a deep black to ivory white with fuscous markings. Most specimens, however, are greenish white with three black stripes on the head and pronotum and a broad dusky line along the center of the abdomen beneath. The wing covers of the male are less broad in proportion to their length than in *niveus*; while the ovipositor is longer and more distinctly turned upwards at the end than in that species.

Measurements: Male—Length of body, 14 mm.; of wing covers, 11.5 mm.; width of wing covers, 5.5 mm. Female—Length of ovipositor, 6.5 mm.

In Indiana this species is fully as common if not more so than *O. niveus*. It is more frequently found on wild plants than that species, being, in autumn, an abundant visitor of sun-flowers and golden rods. Mature specimens were taken in Putnam county, as early as August 9th.

16. ŒCANTHUS ANGUSTIPENNIS, Fitch. The Narrow-winged Tree Cricket.

Œcanthus angustipennis, Fitch, Third Rep. Nox. Ins., N. Y., 1856, 95.
McNeill, Psyche, VI, 1891, 8.

This species is readily distinguished by the narrowness of the wing covers of the male, their breadth being just about one third their length. The wings are longer than in either of the two preceding, extending in one specimen at hand, 9 mm. beyond the wing covers. The head and prothorax are less prominent, and the latter is much narrowed anteriorly. The general color is an ivory white, rather deeply tinged with greenish.

Measurements: Male—Length of body, 13 mm.; of wing covers, 11.5 mm. width of wing covers, 4 mm.

Angustipennis probably occurs in all parts of the state but is much less common than either *niveus* or *fasciatus*. A fully developed male was taken from a leaf of an iron weed, *Vernonia fasciculata* Michx., on August 11th.

This completes the list of *Gryllidæ* so far known to have been taken in the state. Other species undoubtedly occur, and it was a desire to awaken an interest in the family and so lead, if possible, to their discovery, which, in the main, prompted the preparation of the present paper.

The species most likely to occur, but which have not, as yet, been noted are: *Tridactylus terminalis*, Uhler; *Tridactylus minutus*, Scudder; *Œcanthus latipennis*, Riley; *Œcanthus bipunctatus*, DeGeer, and one or two species of *Myrmecophila*, which are the smallest crickets known. They resemble closely the young of cockroaches and inhabit the nests of ants. The writer will be pleased to receive specimens of *Gryllidæ* and other *Orthoptera* from any part of the state, and will return the names of those sent to all who may so desire.

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Entomologizing in Mexico. By W. S. Blatchley.

The outlook in the warfare against infection. By Theodore Potter.

Our present knowledge concerning the green triton, Diemyctylus viridescens. By O. P. Hay.

The green triton, or newt, *Diemyctylus viridescens*, has been before this academy for discussion at a previous meeting. Since that time there have been some accessions to our knowledge regarding it. This pretty and harmless newt probably inhabits all parts of the state, but I have not found it abundant anywhere, though no doubt it is plentiful in suitable localities.

It is quite common in the Eastern States, and has been studied a good deal by the naturalists there, to whom it has presented some interesting problems. It is interesting because of its position near the top of the order Urolela. *Salamandrina perspicillata*, of Europe, is very closely related to it; but since the digits of the hinder foot of that species are reduced to four, it must be regarded as standing higher than ours, which has five digits.

The newt has given the systematists a good deal of trouble, a fact resulting, as in so many other cases, from a lack of knowledge regarding its life-history. Formerly there were believed to be two entirely distinct species, the one living on the land and being of a red color, the other living entirely in the water and being of a general greenish color. Rafinesque, who first described these animals, placed the two forms under different subgenera. Baird saw that they must be included under the same genus, but regarded them as distinct species. Dr. Hallowell seems to have been the first to regard them as belonging to the same species. For a long time, in fact until very recently, they have been regarded as being varieties of the same species. A few observers have, within a few years. claimed to have seen the red land form transform into the aquatic stage, and some have thought that they saw indications of a change of the aquatic animal into the terrestrial form. Hence, it was supposed that the differences were due to seasonal changes. It was supposed that the animal went into the water to deposit its eggs, took on the characters peculiar to that state, and afterwards, when the breeding season was over, again sought the land and became red again.

At the 1891 meeting of the American Association for the Advancement of Science, at Washington, Prof. Gage, of Cornell University, read a paper which gave the results of his studies on this animal for some years. His conclusions, in brief, are that all the modifications that the animal undergoes belong simply to different stages in the development of one and the same individual. The eggs are laid in the water and hatched in due time. For some time the young have gills, like any other well regulated Urodele. When a length of about an inch and a half has been attained, they leave the water, having lost their gills, and betake themselves to the land. They then assume a red color, varying from orange to blood-red, the tail becomes round and the skin usually rough. Here they appear to remain until they are about three years old, hiding under rocks and logs, and appearing after rains. When the season of sexual maturity arrives, they go again into the water, and, according to Gage's opinion, remain there the remainder of their lives, unless the pools dry up or food becomes scarce. Prof. Gage's paper has appeared in the American Naturalist for December, 1891, illustrated with a colored plate.

During the past summer, before I knew of Prof. Gage's work on the newt, I attempted to solve the question about the two forms of the animal by a study of the specimens in the National Museum, about two hundred and fifty in number, and from all parts of the country. I reasoned that if there were two varieties of the animal we ought in a large collection to find them both in all stages of growth; if the red form was only the young stage of the animal then the green aquatic specimens ought to be all larger than the red ones. One of the first things that I discovered was that there was not a single character on which I could depend as a means of distinguishing the two forms. Neither redness, nor roughness, nor lack of tail-fin, belonged to the land form alone. Of some it seemed to be impossible to say with any certainty to which form they ought to be assigned.

Nevertheless it was apparent that the red or *miniatus* form reached a maximum length of a little over three inches, while the undoubted viridescent form ranged from a little less than three inches up to four or more. Yet a breeding male of the viridescent form was found to be only two and three-fourths inches long. On the whole, it seemed clear that at a certain stage the red, land form must enter the water and assume characters to some extent different from those possessed while on land.

As to the color of the aquatic form, olive is the prevailing tint. Yet many have more or less red mingled with it, and not a few are decidly red. It is probable that none of those which have betaken themselves to the water are as scarlet as those living on the land, yet they must come pretty near it. As to the purpose of the coloration assumed in the water, it is not difficult to see that it will be highly protective to an animal that dwells amid green vegetation; but why the land-dwellers should be so conspicuously red is not so easily decided. No concealment seems to be sought here. It is possible that the land form is a distasteful morsel to such animals as it comes in contact with, and the color is developed as a warning signal. Those who have the opportunity to experiment with them ought to endeavor to settle the question. The salamanders are given to eating all such animals, and the red young of the newt might be offered to *Ambystoma tigrinum*, for instance, in order to determine whether or not the latter would eat the young newt.

There are some interesting matters connected wtth the size of the larvae at the time of the transformation. Prof. Gage states that he has never seen a larva at this period less than three centimeters long or more than four, while some of the bright red ones are only five centimeters long, that is, two inches. Now in the national collection I found larvæ yet with remains of gills, and some of these larvæ were two and three-fourths inches long. These were from Jersey City, N. J. Not long ago Prof. Gage sent me a specimen for examination, which he had taken at Wood's Holl, and this one is fully as large as those I have mentioned. The smallest red specimens mentioned by Prof. Gage are two inches long. Some of the red specimens seen by me at Washington were only an inch and a half, an inch and three-quarters, and one only an inch and five-sixteenths long. Here we have evidence of very great variation in the size of the larvæ at the time of transformation. I believe also that there is, during the transformation, a considerable shrinkage in the size of the whole body. Such shrinkage occurs during the transformation of *Amblystoma microstomum*, and probably of most salamanders.

Thus, while we are gradually getting at a correct knowledge of this interesting animal, the green triton, or newt, it is a good subject for further study.

The proper systematic name of the prairie rattlesnake. By O. P. Hay.

The blind crayfishes of Indiana. By W. P. Hay.

The Crustacea of Indiana. By W. P. Hay, M. S.

The following list of the crustaceans of Indiana is to be regarded as a first contribution to the knowledge of this interesting group. Although it represents the labor of quite an extended period, the labor was confined mostly to the central part of the state, and to the larger forms; and there still remains the great multitude of microscopic forms only a few of which are here numbered. It is for the purpose of directing the attention of the

Indiana Academy to this interesting and much neglected part of our fauna that this paper is written.

Cambarus argillicola Faxon. Very common in central Indiana. It is very similar, both in appearance and habits, to its near relative, *C. diogenes*. Like this latter species, *C. argillicola* burrows and raises mud chimneys at the mouth of its hole. It is apparently of smaller size than *C. diogenes*, the largest specimen measuring barely 2½ inches from the rostral spine to the end of the tail. The bearded hand spoken of by Dr. Faxon in his monograph is hardly a constant feature. Indeed, of all the specimens which have come under my notice at least half, without distinction as regards sex, were without the beard. The eggs are laid in the early spring, often, it seems, before the females retire to their burrows. A small female bearing eggs was taken from a pond April 2, and a female with young was dug from a burrow April 20. The burrows were excavated in the tough clay, near a pond, to a depth of about 2½ feet.

Cambarus bartonii Fabricius. This species will probably be found to occur throughout the state. It is much more common, however, in rocky localities than elsewhere. It is a cave-loving species, occurring in nearly every one of the caverns of southern Indiana. I have often observed both it and *C. pellucidus* in the same cave.

Cambarus blandingii Hagen. A number of specimens from English Lake seem to be this species, though they may be the following, which is reported by Dr. Faxon.

Cambarus blandingii var. *acuta* Faxon. This species is reported from Wheatland, Knox county.

Cambarus diogenes Girard. In early spring this is the most conspicuous crayfish, both by its abundance, large size, and fine coloration. The females far surpass any other species in the different colors, which are beautifully blended. As they are strictly a burrowing species, they are to be found only during the breeding season, which begins about the first of April. At this time they are very common, even in the daytime. At night they are abundant. Thirty-five large specimens were collected in one evening, April 2, 1892. Of this number twenty-nine were males and six females. A number of females found in copulation were separated from the rest to observe the time elapsing before the eggs were laid. The first eggs were laid April 18, while another specimen of the same lot, with well developed but unlaid eggs, was killed and dissected April 20.

After the breeding season they retire to their burrows, and for the rest of the year their presence is known only by the chimneys which they raise over the mouth of the holes.

Cambarus immunis Hagen. This species is exceedingly abundant during the summer in muddy ponds. They burrow into the mud on the drying up of the ponds. I have never observed them in running water.

Cambarus pellucidus Tellkampf. The common blind crayfish occurs in many of the caves of southern Indiana. They are usually small, the largest I have ever seen, among 40 specimens, being barely 2 inches in length. They are kept from extinction only by the inacessibility of their home. They are very conspicuous when in the water, and are very easily caught. When startled they are utterly at loss where to go, and often dart out upon the shore. I think it may be safely said that as a rule they grow spinier as one advances southward, although there are exceptions. A female collected in Wyandotte Cave is almost without spines; but three specimens from a small cave near there are exceedingly spiny.

Cambarus pellucidus var. *testii* Hay. This crayfish, although at first thought to be a distinct species, is probably only a variety of the preceding, characterized by the entire absence of spines. There are no teeth on the rostrum or spines on the sides of the carapace, things never lacking in the common species. The type specimens, 12 or 13 in number, were collected in Mayfield's cave, near Bloomington. They have since been received from Truett's cave, in the same county.

Cambarus propinquus Girard. This is apparently the common species throughout the state. In the central portion it is very abundant at all seasons of the year, being almost invariably found in running water. The median carina on the rostrum, one of the characteristic marks of the species, may vary from a long ridge to a mere papilla-like elevation. The color in life is a dingy dark olive. The tips of the chelæ are sometimes red, and the spines on the rostrum brown.

Cambarus putnami Faxon. In his "Monograph on the American Astacidæ," Dr. Faxon mentions the probability of this species occurring in the southern part of the state. I have specimens taken between Paoli and Wyandotte cave, in the summer of 1888.

Cambarus rusticus Girard. This species, which is very like *propinquus*, is tolerably common. It has been collected at Madison and at Indianapolis.

Cambarus sloanii Faxon. The only known locality for this species in Indiana is in the region about New Albany.

Cambarus virilis Hagen. Is very common and widely distributed in the northern part of the state. I have also found it at Irvington.

Palæmon ohionis Smith. The river shrimp has been taken in large numbers in the Ohio at Lawrenceburg. It will probably be found to occur in the lower Wabash and possibly some of the other large streams in the south of the state.

Allorchestes dentata Smith. This small crustacean was taken on one occasion from a small pool along Fall creek, north of Indianapolis. It has also been observed by Prof. S. A. Forbes in northeastern Indiana.

Crangonyx gracilis Smith. Very common in stagnant water in central Indiana. I have never observed it in the streams. Early spring is the best collecting time for this crustacean, as it then attains its largest size.

Crangonyx packardi Smith. I have not yet collected this species, but it is said to be common in the southern portion of the state.

Crangonyx mucronatus Forbes. This interesting species, I think, will be found to occur over a large portion of Indiana. I have found it under logs in a swamp near Irvington, have taken it from at least one well in the vicinity, and have observed and collected it in nearly every cave in Monroe, Lawrence, Crawford and Harrison counties.

Mancasellus tenax Harper. An exceedingly large and abundant species which may be found in early spring in the water courses. I have often observed it in stagnant water, but in running water, as at the mouth of a tile drain, they may be collected by the hundreds.

Asellus communis Say. This species appears to take the place of the preceding species in the ponds. I have rarely observed it in running water, but in early spring it is very common in the ponds about Indianapolis.

Asellus stygius Packard. This interesting blind *Asellus* I have found in two wells, three or four miles north of Irvington. It is also very common in the caves, but does not appear to grow to so large a size as those taken from the wells.

Scyphacella putea W. P. Hay. This very curious and remarkable crustacean is as yet undescribed, but is here included. The type specimens were obtained from a well in Irvington. Soon after the specimens were taken the well was cleaned, and no crustaceans have been observed since. Its nearest relative is *Scyphacella arenicola*, a salt water crustacean.

Branchipus vernalis Verrill. In the central portion of the state, about Irvington, this beautiful crustacean is very abundant. In one sweep of the net I have taken over a hundred of them. It has also been taken at Bloomington, Ind.

Branchipus gellidus W. P. Hay. Abundant at times about Irvington. It was described February, 1883, in the American Naturalist, from specimens collected in the early spring of that year. On the drying up of the ponds it disappeared, and although careful search was made every winter after, it was not seen again till April, 1892, when it was again found to be common. It is much smaller than *B. vernalis*, and seems to congregate in little groups of 15 to 20. They are very delicate and die soon after capture.

Euphiloscia elrodi Packard. This is the only "sow-bug" described from the state, although several species are common.

Diaptomus sanguineus Forbes. At times so common as to give the pond water a pinkish color. I have observed it only about Irvington.

Daphnia rosea Sars. Very abundant, in company with other species, in ponds about Irvington.

Ceriodaphnia quadrangula. Common, in company with other species, in ponds about Irvington.

Ceriodaphnia cristata Birge. Occurs frequently with the two preceding species.

Cyclops parcus Herrick. Collected from ponds about Irvington.

Cyclops insectus Forbes. Collected from ponds about Irvington.

It will be seen that so far thirty-one species of crustaceans have been collected from the state. A little careful search would doubtless more than double the number.

Notes on Elaps fulvius. By A. J. Bigney.

About two years ago a very beautiful snake was taken to the drug store of V. W. Bigney, at Sunman, Ripley county, Indiana; it having been found near Milan, in the same county. It was preserved in alcohol and a little more than a year ago it was sent to me for identification. After carefully examining it I pronounced it to be the Elaps fulvius, or bead snake, belonging to the order of the Harlequin snakes.

A careful study has revealed some interesting facts. The order to which this snake belongs is very widely distributed, being found not only in North America but also in Southern Asia, Australia, South America, and the isles of the sea. The warmer regions are their regular home. In the United States it is found in Virginia, Georgia, Florida, Texas, Arizona, New Mexico, and Arkansas. No mention is made of its being found further north than Virginia and Arkansas. Only one species inhabits North America, but there are several varieties, distinguished chiefly by the arrangement of the colored bands. This snake is ordinarily found in the ground in sweet potato fields. The question naturally arises, How came it so far north? Has it ever been found in this state before? Was it carried here and escaped? I am rather inclined to the latter view. If, however, it has been found in this state by other parties, then this view is evidently erroneous.

The specimen under consideration is about 25 inches long. It has more than 200 gastrostroges, which are entire, and the urostroges bifid. The anal plate is also bifid. Dr. Jordan, in his "Manual," speaks of it as being entire. This is evidently an exception to the rule, and this plate is, therefore, somewhat variable. The snake has seventeen bands of crimson, bordered by yellow. The occipital band is yellow and the bands on the tail also have no red. It has no loral plate, but in another species it is present. It has two fangs in the upper jaw, which are hollow, and on the front side there is a permanent groove; back of these fangs are small teeth. The *Elaps fulvius* is classed among the venomous by Dr. Jordan. If any one has found another specimen in the state I shall be glad to learn of it.

SOME OBSERVATIONS ON HELODERMA SUSPECTUM. By D. A. OWEN, Moore's Hill College.

About the middle of last May the museum of Franklin College came into possession of a fine specimen of *Heloderma suspectum* or "Gila monster," from Sacaton, Arizona. This is one of the largest of lizards, and the only one in America reputed venomous.

The specimen received is eighteen inches long from the tip of his snout to the end of his tail, which is six inches long and of an uniform diameter of about one inch and a half until within a short distance of the end, where it terminates in a blunt point.

The body is beautifully marked by black and flesh colored tubercular scales, much resembling Indian bead work. Its habits are very sluggish, and not infrequently whole days are spent in sleeping. This is almost universally the case during very cloudy weather. Its food has consisted of raw eggs, of which three or four are consumed in a week. Sometimes it will eat an egg each day for two or three days, and then will touch nothing for nearly a week. The method of taking this food is by suction, assisted by sliding back and forth its flat, forked tongue. When the eggs were given without first breaking the parts. it was very difficult to swallow, the food would be forced out through the nostrils and some time would be spent holding the head elevated so that gravity might force it down the throat.

Other foods were offered, but in no case were they touched.

Although its native home is in that arid region where rain seldom falls in abundance, it showed a special fondness for water. It would frequently lie in a pan of water during the whole day. At times, when the appetite made no demands for the food, he would frequently crawl into the pan, as if he preferred to take it by absorption.

In breathing, there seemed to be a full expansion of the lungs every 50 or 60 seconds. The air is then expelled, as it seems, in a kind of pulsations. These pulsations are seen on each side of the neck and vary from fifteen to thirty per minute. But during the torpid state, which began about the middle of October, there appears to be no full expansion of the chest, but respiration is conducted wholly by this pulsation. If, however, the animal be disturbed, the air is immediately forced out of the lungs with a sound very much resembling a deep sigh.

The moulting began about the last of July or the first of August, and was not completed until the last of September. The skin was removed in pieces, beginning about the middle of the body.

In regard to the nature of the vermin and the fatality of the bite there is little to offer that is new. The result of experiments, however, seem to cast some doubt upon the idea formerly held that the action of the poison was very rapid.

The first animal that was bitten was the common tiger salamander. In this case there was no more deleterious effect than would have occurred from the bite of any other animal. The same thing was true with the next, which was a common toad. In both of these cases, after the bite, the heloderma frothed considerably at the mouth and refused to make the second bite.

The next animal bitten was a rat. After the rat had been bitten two or three times, with seemingly no perceptible effects, it was taken out and placed in a cage with a rattlesnake, where it was bitten twice, and within the space of two hours was dead. A second rat, after an absence of a few days, was put in with the heloderma and was bitten three times; once upon the fore leg, and once upon the tail, and again through the lower jaw. The first two bites occurred before nine o'clock in the morning, the third about one in the afternoon. At four o'clock the same day the rat seemed all right, with the exception of being cowed and having a desire to get as far from the lizard as possible. The next morning, upon observation, the rat was found dead, and when picked up a greenish fluid ran out of its mouth.

The heloderma, when undisturbed, is a harmless individual, and at no time was its biting voluntary. But when disturbed he elevated his head with mouth open, giving forth the aspirate sound of *hah*, and if at this time any thing is placed within his open mouth, the jaws immediately close upon it. The biting is simply holding fast for a few minutes. There are no fangs in the upper jaw, as in the rattlesnake, and if there be any poison it must be from the ordinary saliva and depends upon the degree of irritation of the animal.

Judging from the actions of the two rats bitten, one by the snake and the other by the lizard, we believe the poison in the two reptiles acts differently. From the death struggles of the one bitten by the rattlesnake there appears to be a paralysis of the respiratory organs, while from the stupor which appeared to take hold of the other, we judge in that case to be a paralysis of the circulatory organs.

Some observations on photomicrography. By D. W. Dennis.

Contributions to a knowledge of the grain toxoptera (Toxoptera graminum). By F. M. Webster.

BUFFALO GNATS (SIMULIIDÆ) IN INDIANA AND ILLINOIS. By F. M. WEBSTER.

In his "Guide to the Study of Insects," p. 391, and again in his "Our Common Insects," p. 73, Dr. A. S. Packard acknowledges the receipt of examples of a buffalo gnat from Prof. J. T. Cox, State Geologist of Indiana.

In this notice it is not stated whether the examples were taken in Indiana, or in Illinois, where the author accuses the insect of causing the death of horses on the prairies.

The late Dr. E. R. Boardman, of Stark County, Illinois, wrote me some years ago of the former occurrence of these gnats in his State, as follows: "I spent the summer of 1843 here on Spoon River. The settlers used to watch for the appearance of the buffalo gnats every year, and they usually came from the 10th to the 20th of May, from the Winnebago Swamp. That year it was about the 12th or 15th of May, when we were planting corn, that a neighbor rode up and told us to look to our stock, as the gnats were coming. In less than an hour the cattle and horses came tearing in off the prairie, the former bellowing with pain, the latter kicking and throwing themselves on the ground, and rolling to rid themselves of their tormentors. The gnats did not usually remain more than four or five days at the longest, and often not over twenty-four hours, when a wind would carry them off.

"When they used to come in such numbers, I have known them to run stock from here, thirty or forty miles down the Henderson River, and when the stock were recovered they would be so used up by running as to be almost useless. The deer used to leave the swamps about the time the gnats appeared, and take shelter along Spoon River, often coming in droves, and when hard pushed would take to the water.

"The gnats came more like a swarm of bees than anything else I can compare them to. I never saw them at Pawpaw, DeKalb county, nor do I recollect of seeing or hearing of their occurrence here, for the last thirty years—since the swamp has been drained and pastured."

The following, from a letter received several years ago from Mr. John Marten, at that time residing in Decatur, Illinois, will give additional information as to the distribution of Simulium in Illinois, and also add a valuable hint as to remedial measures for the relief of stricken animals.

"I have found the buffalo gnat in Edwards county, Illlinois. In the spring of 1883 or 1884, I do not now remember which, two, and possibly more, horses were killed in that county. During both seasons the gnat was found there. Farmers from Richland and Lawrence counties, north of Edwards, complained of the pest. My observations were too limited to say more than these general things.

"My father-in-law, before his death, told me that in former years the gnats had been very troublesome in Edwards county, and that whenever he had been called upon to treat cattle or horses they always recovered. He condemned, roundly, the notion that the bites of the gnats were necessarily fatal, saying that cures could easily be made by such treatment as would cause copious urination. He used nitrates and kindred remedies. He was a practicing physician and thoroughly acquainted with his profession.

JOHN MARTEN."

Owing to the obscurity regarding the locality from which Prof. Cox obtained his specimens, it was not until the year 1886 that we had any exact information as to the occurrence of the buffalo gnat in Indiana; our attention being called to the fact by Prof. S. B. Boyd, of Washington, Davies county, who informed us that these insects occurred along White River in considerable numbers. With a view of gaining further information respecting this matter, we addressed a letter to Hon. Samuel Hargrove, of Union, Pike county, from whom we received a reply, not only corroborating Prof. Boyd, but stating the fact of their occurrence along the Patoka River, also.

On the 10th of November, 1886, we started on a trip to Pike county and vicinity, by way of Seymour, Jackson county, where we were informed by Mr. J. A. Peters, an extensive farmer of the bottom lands, that no gnats occurred in that vicinity, but about Bloomfield and Worthington, in Greene county, they often annoyed stock greatly. From Seymour we went to Washington, Davies county, where we again met Mr. Boyd, and learned from him that these gnats infested the bottom lands along the entire western, and also a portion of the southern, borders of that county.

In White county we examined a portion of the Patoka River, a small stream whose winding course is nearly due west, emptying its waters into the Wabash River a short distance below the mouth of the White. The bottoms are wide, and the bed is of clay, the current in low water, as it was at that time, is rather sluggish, but in high water it is quite swift and covers the bottoms, which are often cultivated, but fully as often timbered and grown up with brush. The stream also has more or less drift-wood, stumps, and other debris in it, but we found no place where this caused any perceivable increase of the current. We examined such of this drift-wood as we could disengage, but could find no trace of the buffalo gnat in any stage of development.

We learned from people residing along this stream, that in 1882 the gnats occurred as far up as Jasper, Dubois county, and several mules and horses, in the vicinity of Bovine, Pike county, died from the effects of being bitten by gnats. Usually, however, the insects did not occur in that vicinity in any considerable numbers.

At Hazleton, on White River, in Gibson county, Dr. P. H. Curtner informed me that gnats had appeared, with more or less regularity, every season for the last seventeen years, being very much more abundant in seasons of high water during spring time. Localities between Hazleton and the Wabash River were especially noted for the great numbers of gnats occurring there. Dr. Curtner's facts are of especial value, as he has had several years' experience with buffalo gnats in Louisiana, during the war, having been connected with a battery of Federal artillery.

A quite significant fact was noticed, in that wherever the insects were reported as being the most abundant, the stream was very tortuous, thereby presenting many narrow points of bottom-land, more or less covered with trees and underbrush, across which the water flows whenever the stream is very much swollen. Lumbermen, who are much on the river, say that where the bottoms have been cleared, gnats are not usually abundant.

Like the Patoka, White River has rather a sluggish current. At Hazleton, the latter is estimated to flow at the rate of about six miles per hour in ordinary high water; during low water it is much less.

The following letter adds much to a knowledge of the distribution of buffalo gnats in southwestern Indiana:

"MARCO, IND., December 21st, 1886.

"MR. F. M. WEBSTER, DEAR SIR:—I am somewhat acquainted with buffalo gnats. I first find them on the head waters of a stream called River DeShee, and also on Wilson Creek, in the southern part of Harrison township, Knox county, southeast of Vincennes. They are not so much in the White River bottoms as they are in the low, marshy land adjoining said bottoms. I find them in said township, further north, in the vicinity of a low, sluggish creek, called Pond Creek. Where the high lands come near the river, I find none until I get above Edwardsport, at the mouth of Black Creek: but following that creek in Greene county, I find them abundant in low, wet land that makes and adjoins said creek, to-wit: Cain Drain, or Delaware Creek, a large marsh in Knox county, Carico Marsh, the Goose Pond, Bee Hunter Marsh, and Ladies' Creek Marshes, all in Greene county. In the bottoms, on the west side of White River, you will find plenty of them; but above Worthington they have never been known, so far as I have heard.

"The buffalo gnat in his natural state is about one-half as large as the common house fly. They make their appearance in early spring. A few days,—with the temperature from forty to fifty degrees—is apt to bring them. They cannot exercise when the temperature is 32°, but will come immediately upon the weather's getting warmer. Rain and wet weather will down him for awhile. His life varies as to the weather. One week of clear weather, with the temperature from 70 to 80 degrees, ends his existence. Generally they last from four to six weeks. They are very severe on all kinds of stock, and run the cattle and hogs, and drive them to the open ground, where the wind and hot sun has a tendency to drive the gnats down. They have been known to kill horses by blood sucking, and, when full of blood, are about as big as two house flies. They never attack a man.

"As a preventive, we use coal oil, rubbing it on the horse's head, neck, breast and flanks, as these are the parts generally attacked.

"Yours truly, DR. R. A. J."

At least two species of Simulium occur in the Wabash River, near New Harmony, Posey county, in what is known as the Cut Off. This cut off has existed since before the country was settled, though, in an earlier day it was much narrower and used as a mill race, an oil painting by LeSuer, showing it as it appeared at an early day, is yet in possession of a son of Robert Dale Owen, residing at New Harmony. The channel has widened of late years, the bottom being rocky as of old, and at the lower extremity filled with rocks and bowlders, over and among which the water flows very swiftly. A number of head of stock were killed by gnats in this vicinity in 1884, and they were quite troublesome in the spring of 1890. On June 12th of the latter year I caught adults in the vicinity, belonging, without much doubt, to *Simulium pecuarum*, Riley, and feel quite sure that *S. meridionale*, Riley, also occurs there. From the number of pupa shells that, at the time of my visit, were attached to willows and branches of trees which had been inundated in spring, I judge that adults had been quite numerous, Larvæ were also found in the swifter flowing portions of the stream, but in limited numbers.

It appears somewhat strange that the only species of Simulia described by Thomas Say, for a long time a resident of New Harmony, should be accorded to Ohio, his specimens being from Ohio Falls, near Louisville, Kentucky. It would now appear almost impossible that they should not have inhabited the lower Wabash, while he was engaged in his entomological labors and within sight of the locality where they now occur. An almost parallel case is found in the chinch bug, which Say described in 1831 from a single specimen "taken on the east shore of Virginia," while Prof. S. A. Forbes, in 16th Report of the State Entomologist of Illinois, p. 50, gives what seems to be incontrovertible proof that the insect was abundant in Illinois, within a few miles of New Harmony, as early as 1823. Therefore it does not seem improbable that Simulia may not have occurred in the Lower Wabash, and the Little Wabash, in Illinois, even before Say's residence at New Harmony, though, in attempting to secure proof of this I have been less fortunate than Prof. Forbes, as none of the oldest inhabitants about New Harmony can remember of the occurrence of buffalo gnats, except during recent years.

At the field meeting of the Academy, at Richmond, Indiana, May 12, 1892, we found another location for these insects, in Indiana, this being at at Elkhorn Falls, situated five miles below the city. The larvæ, which appear to be different from any I have collected elsewhere, were found clinging to the rock and also to the algæ which overhangs the falls. No adults were found at the time, and but few pupæ.

THE DEVELOPMENT OF THE VIVIPAROUS FISHES OF CALIFORNIA. By CARL H. EIGENMANN.

RECENT ADDITIONS TO THE ICHTHYOLOGICAL FAUNA OF CALIFORNIA. By CARL H. EIGENMANN AND ROSA S. EIGENMANN. Published in part in Proc. U. S. Nat. Mus. for 1892 and in part in the Annals New York Acad. Sci. for 1892.

[ABSTRACT.]

We have prepared an enumeration of the fishes occurring on the Pacific coast of America, north of Cerros island, and to the depth of 150 fathoms. The explorations of the U. S. Fish Commission steamer Albatross, during the last three years, have added a large number of species to those previously known from this region, and our own explorations have added about as many new forms from San Diego alone as were discovered by the Albatross along the whole coast included in the present paper. These additions.

as well as the extension of the habitat of many species, make the present list desirable.

Several forms have recently been discovered by the Albatross in deeper water. Most of these, however, have little relationship to the littoral fauna and the deeper water has not been sufficiently explored to warrant a list at the present time.

We have placed the dividing line between the littoral and the bathybial faunas of this region at 150 fathoms, because all of the genera so far recorded from this depth have representatives in the shallower water—fifteen to fifty fathoms. Some of the littoral genera, as Sebastodes, have representatives in deeper water, but this is not of general occurrence.

Cerros island is a convenient and natural southern boundary to this region. South of it few, if any, of the characteristic genera (Sebastodes, genera of Embiotocidae,) of this region are found. A number of southern forms extend further north, but the number has not been materially increased by our explorations at San Diego; on the other hand a large number of northern forms, or representatives of northern forms, which had not been found south of Point Conception, were added to the San Diego fauna. The California fauna has hitherto been divided into a southern and a northern at Point Conception. This division was the result of insufficient exploration, and the results mentioned above have made it evident that no definite boundaries can be assigned for a northern and a southern California fauna.

It is quite evident, and readily admitted, that the fauna of California is distinct from the Alaskan fauna, and the latter has been added for convenience and comparison only. But four of the species found at San Diego are also found in Alaska. The California fauna is characterized by the abundance of species of Sebastodes, of Cottidae and of Embiotocidae. The last are entirely absent from Alaska, while only a few species of Sebastodes are found here. The boundary between these two regions lies somewhere between Sitka and Puget Sound. No Embiotocidae are found at Sitka.

The relative number of species at the principal localities is as follows:

The whole of Alaska	109	species
Puget Sound	106	"
San Francisco	155	"
Monterey	149	"
Santa Barbara	119	"
San Pedro	82	"
San Diego, including Cortes Banks	168	"

There are known from the entire region 382 species, belonging to 228 genera. Of these 116 genera, or more than half, are also found in the Atlantic ocean, and thirty-two species are found both in the Atlantic and in the Pacific. The genera having species in both oceans practically all belong to one of three classes: First, Tropical genera; second, Arctic genera, whose species are distributed throughout the Arctic seas; third, Pelagic and other genera having a wide distribution.

Among the remarkable additions made to the fauna of California during recent years are the following:

Bronchiostoma elongatum, which had been recorded but once, we have found in large quantities at San Diego.

Rhinoptera encenadæ, based on a fragment of a jaw found at Encenada.

Perkinsia, a new genus of herrings.

Six species of Scopelidae.

The albacore Euthynnus pelamys, whose nearest recorded habitat had been Japan, was found at San Diego.

On Indiana shrews. By Amos W. Butler.

Among the smaller mammals is a group of small forms generally known as shrews or mole mice. These are insect eating forms. They are little mouse-like bodies. The snout is quite elongated, extending beyond the incisors some distance. It is naked, and on its sides are to be found the nostrils. Although these small mammals are very abundant they are not often seen. They are doubtless most active at night but are not strictly nocturnal, for examples are sometimes to be found moving about in the bright sunlight. They feed upon such animal food as comes in their way, chiefly grubs, larvæ, slugs, terrestrial insects. They are very pugnacious, following mice into their nests and often attacking them. They also attack and kill each other, eating the carcass. They eat almost any kind of animal food, but of vegetation eat little. They are said to be fond of beechnuts, and will, when starved to it, eat corn, oats, wheat and other grains.

In confinement they have been known to attack and kill mice much larger than themselves. Their eyes are small, and while not covered, they can see but imperfectly. Their burrows may be found everywhere beneath meadow, pasture and lawn, under the accumulated vegetable mould of the forest, or the collection of decaying weeds of the thicket. Anywhere and everywhere their small tunnels may be found. In no respect, that I know, are they injurious, but in all laborers in their little spheres for good. It has been thought, from the number of dead shrews that are sometimes found, that these little mammals are subject to epidemics.

They are naked and blind at birth. None hibernate, but all move about in the coldest weather. Shrews seem to be rejected as food by other animals, on account of an unpleasant odor they emit. Often have I known a cat to catch one and carry it about for some time, apparently loth to give it up, but never eating it and, in the end, rejecting it. Many superstitions are prevalent in Europe, particularly in Great Britain, regarding these little creatures but, so far as I know, none of them are notable in the folk-lore of our land.

The most abundant shrew in our state, and perhaps the most widely distributed in the United States, is the short-tailed shrew, *Blarina brevicauda*, (Say). An interesting account of a nest of this species is given by my friend, Mr. Charles Dury, of Avondale, Cincinnati, Ohio, in a letter of Dec. 28, 1891. The notes have since been published, (Journal Cincinnati Soc. Nat. Hist., 1892, p. 183), and I give them here:

"It is well known to entomologists that some very curious and interesting insects live in the nests of mice and other small mammals. December 13, 1891, I went out to hunt nests of 'field mice,' in hopes of finding a wonderful little beetle, called *Leptimus testaceous*, said to live in such nests. This species was an especial desideratum to me, as I had never succeeded in finding it. I went to an old orchard, and under the first log rolled over I discovered a nest and secured a mouse as she rushed out. She proved to be the 'Short-tailed Meadow Shrew,' *Blarina brevicauda*, (Say). The nest was made of small bits of leaves of the sycamore tree, lined with grass fibers, and situated in a hole or pocket excavated in the ground. I lifted the nest into the sifting net and sifted it over a sheet of white paper, and was overwhelmed at the result. The fine debris was a jumping, crawling mass of insect life, beetles, fleas, ticks and larvæ. I gathered and bottled 106 *Leptimus*, and many ran over the edge of the paper and escaped. There were over a hundred large, vicious looking fleas, most energetic biters (as I discovered from those that secured a lodgment in my clothing). How the mouse could live in such a den is a mystery. The other beetles associated with *Leptimus* were *Staphylinidæ*, or 'Rove Beetles' of species new to me, and so far I have been unable to identify them. *Leptimus* is a small, flat beetle, of a pale testaceous color, one-eighth inch long, without any trace of eyes."

A smaller shrew, which seems to be comparatively common in Vigo county and is found in the Whitewater valley, is *Blarina exilipes*, (Baird.) This shrew is locally known in Vigo county as the "Bee Shrew," from its habit of entering the hives and destroying the young brood.

A form from Hanover, Jefferson county, which is about the size of the last mentioned, was identified by Prof. S. F. Baird as the Cinereus Shrew, *Blarina cinerea*, (Bach.).

From Franklin county several very small shrews were sent to Dr. Elliott Coues. He pronounced them the "Least Shrew," *Blarina parva*, (Say). The species had remained unknown from the time of Say's description. This is, perhaps, the smallest mammal in the United States, and seems to be rather common in the Whitewater valley.

A specimen from North Manchester, Wabash county, taken by Mr. A. B. Ulrey, proves to be the Common Shrew, *Blarina platyrhinus*, (DeK), which has not before been found in the state. A revision of our shrews will probably soon be undertaken, and it is very much needed for they are now in a very tangled condition. Further investigation will doubtless add other forms to our fauna.

There are three species described by Duvernoy in 1842, from this state. that are not now known. They are:

Brachysorex harlani, (Duver.), New Harmony, Ind.

Brachysorex brevicaudatus, (Duver.), New Harmony, Ind.

Amphisorex lesuerii, (Duver.), Wabash valley, Ind.

I should like to request all who have specimens of shrews and other small mammals to inform me of that fact, and to urge upon all our members the importance of obtaining and preserving all such animals they can. Especially is such material desirable from all parts of the Wabash valley. The specimens may easily be dropped into small bottles or jars of alcohol after being tagged and marked, in lead pencil, with date and locality of capture. A little co-operation on the part of the members of our academy, a little thoughtfulness in saving what is thrown in our way, will do much to clear up many of the murky places in our nomenclature, many of the fogs along the lines of geographical distribution.

NOTES ON INDIANA BIRDS. By AMOS W. BUTLER.

Since the publication of my recent paper on Indiana birds* several valuable notes have been received, relating to the birds of the state. Besides these, a fuller notice of some of the brief notes given in the paper mentioned may be worthy of note. Not only is much additional information needed as to the occurrence of birds within the state, but also it is of great value to have continued observations on the range, breeding range and habits of birds. From the results of such work, carefully performed, we may map the range of birds by counties and even by townships, and, as a result, be enabled to solve many of the knotty and unravelled problems of geographical distribution. One of the labors which this academy may well carry on, and none can be more valuable, is a biological survey of the state, carefully and sincerely worked out.

Junco hyemalis shufeldti (Coale). Shufeldt's Junco. The specimen of this bird taken at Lafayette, and reported by Dr. Erastus Test, is the second one taken east of Illinois. A single specimen having been taken in Maryland near Washington. This is a form of the Rocky Mountain region which seems to extend its range southeastward.

Ammodramus henslowii (Aud.) Henslow's Sparrow. Mr. Ruthven Deane informs me that he spent a day in July, 1891, making the acquaintance of Henslow's Sparrows at English Lake, Ind. He reports seeing no less than twenty-five specimens and says: "two of us killed about ten. They have been there all summer." Within five days after receiving Mr. Deane's notes my friend, Mr. Charles Dury, of Avondale, Cincinnati, Ohio, informed me of a visit of two friends of his to English Lake in July and August. He said they found Henslow's Sparrows rather common and breeding, and took some specimens, including some young birds. An adult taken there was kindly presented to me by Mr. Ralph Kellogg, one of the collectors. Upon inquiry, I learned that these gentlemen and a friend visited the same locality noted by Mr. Deane, and, further, that they were acquainted and had collected in the same meadows.

Cistothorus stellaris (Licht). Short-billed Marsh Wren. I am under obligations to Mr. Deane, to whom I am indebted for many valuable notes, for some observations on the breeding of the Short-billed Marsh Wren in the state. He says an employe at their club house at English lake brought in a nest taken there two or three years ago. In Mr. G. Frean Morcom's col-

*The Birds of Indiana, with illustrations of many of the species, by Amos W. Butler. (Transactions Indiana Horticultural Society, 1890.)

lection is a set of five eggs of this species, taken at Davis Station, Ind., June 3d, 1887. Mr. C. E. Aiken informs me he found them in marshes bordering sloughs in Lake county, in 1871.

Protonotaria citrea (Bodd)—Prothonotary Warbler. I desire to express my appreciation of the work of Mr. Herbert W. McBride in exploring the counties of Elkhart, Lagrange and Steuben, in Indiana, and St. Joseph county, Michigan, thereby adding materially to our knowledge of the range of the birds in that region, and especially in extending the known range of the Prothonotary Warbler into all of these counties. It was found commonly in all but Steuben. This, with Mrs. Jane L. Hine's discovery of the species in DeKalb county, is very interesting to students of bird distribution.

For the following notes I am indebted to Mr. C. E. Aiken, of Salt Lake City, Utah, well known for his zoological investigations in Colorado. He formerly lived in Chicago and collected in northwestern Indiana, in 1866–7–9 and 71, and occasionally in later years:

Ardea egretta (Gmel)—American Egret. Mr. Aiken informs me it breeds on the Kankakee river, near Water Valley, Ind.

Charadrius squatarola (L) –Black-bellied Plover. One was killed by Mr. Aiken, in Lake county, in 1871.

Contopus borealis (Swains)—Olive-sided Flycatcher. Not rare in Lake county where I obtained a number of specimens in 1871. (Aiken.)

Xanthocephalus xanthocephalus (Bonap—) Yellow-headed Blackbird. Found abundantly along the Calumet river, in Lake county, in 1871. (Aiken.)

Coccothraustes vespertina (Coop)—Evening Grosbeak. A large number of specimens were obtained near Whiting Station, Ind., in 1886–7, by Mr. R. A. Turtle, of Chicago. (Aiken.)

Loxia curvirostra minor (Brehm)—American Crossbill. One of the most interesting of Mr. Aiken's notes is one of the occurrence of the crossbills in the extreme heat of summer, in the vicinity of Chicago and northwest Indiana. Of the American Crossbill he says: "In July and August, 1869, this bird became very abundant in the door yards in Chicago, and remained until late in the fall. They fed greedily upon seeds extracted from sunflowers and were so sluggish that one could approach within a few feet of them, so that they fell an easy prey to boys with catapults. In the latter part of August, of the same year, I found them common in flocks about farm yards in Lake county, Indiana.

Loxia leucoptera (Gmel)—White-winged Crossbill. Accompanied the preceding species, in 1869, and remained through the winter. Noticed in Lake county preceding. (Aiken.)

Ammodramus lecontei (Aud)—Leconte's Sparrow. I am pleased to be able to note, upon the authority of Mr. Aiken, the occurrence of this bird in northwest Indiana. About April 15th, 1887, he observed two birds which he thought were this species at Water Valley. About the same time in 1889, near the same place, he saw three of what appeared to be the same birds. Two of them were shot and proved to be this species.

Geothlypis formosa (Wils)—Kentucky Warbler. Mr. Aiken is able to extend the range of this species as far as Gibson Station, Ind., where, he says, several specimens were taken in May, 1887.

In addition might be added that the extreme dryness of the fall for the past two years has had a noticeable effect in lessening the number of marsh birds and water fowl throughout the part of the state where shooting such game is extensively indulged in. Rail, snipe and duck shooting has been worthless the past two autumns. Birds were few, for their favorite haunts were unsuited to their wants. Marshes and sloughs were dry, as were the creeks. Much of the lakes had disappeared, leaving instead "mud flats." Many species, ordinarily common, were rare and others altogether wanting. The open winters two years past and so far this winter, have encouraged many species which ordinarily pass the winter further south to remain with us, and other species which stay in winter in limited numbers have remained in quantities.

Some notes on the birds of Indiana.* By R. Wes McBride.

Loon, *Urinator imber*, Gunn. Mr. A. W. Butler, in his admirable and excellent catalogue of the birds of Indiana, says of the Loon, or Great Northern Diver: "I have no knowledge of their breeding within the state, although they will probably be found to do so." I can personally testify that it is a summer resident of Steuben county, and that it breeds in at least two of the many beautiful lakes of that county. Their eggs have been taken at Lake James and Crooked Lake. I have been familiar with those lakes for more than twenty years, and have never failed to find them there in summer. I have also seen them in the breeding season in Hamilton Lake and Golden Lake, also in Steuben county; in Turkey Lake, on the line between Steuben and Lagrange counties, and in Bear Lake, Noble county.

Yellow-bellied Wood-pecker, *Sphyrapicus varius*, L. Is said, in the catalogue, to have bred rarely, if at all, in DeKalb county since 1888. Herbert W. McBride found a nest with three eggs near Waterloo, May 13, 1889.

Bobolink, *Dolichonyx oryzivorus* L. Ten years ago this bird was very rare in DeKalb and Steuben counties. Now it is a common summer resident and breeds in both counties. It is, however, still very rare in Elkhart county, only a short distance west, with the apparent conditions not materially different.

Brown Creeper, *Certhia familiaris americana*, Bp. Of this bird Mr. Butler says: "I have never known it to breed in the state, but Mr. H. W. McBride thinks it breeds in DeKalb county." I can say positively that I know it breeds in Steuben county. In my note-book I find the following under date of May 8th, 1882: "Brown Creeper; taken near Golden Lake, Steuben county, Indiana. Nest in crevice, where the bark had started from a dead tree, about four feet from the ground, in a swampy tract in "Crane town." Nest composed of sticks, bark and feathers. Six eggs, beauties. Incubation commenced. Embryos about half developed." I have a very distinct recollection of the matter. The "Crane town" referred to in the note is a heronry which we were exploring. The water was high and we were in a boat. I placed my hand against a tree to push the boat past it, when the bird flew off the nest, which was within a few inches of my hand. The bird remained near me until after I had secured the eggs and examined the nest. The appearance and characteristics of the Brown Creeper are so marked that it could hardly be mistaken for any other bird. I could not possibly be mistaken in its identification. In addition to this, the location and construction of the nest and the eggs themselves are all typical and characteristic.

Another nest and set of eggs were taken in May, 1883, at Fox Lake, near Angola, by my sons, Charles H. and Herbert W. The identification in this case was as satisfactory and unmistakable as in the other. Since that time, while I have frequently seen them during the breeding season, both in Steuben and DeKalb counties, I have found no other nests.

Tufted Titmouse, *Parus bicolor*, L. Is noted in the catalogue as an occasional straggler in northern Indiana. It breeds in Elkhart county. June 12th, 1891, Herbert W. McBride found a nest near Elkhart containing seven young birds.

The scales of lepidoptera. By M. B. Thomas.

The Ægeria of Central Ohio. By D. S. Kellicott.

Some insects of Tasmania. By F. M. Webster.

[Abstract.]

Although occupying a position in the southern hemisphere similar as to latitude to the northern half of Indiana and southern Michigan, the insect fauna more nearly resembles that of southern Texas, being strikingly semi-tropical. In the vicinity of Hobart, during the last of January, a season corresponding to our August, Phytophagus coleoptera, especially of the Chrysomelidæ and Rhynchophora, were very abundant, while carnivorous species, though strikingly poorly represented, included several Coccinellidæ and one Lepidopterous species—a rare object in any country. A noticeable feature, but one peculiar to island insects, was the lack of flying species along the coast.

A single butterfly, swift and strong of wing, was the only capture made in Lepidoptera. Another feature of island insects was noticed in the preponderance of species of a bronzy or yellowish color. The young euculyptus trees afford a rich field for collectors during the summer season.

Early published references to injurious insects. By F. M. Webster.

The continuity of the germ plasm in vertebrates. By Carl H. Eigenmann. Published in part in the Journal of Morphology, pp. 481–492, plate XXXI, 1892, under the title "On the precocious segregation of the sex-cells in *Micrometrus aggretatus* Gibbons."

The theory of the continuity of the germ plasm as finally formulated by Weismann assumes that "there is not only a continuity between the ovum which gives rise to parent and the ovum which gives rise to the offspring" but in the successive generations between the ovum which produces the parent and the ovum which produces the offspring the character of the original ovum is never lost by differentiation. There is then a continuous chain of reproductive cells quite apart from the body cells or more frequently a series of body cells through which the unchanged germ plasm of the parent is transmitted to future generations. The germ cells are, therefore, not the product of the adult body but the direct offspring from the germ cell of the preceding generations.

The observations bearing out much of this theory have been mostly confined to invertebrates. All of our works on the comparative anatomy of vertebrates, as well as our works on embryology, tell us that the sexual organs in vertebrates arise from the germinal epithelium which is not differentiated until the embryo is completely formed. The most lucid descriptions of the early stages were given by Balfour for Elasmobranchs ten years ago, and the latest observations published by Jungersen in 1889 have not given anything concerning the stages less than two millimeters long.

While preparing the sections for the ontogeny of *Cymatogaster aggregatus*, one of the viviparous Embiotocidae, I frequently observed large, indifferent cells in the mesoblast. I at first supposed them to be cells in a pathological condition. When, however, all the eggs from one ovary were observed to contain such cells, I re-examined every embryo, and soon found that the cells are not pathological, but are a normal structure present in all embryos of a certain age. Further study showed them to be sex-cells of the future germinal epithelium. Our knowledge of the early stages of the sex-cells of vertebrates does not extend back beyond the condition described by Balfour and Jungersen. In the present study I have been able to trace them back to probably the fifth segmentation.

Our knowledge of the sex-cells in general has been summed up by Weismann as follows: "In certain insects the development of the egg into the embryo, that is, the segmentation of the egg, begins with the separation of a few small cells from the main body of the egg. These are the reproductive cells, and at a later period they are taken into the interior of the animal and form its reproductive organs. Again, in certain smaller fresh-water crustacea (Daphnidæ) the future reproductive cells become distinct at a very early period, although not quite at the beginning of segmentation, *i. e.*, when the egg has divided into not more than thirty segments. Here also the cells which are separated early form the reproductive organs of the animal. The separation of the reproductive cells from those of the body takes place at a still later period, viz. at the close of segmentation, in Sagitta, a pelagic free-swimming form. In vertebrata they do not become distinct from the cells of the body until the embryo is completely formed." It will be seen that in some vertebrates (*Cymatogaster*) a similar segregation of "germ plasm" takes place quite early. In brief, the sex-cells of *Cymatogaster* first become normally conspicuous in the mesoblast where the germ layers are fused before any protovertebræ are formed. They can be seen in earlier stages, but they do not stand out so prominently from the other cells. In exceptional cases, the sex-cells can be traced back to probably the *fifth* segmentation.

The sex-cells can first be distinguished from the surrounding cells about the time the blastopore closes. The earliest ones distinguishable, exclusive of abnormal cases, are from an ovary in the eggs of which the blastopore is not yet closed, or is just closed and in which the mesoderm is not yet split off from the entoderm. Only two cells which can with certainty be said to be sex-cells are seen in one of these eggs. They differ from the surrounding cells in having well-defined, rounded outlines, and in the distribution of the chromatin in the nucleus. The chromatin of the surrounding cells is collected in one, or, if the cells are undergoing division, in two or three masses. The chromatin of the sex-cells is uniformly distributed in small granules.

In the eggs of another ovary, in which thickenings are formed for some distance, and the mesoblast is separated from the entoderm by a well-marked line, the sex-cells stand out from the surrounding cells with great prominence. This is not due to any marked change in the sex-cells themselves, but rather to the fact that the surrounding cells have undergone further division and are crowded so that the boundaries are not defined, while those of the rounded sex-cells are well marked.

The largest and most conspicuous cell of this stage lies in the mesoblast just beside the chorda. It measures 18x23 *m*, and has a nucleus measuring about 6 *m*. On comparing this with segmenting eggs, it is found that it agrees in size with some of the cells of an egg undergoing the ninth segmentation and in all probability it is a cell remaining unchanged from that stage. It contains yolk particles. Most of the sex-cells are collected in a limited region at this stage in the thickened portion of the embryo, where the three germ layers fuse. This would lend force to the supposition that they are derived from two cells at most—one dextral and one sinistral. There are a few scattered cells in other parts of the embryo which cannot be so derived unless they early migrate from their original position.

There are, on an average, thirteen sex-cells in an egg of this stage. The largest number noticed is seventeen, the smallest nine.

In a larva just hatched, the longest diameter of which, measuring in a straight line, is 0.45 mm., there are ten sex-cells. In this embryo about nine protovertebræ have been formed. Most of the sex-cells are large, the largest having a diameter of 23 *m*, with a nucleus of 8 *m*. The smallest cell measures but 11 *m* in diameter. The *distribution* of these cells has become markedly changed from the conditions obtaining in the two-protovertebræ stage. Two of the cells, in the embryos examined, are found in the cephalic region, one on either side a short distance posterior to the origin of the chorda. The remainder are distributed as follows: one below the seventh sinistral protovertebra; three in the left side of the tail, *i. e.* in the region in which protovertebrae have not yet appeared; and three in the right side of the tail.

The cells in this stage stain deeper and much more uniformly than the surrounding cells with Grenacher's hæmatoxylin. They greatly resemble the very early conditions of these cells, and the number would seem to indicate that there has been no segmentation since the two-protovertebræ stage. In other larvæ of the same stage there are ten, eight, five, and nine cells, respectively.

In larvæ 2.5 mm. long there are fourteen to sixteen cells and the number cannot have been increased much since their earliest condition, even if we assume that two or more have been lodged in the gill region, and two in the anterior part of the body. The majority of the cells in this larva are confined to a region only 0.20 mm. long; and if we consider the doubtful cells in the anterior region, the total length over which these cells are distributed is about 0.50 mm. from the anus forward. The sex-cells in this stage measure 9–13 *m*. Balfour's admirable account of these "primitive ova" (Elasmobranch Fishes, pp. 130–136) might almost be used bodily to describe the same structures in *Cymatogaster* and *Abeona* 2.5 mm. long. He observed that the younger ones contain many yolk spherules, and suggests that the cells themselves may have migrated to their position from a peripheral portion of the blastoderm, since "they are the only mesoblast cells filled at this period with yolk spherules." He was at a loss as to how they arose, and thought he could detect cells intermediate in size between them and the neighboring cells. As has been seen, the yolk particles simply remain unchanged from the original condition when the sex-cells are segregated.

Several figures would seem to indicate that one of the larger cells of an early stage divides and gives rise to the groups of smaller cells in a later stage. This can scarcely be the case, since the number of cells in the earlier and later stages are about equal, unless a number of the earlier cells atrophy or are resorbed. The loss of four cells, two in the gill region, and two in the region of the fifth body somite, is probable, but even with the addition of these, the number of cells in the last stage examined does not exceed the average number in early stages when the cells are quite large. The reduction in size can, therefore, be explained only by supposing that the individual cells are reduced in size during development. It would be interesting to consider here the causes that lead these sex-cells to again grow and divide. Since, however, this process does not begin in the stages under consideration, this matter must be left till later stages are examined.

Biological Stations. By Carl H. Eigenmann.

The early naturalists noted briefly the animals and plants they saw at home or abroad. A few centuries later they added figures to their enumerations. Later still skins were preserved, and last of all the whole animals were preserved, gathered into large museums, where they soaked and rotted twenty-five years, perhaps, before some one came along to study them. Some of our ornithologists and conchologists, and even some ichthyologists have not yet passed beyond this skin stage in their development. Many others, on the other hand, have passed this last stage and have ceased to content themselves with the catalogueing of specimens and now study the method, whys and wherefores of the things about them.

This school was established when Johannes Müller first dipped a net for pelagic animals. When it was found that the hows, whys and wherefores could best be studied in the lowest creatures, naturalists flocked to the sea shore, at first during their vacations. As methods for study increased and apparatus multiplied permanent Marine Biological Stations were evolved. First of these were the Naples Zoological Station and Agassiz's School at Penikese, both established in 1873. The aims of the two were slightly different. The Naples station was for original investigation. The Penikese school it was hoped would awaken an interest in zoology in America. There are now a large number of stations along the European coast, some large and some small, but it is not the intention to speak of these.

Penikese died with Agassiz. I have lately been on a pilgrimage to the old buildings. The motto "eat, drink and be merry" still hangs in the old dining-hall. On the walls of the lecture-room are the mottoes placed there by Agassiz's pupils: "A laboratory is to me a sanctuary. I would have nothing done in it unworthy its great author." "Study to translate what actually exists. Be courageous enough to say 'I do not know,'" and "Study nature not books." The outlines of the last lecture delivered at Penikese eighteen years ago are still on the blackboard. At this window Dr. Whitman stuffed terns, at the other Dr. Brooks cracked clams and at another Dr. Jordan studied seaweeds.

Penikese had been donated and the buildings erected by a tobacco merchant, Anderson, of New York. It was found that the location was too inaccessible and the fauna of the island too poor so that the $30,000 buildings were abandoned for less commodious but more favorably situated quarters. There are at present several marine laboratories on the coast of America, and several summer schools which are located on the seashore, and do a certain amount of marine biological work.

In 1881 a number of Boston women established a laboratory at Annisquam, Mass., where students and teachers could work during the summer. These ladies were afterwards instrumental in the foundation of the Marine Biological Association whose laboratory is at Woods Holl on Vineyard Sound.

Alexander Agassiz several years ago built the Newport Marine Laboratory, to which he has frequently invited students. Here the advanced students of Harvard University work during the summer. This laboratory is the best equipped of any in the United States, but it is practically private and has room for but eight students.

The United States Fish Commission, after spending several summers at various places on the Atlantic finally built a permanent station at Woods Holl. This is by far the largest station in America and it was Professor Baird's hope and intention to make it the equal of the famous station at Naples. But the elaborate laboratories, aquaria, docks, boats and large hotel did not attract the men it was hoped to collect.

Another laboratory has lately been established on Long Island, but of this nothing definite can be said yet. Still another has been established by the University of Pennsylvania.

This brings us back to the station of the Marine Biological Association which deserves a better notice.

It is by far the most important in its scope, aims, methods and future prospects. It is chiefly supported by the munificence of Boston people. The buildings consist at present of the laboratory and the newly acquired dwelling house. The north side of the upper floors is divided into small rooms 7x10 feet. Each of these is supplied with a table, an aquarium, sink, shelves and a full set of reagents and glassware. These rooms are occupied by investigators doing independent work and are offered free. The remaining portion of the second floor is occupied by the library, the director's rooms, reagent room and the laboratory of the advanced students. The lower floor by the lecture room and laboratory for students most of whom are teachers at one place or another.

This is the Mecca of the modern school of naturalists, and there are collected, at this place, teachers and students from all the leading institutions.

The laboratories for students are open during July and August. Investigators come earlier and stay later.

In enumerating what has been done on the east coast it is perhaps well to state what may be done on our west coast. Our eastern laboratories necessarily close during winter. On the Southern California coast where the thermometer never records the freezing point ice does not drive the investigator away in winter. The boundless wealth of the fauna and flora together with the favorable climate will doubtless sometime attract to this region a number at least the equal of that now collected at Woods Holl or Naples. At present the sole marine station on the whole coast is my little laboratory at San Diego which is a mile from the shore and the windows of which are now nailed up.

I have before [San Francisco Chronicle, November 30, 1890.] urged the establishment of marine laboratories on the west coast where they can equal the Naples station and it is to be hoped that one may soon be endowed not only for elementary work but for original research with a permanent corps of investigators.

P. S.—Since this was written Timothy Hopkins has endowed a marine laboratory to be established at Monterey, and Adolph Sutro will maintain another at the entrance of San Francisco Bay. Who will utilize the best locality—San Diego?

THE EYES OF BLIND FISH. BY CARL H. EIGENMANN. Published in Proc. U. S. Nat. Mus. for 1892, with plates.

[ABSTRACT.]

Whenever the conditions are favorable blind fishes are developed. These are always related to species inhabiting neighboring open waters. Blind fishes are found in caves, in the deep sea, and at San Diego one lives beneath rocks. While such regions usually contain blind fishes not all the fishes inhabiting these regions are blind. Many species found in the deeper parts of the ocean have well developed eyes, while others living in shallower water are blind. The explanation for this fact probably lies in the length of time a given species has inhabited the present locality. In all blind fishes the eyes have undergone a process of degeneration. This is very strikingly seen in the development of the Point Loma blind fish, *Typhlogobius californiensis* Steindachner. The embryo, before it is hatched, has eyes as well developed as the embryo of any other fish. When the individuals have reached the length of an inch they can still see a short distance, but it is evident that the eye has stopped growing long before this age is reached. In the adult condition the eye has become degenerate and covered with a thick skin, and the fish is totally blind.

ON THE PRESENCE OF AN OPERCULUM IN THE ASPREDINIDÆ. BY CARL H. EIGENMANN. Published in American Naturalist, January, 1892, p. 71, plate VI.

[ABSTRACT.]

In our "Revision of the South American Nematognathi," (p. 9) we defined the Bunocephalidæ—Aspredinidæ as having no opercle. In this we followed Cope, who separated the Aspredinidæ from the remaining Nematognathi by their lack of an opercle.

We have lately obtained a specimen of *Aspredo aspredo* Linnaeus from the Museum of Comparative Zoology, and have re-examined this point. The closer inspection has demonstrated the presence of a minute operculum attached to the upper posterior border of the expanded hyomandibular. It is movable in moist preparations but becomes immovably fixed with drying, which may have led to the original statement. The interopercle is about as large as the opercle, and apparently immovably joined to the hyamandibular and preopercle. (The skull of this species, with the suspensorium, was figured.)

A REVIEW OF THE EMBIOTOCIDÆ. BY A. B. ULREY. In press, Report of the U. S. fish commission.

[ABSTRACT.]

On examining specimens of this family and the literature bearing on the subject, I find the following species, with their localities:

1. Hypsurus caryi Agassiz. Habitat: Coast of California from San Diego to San Francisco.

2. Damalichthys argyrosomus Girard. Habitat: Pacific coast from San Diego to Vancouver Island.

3. Hyperprosopon analis A. Agassiz. Habitat: Port Harford to San Francisco. Rare.

4. Hyperprosopon argenteus Gibbons. Habitat: Astoria to Encenada.

5. Hyperprosopon agassizi Gill. Habitat: Coast of California.

6. Holconotus rhodoterus Agassiz. Habitat: Coast of California from San Francisco to San Diego.

7. Amphistichus argenteus Agassiz. Habitat: San Diego to Cape Flattery.

8. Rhacochilus toxotes Agassiz. Habitat: San Francisco to San Pedro.

9. Neoditrema ransonneti Steindachner and Doderlein. Habitat: Japan.

10. Ditrema temminckii Bleeker. Habitat: Japan.

11. Ditrema smittii Nyström. Habitat: Japan.

12. Embiotoca jacksoni Agassiz. Habitat: San Diego to Puget Sound.

13. Phanerodon lateralis Agassiz. Habitat: Vancouver Island to San Diego. Rare southward.

14. Phanerodon furcatum Girard. Habitat: San Diego to San Francisco.

15. Phanerodon atripes Jordan and Gilbert. Habitat: Monterey to Cortes Banks.

16. Brachyistius frenatus Gill. Habitat: San Diego to Puget Sound.

17. Brachyistius rosaceus Jordan and Gilbert. Habitat: Off San Francisco in deep water.

18. Cymatogaster aggregatus Gibbons. Habitat: Pacific coast of the United States.

19. Abeona minima Gibbons. Habitat: San Diego to San Francisco.

20. Abeona aurora Jordan and Gilbert. Habitat: Monterey Bay.

21. Hysterocarpus traski Gibbons. Habitat: California (Sacramento river in fresh water).

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