TRANSACTIONS

OF

THE ACADEMY OF SCIENCE OF ST. LOUIS.

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NIXON-JONES PRINTING CO.

CORRECTIONS.

P. 144. — For Plates 1, 2, and 3, read Plates XXII., XXIII., and XXIV. — It should also be noted that plates I.–XXIV. replace numbered pages of text.

163, several places. — For Crotallaria read Crotalaria.

171, second line from bottom. — For Anthremus, read Anthrenus.

201, first line.— For constructions, read properties.

202, first four equations.— For 2, read 4.

214, fifth line.— For least, read greatest.

224–8. — For s, read 2.

241, sixth line from bottom.— For *filamenta*, read *filifera*.

293, equation 43.— For $\dfrac{my - \pi\sigma(x^2 + y^2)^{\frac{3}{2}}}{mx}$

read $\dfrac{my - 2\pi\sigma(x^2 + y^2)^{\frac{3}{2}}}{mx}$.

427, line 8.— For *Schradophyllum Jacquinii* read *Sciadophyllum Jacquini.*

Concerning No. 12, Mr. Roever submits the following note:—

After the introduction of the electrified point or the electrified line into a field of electric force which before the introduction of the electrified point or the electrified line is uniform in direction and magnitude at every point (and may be the field of an isolated electrified plane of infinite extent) the equipotential surfaces cease to be planes (except at an infinite distance). Owing to this fact the following wording should be substituted for that on the title page:—

Geometrical properties of the lines of force proceeding from

(a) A system consisting of an electrified straight line surrounded by a field of electric force which before the introduction of the electrified line was uniform in direction and magnitude at every point. The electrified line is perpendicular to the direction of the force in the original field.

(b) A system consisting of an electrified point surrounded by a field of electric force which before the introduction of the electrified point was uniform in direction and magnitude at every point.

The wording on pages 273 and 285 (printed in italics) and in several other places should also be changed. The reader will, however, receive a correct impression from the uncorrected statements by thinking of a field of electric force which is uniform in direction and magnitude at every point whenever "electrified plane" is mentioned. He will also think of the magnitude of the field force as being represented by F instead of by $2\pi\sigma$.

Notwithstanding these corrections, the mathematical results reached are correct.

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MEMBERS.

1. PATRONS.

Harrison, Edwin........................3747 Westminster pl.

2. ACTIVE MEMBERS.

Adams, Wellington....................607 Chemical bldg.
Alden, John T..........................Colonial bldg.
Allen, Edmund T......................2805 Russell av.
Alt, Adolf................................3036 Locust st.

Bailey, Charles.........................87 Vandeventer pl.
Barck, C...................................2715 Locust st.
Barnard, George D. ....47 Vandeventer pl.
Bartlett, George M...................215 Pine st.
Baumgarten, G.........................2643 Chestnut st.
Bernays, A. C...........................3623 Laclede av.
Biebinger, F. W........................1421 S. 11th st.
Bliss, M. A...............................4929 Lotus av.
Boogher, John H.......................4034 Delmar boul.
Bouton, Charles L.................. ...2709 Park av.
Bremer, Ludwig........................3723 West Pine boul.
Brennan, Martin S.....................1414 O'Fallon st.
Brookings, Robert S..................2329 Locust st.
Brown, Daniel S........................2212 DeKalb st.
Bryson, John P.........................209 N. Garrison av.
Budgett, S. P............................3810 Washington av.
Burroughs, W. S.......................240 Dickson st.
Busch, Adolphus.......................Busch pl.

Cale, George W., Jr....... ....4403 Washington boul.
Carpenter, George O..................Russell and Compton avs.
Chaplin, Winfield S...... ....3636 West Pine boul.
Chase, E. C...............................3325 Morgan st.
Chauvenet, Louis.......................5501 Chamberlain av.
Chouteau, Charles P..................918 Security bldg.
Clifford, Alfred.........................4168 West Pine boul.
Collins, Robert E ....3811 Westminster pl.

Compton, P. C.........................4156 Washington boul.
Comstock, T. G.........................3401 Washington av.
Coulter, John M.........................University of Chicago, Chicago, Ill.
Crunden, Frederick M.............. .Public Library.
Cushman, Allerton S...................603 N. Garrison av.

Dameron, E. C...........................Clarksville, Mo.
Davis, H. N................................56 Vandeventer pl.
Dodd, S. M.................................415 Locust st.
Douglas, A. W............................9th and Spruce sts.
Drake, George S........................Boatmen's Bank.
Duenckel, F. W..........................1936 Louisiana av.
Durant, George F.......................9 Benton pl.

Eliot, E. C.................................5468 Maple av.
Eliot, Henry W...........................2635 Locust st.
Engler, Edmund A......................Washington University.
Erker, A. P.................................617 Olive st.
Espenschied, Charles..................3500 Washington av.
Evers, Edward............................1816 N. Market st.
Ewing, A. E................................3333 Washington av.

Fischel, W. E..............................2647 Washington av.
Fletcher, W. C. ....Granite City, Ill.
Forbes, S. A...............................Urbana, Ill.
Fordyce, John R..........................3634 Washington boul.
Frankenfield, H. C..... ....U. S. Weather Bureau.
Frerichs, Frederick W...............Herf & Frerichs Chem. Co.
Fry, Frank R...............................3133 Pine st.

Glasgow, Frank A.......................2608 Locust st.
Glasgow, William C ....2847 Washington av.
Goodman, C. H...........................3329 Washington av.
Graham, B. B.............................3500 Morgan st.
Gray, M. L..................................604 Houser bldg.
Green, John.................................2670 Washington av.
Gregory, E. H., Jr.......................3525 Lucas av.
Grindon, Joseph.................... ....509 N. Theresa av.
Gruner, Philip.............................3406 Hawthorne boul.
Gurney, James............................Tower Grove and Magnolia avs.

Haarstick, Henry C ....Main and Walnut sts.
Hambach, G................................Washington University.

Hammon, W. H.........................U. S. Weather Bureau,
San Francisco, Cal.
Hardaway, W. A.......................2922 Locust st.
Hartmann, R...........................14 S. 2d st.
Herthel, Adolph.......................1739 Waverly pl.
Hicks, Frederick C....................Columbia, Mo.
Hirschberg, F. D......................3818 Lindell boul.
Hitchcock, A. S.......................Manhattan, Kas.
Hitchcock, Henry......................709 Wainwright bldg.
Hodgman, Charles......................300 N. 4th st.
Holmes, J. M..........................3810 Page av.
Hough, Warwick........................3877 Washington boul.
Hulbert, George F.....................4270 Delmar boul.
Hummel, Charles.......................2621 Eads av.
Hunicke, H. A.........................Washington University.
Hurter, Julius........................2346 S. 10th st.

Ives, Halsey C........................Museum of Fine Arts.

Jackson, George P. B..................1019 Thornby pl.
James, John A. James..................2836 Lafayette av.
Jester, E. T..........................c/o Liggett & Myers Co.
Jewett, Eliot C.......................Monterey, Mex.
Johnson, Professor J. B...............Washington University.
Johnson, Dr. J. B.....................4244 Washington boul.
Johnson, R. DeO.......................Flat River, Mo.

Keyes, Charles R......................944 Fifth st., Des Moines, Ia.
Kinealy, J. H.........................Washington University.
King, Goodman.........................78 Vandeventer pl.
Kinner, Hugo..........................1103 Rutger st.
Kinsley, Carl.........................Washington University.
Kinsman, G. C.........................Decatur, Ill.
Kolbenheyer, F........................2006 Lafayette av.
Kotany, L.............................411 Olive st.
Krall, George W.......................Manual Training School.
Kribben, B. D.........................701 Bank of Commerce bldg.
Kromrey, Hugo.........................513 Walnut st.

Lackland, R. J........................1623 Lucas pl.
Lazell, E. W..........................c/o Bell Telephone Co.
Leighton, George B....................803 N. Garrison av.
Leighton, George E....................803 N. Garrison av.
Lemoine, E. S.........................1622 Washington av.
Letterman, George W...................Allenton, Mo.

Mack, Charles J........................113 N. Broadway.
Madill, George A......................4140 Lindell boul.
Mallinckrodt, Edward................26 Vandeventer pl.
Markham, George D................. Colonial bldg.
Marx, Ella..................................3332 Morgan st.
Meier, Frederick..........................2340 Whittemore pl.
Meisenbach, A. H.......................2229 S. Broadway.
Miller, Charles F........................1751 Missouri av.
Moore, Robert...........................61 Vandeventer pl.
Morton, I. W......... ....9th and Spruce sts.
Mudd, Henry H..........................2604 Locust st.

Nagel, Charles............................2044 Lafayette av.
Nelson, N. O..............................8th and St. Charles sts.
Neville, J. E...............................3960 Delmar boul.
Nipher, Francis E.......................Washington University.

Olshausen, E. P..........................1115 Rutger st.
Olshausen, George R..................13 Artillerie st., Berlin, Germany
O'Reilly, A. J.............................33 City Hall.
O'Reilly, Robert J......................3411 Pine st.

Pammel, L. H.............................Ames, Ia.
Parsons, Charles.........................2804 Pine st.
Pegram, George H.......................Chief Engineer, U. P. Ry., Omaha, Neb.
Pell, Alexander........... ....1023 Park av.
Pettus, W. H. H.........................2834 Chestnut st.
Pickard, John..............................Columbia, Mo.
Pike, S. B...................................Amer. Central bldg.
Post, M. Hayward...... ....3015 Lucas av.
Potter, William B........................3312 Washington av.
Preetorius, Emil ....c/o Westliche Post.
Prewitt, T. F...............................3101 Pine st.
Pritchett, Henry S.......................Supt. U. S. Coast Survey, Washington, D. C.
Pulsifer, William H........ ....Newton Centre, Mass.

Ramel, A.....................................Washington University.
Ravold, Amand............................2806 Morgan st.
Robert, E. S................................Union Trust bldg.
Robertson, Charles......................Carlinville, Ill.
Rolfs, P. H..................................Lake City, Fla.

Runge, Edward C......................Supt. Insane Asylum.
Russell, Colton..........................4652 Wagoner pl.

Sander, Enno............................129 S. 11th st.
Sanger, Charles R......................Washington University
Schmalz, Leopold ....2824 Shenandoah av.
Schneck, Jacob ....Mt. Carmel, Ill.
Schwarz, Henry..........................1723 Chouteau av.
Schweitzer, P............................Columbia, Mo.
Scott, Henry C...........................64 Vandeventer pl.
Seddon, James A........................1516 Lucas pl.
Seever, William J ....1600 Lucas pl.
Senseney, E. M..........................2829 Washington av.
Sheldon, W. L............................4200 Morgan st.
Shepley, John F ....60 Vandeventer pl.
Simmons, E. C............................9th and Spruce sts.
Simmons, W. D...........................Simmons Hardware Co.
Sluder, Greenfield... ....2647 Washington av.
Smith, D. S. H...........................3646 Washington boul.
Smith, Holmes ....Washington University.
Smith, Irwin Z............................87 Vandeventer pl.
Smith, Jared G ....Dept. Agriculture, Washington, D. C.
Spencer, H. N.............................2725 Washington av.
Spiegelhalter, Joseph ....2166 Lafayette av.
Starr, John E..............................32 Pine st., N. Y. City.
Staudinger, B..............................1703 Olive st.
Stedman, J. M.............................Columbia, Mo.
Stevens, Charles D ....1749 S. Grand av.
Stewart, A. K..............................Turner bldg.
Straub, A. W...............................1553 S. Grand av.
Strauss, Julius C.........................3516 Franklin av.

Taussig, Albert E............... .....2647 Washington av.
Taussig, William ....3447 Lafayette av.
Teichmann, William C...............1141 Market st.
Terry, Robert J...........................Mo. Medical College.
Thacher, Arthur........... ....4109 Washington boul.
Timmerman, A. H....... ....Rolla, Mo.
Tittmann, Eugene C...................1811 Kennett pl.
Tivy, W. H.................................215 N. 2d st.
Toensfeldt, J..............................912 S. 9th st.
Trelease, William........................Mo. Botanical Garden.
Turner, John W ....717 N. Garrison av.

Updegraff, Milton......................Columbia, Mo.

Von Schrader, Otto U...............3817 Washington boul.
Von Schrenk, Hermann..............1724 Washington av.

Walsh, Edward, Jr.....................Miss. Glass Co.
Watts, M. F...............................4362 Morgan st.
Wheeler, H. A ....3124 Locust st.
Whitaker, Edwards....................300 N. 4th st.
Whitten, J. C.............................Columbia, Mo.
Whittier, Charles T.....................2727 Olive st.
Winkelmeyer, Christopher..........3540 Chestnut st.
Winslow, Arthur.........................Lyceum bldg., Kansas City, Mo.
Wislizenus, Fred........................1817 Longfellow av.
Witt, Thomas D..........................6th and Olive sts.
Wittenberg, Paul.........................2d and Pine sts.
Woodward, C. M.........................3013 Hawthorne boul.

Yeatman, James E.....................1410 E. Grand av.

EXCHANGES.*

Africa.

MAURITIUS.

Port Louis.

Royal Alfred Observatory.

North America.

CANADA.

Halifax (*Nova Scotia*).

Nova Scotian Institute of Science.

Hamilton (*Ontario*).

Hamilton Association.

Montreal (*Quebec*).

"Canadian Record of Science."

Natural History Society.

Ottawa (*Ontario*).

Geological and Natural History Survey of Canada.

Institut Canadien Français.

Royal Society of Canada.

Quebec (*Quebec*).

Entomological Society of Canada.

Literary and Historical Society of Quebec.

Université Laval.

St. John (*New Brunswick*).

Natural History Society of New Brunswick.

Toronto (*Ontario*).

Astronomical and Physical Society.

Canadian Institute.

Winnipeg (*Manitoba*).

Manitoba Historical and Scientific Society.

COSTA RICA.

San José.

Central Office of Statistics and Meteorology.

Museo Nacional.

* Conformed, as far as practicable, to the International Exchange List of 1897 of the Smithsonian Institution.

GUATEMALA.

Guatemala.

Secretaria de Fomento.

MEXICO.

Mexico.

Ministerio de Fomento, Colonizacion, etc.

Museo Nacional.

Sociedad Cientifica "Antonio Alzate."

Sociedad Mexicana de Geografia y Estadistica.

Sociedad Mexicana de Historia Natural.

Tacubaya.

Observatorio Astronomico Nacional.

SAN SALVADOR.

San Salvador.

Observatorio Meteorológico y Astronómico.

UNITED STATES.

Albany (*N. Y.*).

New York State Library.

New York State Museum of Natural History.

Ann Arbor (*Mich.*).

University of Michigan Library.

Auburn (*Ala.*).

Agricultural Experiment Station.

Austin (*Tex.*).

Geological Survey of Texas.

State Library of Texas.

Texas Academy of Science.

Baltimore (*Md.*).

"American Chemical Journal."

Johns Hopkins University, Biological Library.

Johns Hopkins University Library.

Maryland Academy of Sciences.

Peabody Institute Library.

Baton Rouge (*La.*).

State University Library.

Boston (*Mass.*).

American Academy of Arts and Sciences.

Massachusetts Horticultural Society.

Public Library.

Society of Natural History.

Brooklyn (*N. Y.*).

The Brooklyn Library.

Brookville (*Ind.*).

Society of Natural History.

United States — *Continued.*

Buffalo (*N. Y.*).

Society of Natural Sciences.

Cambridge (*Mass.*).

Entomological Club.

Harvard College Library.

Harvard College Observatory.

Museum of Comparative Zoology.

Peabody Museum of American Archaeology and Ethnology.

Chapel Hill (*N. C.*).

Elisha Mitchell Scientific Society.

Charleston (*S. C.*).

Elliott Society of Science and Art.

Charlotteville (*Va.*).

University of Virginia Library.

Chicago (*Ill.*).

Academy of Sciences.

Field Columbian Museum.

Historical Society.

John Crerar Library.

Public Library.

University of Chicago Library.

Cincinnati (*O.*).

Ohio Mechanics' Institute.

Columbia (*Mo.*).

State University Library.

Davenport (*Ia.*).

Academy of Natural Sciences.

Denver (*Col.*).

Colorado Scientific Society.

Des Moines (*Ia.*).

Iowa Academy of Science.

Golden (*Col.*).

State School of Mines.

Good Hope (*Ill.*).

"American Antiquarian."

Granville (*O.*).

Denison Scientific Association.

Hanover (*N. H.*).

Dartmouth College Library.

Houston (*Tex.*).

State Geological and Scientific Association.

United States — *Continued.*

Ithaca (*N. Y.*).

Cornell University Library.

Jefferson City (*Mo.*).

State Geological Survey.

State Library.

Kansas City (*Mo.*).

Academy of Science.

Knoxville (*Tenn.*).

East Tennessee University Library.

Lawrence (*Kan.*).

Kansas University Library.

Lincoln (*Neb.*).

Nebraska University Library.

Louisville (*Ky.*).

Public Library of Kentucky.

Madison (*Wis.*).

Washburn Observatory.

Wisconsin Academy of Science, Arts and Letters.

Wisconsin Historical Society.

Wisconsin University Library.

Meriden (*Conn.*).

Scientific Association.

Milwaukee (*Wis.*).

Natural History Society of Wisconsin.

Naturhistorischer Verein.

Public Museum.

Minneapolis (*Minn.*).

Geological and Natural History Survey of Minnesota.

Minnesota Academy of Natural Science.

Mount Hamilton (*Cal.*).

Lick Observatory.

New Brighton (*N. Y.*).

Natural Science Association of Staten Island.

New Haven (*Conn.*).

"American Journal of Science."

Connecticut Academy of Science.

Yale University Astronomical Observatory.

Yale University Library.

New York (*N. Y.*).

Academy of Science.

American Geographical Society.

American Museum of Natural History.

UNITED STATES — *Continued.*

New York — *Continued.*

Association of Engineering Societies.
Botanical Garden.
Chemical Society.
Linnaean Society of New York.
Mathematical Society.
Microscopical Society.
Public Library.
Torrey Botanical Club.

Northfield (*Minn.*).

Carleton College Observatory.

Oberlin (*O.*).

Oberlin College Library.

Peoria (*Ill.*).

Scientific Association.

Philadelphia (*Pa.*).

Academy of Natural Science.
American Entomological Society.
American Philosophical Society.
"Journal of Comparative Medicine and Surgery."
"Journal of Pharmacy."
Library Company.
Numismatic and Antiquarian Society.
Pennsylvania Woman's Medical College.
Pharmaceutical Association.
"Polyclinic."
Wagner Free Institute of Science.
Zoological Society.

Portland (*Me.*).

Society of Natural History.

Poughkeepsie (*N. Y.*).

Vassar Brothers Institute.

Princeton (*N. J.*).

Museum of Geology and Archaeology.

Rochester (*N. Y.*).

Academy of Science.
Geological Society of America.

Rolla (*Mo.*).

Missouri School of Mines.

Sacramento (*Cal.*).

State Mining Bureau.

Salem (*Mass.*).

Essex Institute.
Peabody Academy of Science.

United States — *Continued.*

San Diego (*Cal.*).

Society of Natural History.

San Francisco (*Cal.*).

Astronomical Society of the Pacific.

California Academy of Science.

Geographical Society of California.

Technical Society of the Pacific Coast

Santa Barbara (*Cal.*).

Society of Natural History.

Springfield (*Ill.*).

Geological Survey of Illinois.

Springfield (*Mo.*).

Drury College Library.

St. Louis (*Mo.*).

"Journal of Ophthalmology."

Mercantile Library.

Missouri Botanical Garden.

Public Library.

St. Louis University Library.

Washington University Library.

Topeka (*Kas.*).

Kansas Academy of Science.

Trenton (*N. J.*).

Natural History Society.

Urbana (*Ill.*).

State Laboratory of Natural History.

Urbana (*O.*).

Central Ohio Scientific Association.

Washington (*D. C.*).

Philosophical Society.

Smithsonian Institution.

United States Bureau of Education

United States Bureau of Ethnology.

United States Department of Agriculture.

——, Division of Entomology.

——, Weather Bureau.

United States Fish Commission.

United States Geological Survey.

United States Naval Observatory.

United States War Department, — Engineer Department, U. S. A.

Worcester (*Mass.*).

American Antiquarian Society.

Society of Antiquity.

West Indies.

Gordon Town (*Jamaica*).

Public Gardens and Plantations.

Kingston (*Jamaica*).

Institute of Jamaica.

South America.

Argentine Republic.

Buenos Aires.

Museo Nacional de Buenos Aires.

Sociedad Cientifica Argentina.

Statistical Bureau.

Cordoba.

Academia Nacional de Ciencias.

Observatorio Nacional Argentino.

Brazil.

Rio de Janeiro.

Instituto Historico, Geographico y Ethnographico.

Museu Nacional.

Nautical Observatory.

São Paulo.

Commissão Geographica e Geologica.

Chile.

Santiago.

Deutcher Wissenschaftlicher Verein.

Sociedad Cientifica de Chile.

Uruguay.

Montevideo.

Museo Nacional.

Asia.

India.

Bombay.

Natural History Society.

Calcutta.

Asiatic Society of Bengal.

Indian Museum.

Japan.

Tokyo.

Deutsche Gesellschaft für Natur- und Völkerkunde Ost-Asiens.

Imperial University of Japan.

Netherlands Indies.

Batavia (*Java*).

Magnetic and Meteorological Observatory.

STRAITS SETTLEMENTS.

Singapore.

Royal Asiatic Society, — Straits Branch.

Australasia.

NEW SOUTH WALES.

Sydney.

Australian Museum.

Geological Survey of New South Wales,— Department of Mines.

Linnean Society of New South Wales.

Royal Society of New South Wales.

QUEENSLAND.

Brisbane.

Geographical Society of Australasia,— Queensland Branch.

Queensland Museum of Natural History.

SOUTH AUSTRALIA.

Adelaide.

Royal Society of South Australia.

TASMANIA.

Hobarton.

Royal Society of Tasmania.

VICTORIA.

Melbourne.

National Museum of Victoria.

Royal Society of Victoria.

Europe.

AUSTRIA-HUNGARY.

Bistritz (*Transylvania*).

Gewerbeschule.

Brünn (*Moravia*).

K. K. Mährisch Landwirthschafts-Gesellschaft.

Naturforschender Verein.

Budapest (*Hungary*).

"Ethnologische Mittheilungen aus Ungarn."

K. Magyar Természettudományi Társulat.

(*R. Hungarian Society of Natural Sciences.*)

K. Magyar Tudományos Egyetem.

(*R. Hungarian University.*)

K. Ungar. Geologische Anstalt.

Magyar Nemzeti Museum.

(*Hungarian National Museum.*)

Magyar Tudományos Akademia.

(*R. Hungarian Academy of Sciences.*)

Ornithologische Gesellschaft.

AUSTRIA-HUNGARY — *Continued.*

Graz (*Styria*).

Naturwissenschaftlicher Verein für Steiermark.

Steiermärkischer Industrie und Gewerbe Verein.

Hermannstadt (*Transylvania*).

Siebenbürgischer Verein für Naturwissenschaften.

Verein für Siebenburgische Landes-Kunde.

Klagenfurth (*Carinthia*).

Naturhistorisches Landesmuseum für Kärnten.

Klausenburg (*Transylvania*).

Medicinische Naturwissenschaftliche Section des Siebenbürgischen Museum Vereins.

Krakau (*Galicia*).

Académie des Sciences de Cracovie.

Laibach (*Carniola*).

Krainsches Landesmuseum Rudolfinum.

Leipa (*Bohemia*).

Nord-Böhmischer Excursions-Club.

Linz (*Upper Austria*).

Museum Francisco-Carolinum.

Prag (*Bohemia*).

K. Böhmische Gesellschaft der Wissenschaften.

Naturwissenschaftlicher Verein "Lotos."

Pressburg (*Hungary*).

Verein für Naturkunde.

Reichenberg (*Bohemia*).

Verein der Naturfreunde.

Salzburg (*Salzburg*).

Stadtisches Museum Carolino-Augusteum.

Trencsin (*Hungary*).

Naturwissenschaftlicher Verein des Trencsiner Comitates.

Trieste (*Istria*).

Museo Civico di Storia Naturale.

Società Adriatica di Scienze Naturali.

Wien (*Lower Austria*).

Anthropologische Gesellschaft.

Kaiserliche Akademie der Wissenschaften.

K. K. Central-Anstalt für Meteorologie und Erd-Magnetismus.

K. K. Geographische Gesellschaft.

K. K. Geologische Reichsanstalt.

K. K. Naturhistorisches Hof Museum.

K. K. Zoologisch-Botanische Gesellschaft.

Niederoesterreichischer Forst-Verein.

AUSTRIA-HUNGARY — *Continued.*

Wien — *Continued.*

Oesterreichischer Touristen-Club.

Oesterreichischer Reichs-Forst-Verein.

Verein zur Förderung des Landwirthschaftlichen Versuchswesens.

Verein zur Verbreitung Naturwissenschaftlicher Kenntnisse.

BELGIUM.

Anvers [Antwerp].

Académie d'Archéologie de Belgique.

Bruxelles.

Académie Royale des Sciences, des Lettres et des Beaux Arts de Belgique.

Observatoire Royal.

Société Belge de Géographie.

Société Belge de Microscopie.

Société Entomologique de Belgique.

Société Malacologique de Belgique.

Société Royale de Botanique de Belgique.

Société Royale Linnéenne de Bruxelles.

Société Scientifique de Bruxelles.

Société Scientifique Flammarion d'Ixelles.

Liège.

Société Géologique de Belgique.

Louvain.

Université Catholique.

DENMARK.

Kjöbenhavn [Copenhagen].

Kongelige Danske Videnskabernes Selskab.

FRANCE.

Abbeville (*Somme*).

Société d'Emulation.

Alais (*Gard*).

Société Scientifique et Littéraire.

Amiens (*Somme*).

Académie des Sciences, Lettres, et Arts.

Société Linnéenne du Nord de la France.

Angers (*Maine-et-Loire*).

Académie des Sciences et Belles Lettres.

Société des Etudes Scientifiques.

Arras (*Pas-de-Calais*).

Académie des Sciences, Lettres, et Arts.

Autun (*Saône-et-Loire*).

Société d'Histoire Naturelle.

FRANCE — *Continued.*

Auxerre (*Yonne*).

Société des Sciences Historiques et Naturelles.

Avranches (*Manche*).

Société Académique du Cotentin.

Bar-le-Duc (*Meuse*).

Société des Lettres, Sciences et Arts.

Bastia (*Corsica*).

Société des Sciences Historiques et Naturelles de la Corse.

Bayeux (*Calvados*).

Société d'Agriculture, Sciences, Arts et Belles-Lettres.

Bayonne (*Basses-Pyrénées*).

Société des Sciences et Arts.

Besançon (*Doubs*).

Société d'Emulation du Doubs.

Bordeaux (*Gironde*).

Académie Nationale des Belles-Lettres, Sciences et Arts.

Société Linnéenne de Bordeaux.

Société des Sciences Physiques et Naturelles.

Caen (*Calvados*).

Académie Nationale des Sciences, Arts et Belles-Lettres.

Faculté des Sciences de Caen, — Laboratoire de Géologie.

Société Linnéenne de Normandie.

Chalons-Sur-Marne (*Marne*).

Société d'Agriculture, Commerce, Sciences et Arts du Département de la Marne.

Chambéry (*Savoie*).

Académie des Sciences, Belles-Lettres et Arts de Savoie.

Cherbourg (*Manche*).

Société Académique.

Société Nationale des Sciences Naturelles et Mathématiques.

Dijon (*Côte-d'Or*).

Académie des Sciences, Arts et Belles-Lettres.

Draguignan (*Var*).

Société des Etudes Scientifiques et Archéologiques.

Elbeuf (*Seine-Inférieure*).

Société d'Enseignement Mutuel des Sciences Naturelles.

FRANCE — *Continued.*

Epinal (*Vosges*).

Société d'Emulation du Département des Vosges.

Evreux (*Eure*).

Société Libre d'Agriculture, Sciences, Arts et Belles-Lettres du Département de l'Eure.

Grenoble (*Isère*).

Académie Delphinale.

Faculté des Sciences.

Lyon (*Rhône*).

Académie des Sciences, Belles-Lettres et Arts.

Bibliothèque Universitaire.

Société des Sciences Industrielles.

Société Linnéenne de Lyon.

Marseille (*Bouches-du-Rhône*).

Académie des Sciences, Lettres et Arts.

Société Scientifique Industrielle.

Montauban (*Tarn-et-Garonne*).

Académie des Sciences, Belles-Lettres et Arts du Département de Tarn-et-Garonne.

Montpellier (*Hérault*).

Académie des Sciences et Lettres.

Nancy (*Meuthe-et-Moselle*).

Académie de Stanislas.

Société des Sciences.

Nevers (*Nièvre*).

Société Nivernaise des Lettres, Sciences et Arts.

Nice (*Alpes-Maritimes*).

Société des Lettres, Sciences et Arts des Alpes Maritimes.

Niort (*Deux-Sèvres*).

Société de Statistique, Sciences et Arts des Deux-Sèvres.

Paris.

Académie des Sciences.

Association Française pour l'Avancement des Sciences.

Ecole Normale Supérieure.

Ecole Polytechnique.

"Feuille des Jeunes Naturalistes."

Institut National Agronomique.

Institut Pasteur.

Journal de Micrographie.

Musée Guimet.

Muséum d'Histoire Naturelle.

Revue Archéologique.

FRANCE — *Continued.*

Paris — *Continued.*

Revue Géographique Internationale.
Société Académique Indo-Chinoise.
Société d'Anthropologie.
Société de Biologie.
Société Entomologique de France.
Société d'Ethnographie.
Société Zoologique de France.

Pau (*Basses-Pyrénées*).

Société des Sciences, Lettres et Arts.

Perpignan (*Pyrénées-Orientales*).

Société Agricole, Scientifique et Littéraire des Pyrénées-Orientales.

Reims (*Marne*).

Académie Nationale de Reims.
Société des Sciences Naturelles.

Rouen (*Seine-Inférieure*).

Académie des Sciences, Belles-Lettres et Arts.
Société des Amis des Sciences Naturelles.

Saint Brieuc (*Côtes-du-Nord*).

Société d'Emulation des Côtes-du-Nord.

Saint Dié (*Vosges*).

Société Philomathique Vosgienne.

Saint Dizier (*Haute-Marne*).

Société des Lettres, des Sciences, des Arts, de l'Agriculture et de l'Industrie.

Toulouse (*Haute-Garonne*).

Académie des Sciences, Inscriptions et Belles-Lettres.
Association Pyénéenne, et Union des Sociétés Savantes du Midi.
Bibliothèque de la Faculté des Sciences.

Vendôme (*Loir-et-Cher*).

Société Archéologique, Scientifique et Littéraire du Vendômois.

Vitry-le-François (*Marne*).

Société des Sciences et Arts.

GERMANY.

Altenburg (*Saxe-Weimar*).

Naturforschende Gesellschaft des Osterlandes.

Augsburg (*Bavaria*).

Naturwissenschaftlicher Verein für Schwaben und Neuburg.

Bamberg (*Bavaria*).

Naturforschende Gesellschaft.

GERMANY — *Continued.*

Berlin (*Prussia*).

Botanischer Verein der Provinz Brandenburg.

Deutsche Chemische Gesellschaft.

Deutsche Geologische Gesellschaft.

Deutsche Landwirthschaftliche Gesellschaft.

Gesellschaft für Erdkunde.

Gesellschaft Naturforschender Freunde.

Kaiserliches Gesundheits-Amt.

Königlich Preussische Akademie der Wissenschaften.

Verein zur Beförderung des Gartenbaues in den Königlich Preussischen Staaten.

Bonn (*Prussia*).

Naturhistorischer Verein der Preussischen Rheinlande, Westfalens und des Regierungsbezirks Osnabrück.

Braunschweig (*Brunswick*).

Verein für Naturwissenschaften.

Bremen.

Geographische Gesellschaft.

Naturwissenschaftlicher Verein.

Breslau (*Silesia*).

Schlesische Gesellschaft für Vaterländische Cultur.

Chemnitz (*Saxony*).

Naturwissenschaftliche Gesellschaft.

Danzig (*Prussia*).

Naturforschende Gesellschaft.

Darmstadt (*Hesse*).

Verein für Erdkunde.

Dresden (*Saxony*).

Gesellschaft für Natur- und Heilkunde.

Königliches Zoologisches und Anthropologisch-Ethnographisches Museum.

Naturwissenschaftliche Gesellschaft "Isis."

Verein für Erdkunde.

Dürkheim (*Bavaria*).

Naturwissenschaftlicher Verein "Pollichia."

Elberfeld (*Prussia*).

Naturwissenschaftlicher Verein von Elberfeld und Barmen.

Emden (*Prussia*).

Naturforschende Gesellschaft.

Erfurt (*Prussia*).

Akademie Gemeinnütziger Wissenschaften.

GERMANY — *Continued.*

Frankfurt-am-Main (*Prussia*).

Physikalischer und Aerzlicher Verein.

Senckenbergische Naturforschende Gesellschaft.

Verein für Geographie und Statistik.

Frankfurt-an-der-Oder (*Prussia*).

Naturwissenschaftlicher Verein des Regierungsbezirkes.

Freiburg-im-Breisgau (*Baden*).

Naturforschende Gesellschaft.

Giessen (*Hesse*).

Oberhessische Gesellschaft für Natur- und Heilkunde.

Görlitz (*Prussia*).

Naturforschende Gesellschaft.

Göttingen (*Prussia*).

Königliche Societät der Wissenschaften.

Greifswald (*Prussia*).

Geographische Gesellschaft.

Naturwissenschaftlicher Verein von Neuvorpommern und Rügen.

Halle-an-der-Saale (*Prussia*).

Kaiserliche Leopoldinisch-Carolinische Deutsche Akademie der Naturforscher.

Landwirthschaftliches Institut der Universität.

Naturforschende Gesellschaft.

Verein für Erdkunde.

"Zeitschrift für die Gesammten Naturwissenschaften."

Hamburg.

Naturwissenschaftlicher Verein, Hamburg-Altona.

Hanau (*Hesse*).

Wetterauische Gesellschaft für die Gesammte Naturkunde.

Hannover (*Prussia*).

Naturhistorische Gesellschaft.

Heidelberg (*Baden*).

Naturhistorisch-Medicinischer Verein.

Jena (*Saxe-Weimar*).

Geographische Gesellschaft für Thüringen.

"Jenaische Zeitschrift für Medizin und Naturwissenschaften."

Karlsruhe (*Baden*).

Naturwissenschaftlicher Verein.

Kassel (*Prussia*).

Verein für Naturkunde.

GERMANY — *Continued.*

Kiel (*Prussia*).

Königliche Sternwarte.

Naturwissenschaftlicher Verein für Schleswig-Holstein.

Universitäts Bibliothek.

Königsberg (*Prussia*).

Königliche Physikalisch-Oekonomische Gesellschaft.

Landshut (*Bavaria*).

Botanischer Verein.

Leipzig (*Saxony*).

Dr. Felix Flügel, 39 Sidonien Strasse.

Königlich Sächsische Gesellschaft der Naturwissenschaften.

Naturforschende Gesellschaft.

Verein für Erdkunde.

"Zoologischer Anzeiger."

Lüneburg (*Prussia*).

Naturwissenschaftlicher Verein.

Magdeburg (*Prussia*).

Naturwissenschaftlicher Verein.

Mannheim (*Baden*).

Verein für Naturkunde.

Marburg (*Prussia*).

Gesellschaft zur Beförderung der Gesammten Naturwissenschaften.

Metz (*Lorraine*).

Académie de Metz.

Société d' Histoire Naturelle.

Verein für Erdkunde.

München (*Bavaria*).

Deutscher und Oesterreichischer Alpen-Verein,— Section München.

Königlich Bayerische Akademie der Wissenschaften.

Münster (*Westphalia*).

Provinzial-Verein für Wissenschaft und Kunst.

Nürnberg (*Bavaria*).

Naturhistorische Gessellschaft.

Offenbach (*Baden*).

Verein für Naturkunde.

Osnabrück (*Prussia*).

Naturwissenschaftlicher Verein.

Passau (*Bavaria*).

Naturhistorischer Verein.

GERMANY — *Continued.*

Posen (*Prussia*).

Historische Gesellschaft für die Provinz Posen.

Regensburg (*Bavaria*).

Historischer Verein für die Oberpfalz.

Königlich Bayerische Botanische Gesellschaft.

Naturwissenschaftlicher Verein.

Rostock (*Mecklenburg*).

Verein der Freunde der Naturgeschichte in Mecklenburg.

Stettin (*Prussia*).

Entomologischer Verein.

Stuttgart (*Würtemberg*).

Mathematisch-Naturwissenschaftlicher Verein in Würtemberg.

Verein für Vaterländische Naturkunde in Würtemberg.

Thorn (*Prussia*).

Copernicus Verein für Wissenschaft und Kunst.

Wiesbaden (*Prussia*).

Verein für Naturkunde.

Würzburg (*Bavaria*).

Physikalisch-Medizinische Gesellschaft.

GREAT BRITAIN AND IRELAND.

Alnwick (*England*).

Berwickshire Naturalists' Club.

Belfast (*Ireland*).

Naturalists' Field Club.

Bristol (*England*).

Naturalists' Society.

Dublin (*Ireland*).

Royal Dublin Society.

Royal Irish Academy.

Edinburgh (*Scotland*).

Geological Society.

Royal Physical Society.

Royal Scottish Society of Arts.

Royal Society of Edinburgh.

Glasgow (*Scotland*).

Geological Society.

Natural History Society.

Philosophical Society.

Halifax (*England*).

Yorkshire Geological and Polytechnical Society.

Great Britain and Ireland — *Continued.*

Kew (*England*).

Royal Botanic Gardens.

Leeds (*England*).

Philosophical and Literary Society.

Liverpool (*England*).

Biological Society.

London (*England*).

British Museum.

Entomological Society.

" Nature," c/o The Macmillan Co.

Royal Geographical Society.

Royal Microscopical Society.

Royal Society.

Manchester (*England*).

Literary and Philosophical Society.

Microscopical Society.

Newcastle-upon-Tyne (*England*).

Natural History Society of Northumberland, Durham, and Newcastle-upon-Tyne.

York (*England*).

Yorkshire Philosophical Society.

Italy.

Bologna.

Accademia delle Scienze dell' Istituto di Bologna.

Catania.

Accademia Gioenia di Scienze Naturali.

Firenze [Florence].

Biblioteca Nazionale Centrale.

" Nuovo Giornale Botanico Italiano."

R. Accademia Economico-Agraria dei Georgofili.

R. Istituto di Studi Superiori.

Genova [Genoa].

Accademia delle Scienze, Lettere ed Arti.

Museo Civico di Storia Naturale.

Società Ligustica di Scienze Naturali e Geografiche.

Società dei Naturalisti.

Milano [Milan].

Fondazione Scientifica Cagnola.

R. Istituto Lombardo di Scienze e Lettere.

Società Italiana di Scienze Naturali.

Modena.

R. Accademia di Scienze, Lettere ed Arti.

ITALY — *Continued.*

Napoli [Naples].

Accademia Pontaniana.

R. Accademia delle Scienze e Belle Lettere.

R. Accademia delle Scienze Fisiche e Mathematiche.

Società di Naturalisti.

Padova [Padua].

R. Accademia di Scienze, Lettere ed Arti.

Società Veneto-Trentina di Scienze Naturali.

Palermo.

Orto Botanico.

Società d' Acclimazione e di Agricoltura in Sicilia.

Pisa.

Società Toscana di Scienze Naturali.

Roma.

Biblioteca Nazionale Vittorio Emanuele.

Istituto d' Igiene Sperimentale dell' Università.

R. Accademia dei Lincei.

R. Comitato Geologico d' Italia.

R. Stazione Chimico Agraria.

Società Italiana delle Scienze.

Siena.

R. Accademia dei Fisiocritici.

Torino [Turin].

Accademia Reale delle Scienze.

Club Alpino Italiano,— Sezione Torino.

Museo di Zoologia e di Anatomia Comparata della R. Università.

Venezia [Venice].

R. Istituto Veneto di Scienze, Lettere et Arti.

LUXEMBURG.

Luxemburg.

Institut Luxembourgeois,— Section des Sciences Naturelles.

NETHERLANDS.

Amsterdam.

Genootschap ter Bevordering van Natuur- Genees- en Heelkunde.

K. Akademie van Wetenschappen.

K. Nederlandsch Aardrijkskundig Genootschap.

K. Zoologische Genootschap "Natura Artis Magistra."

's Gravenhage [The Hague].

Die Triangulation von Java.

NETHERLANDS — *Continued.*

Haarlem.

Fondation de P. Teyler von der Hulst.

Hollandsche Maatschappij van Wetenschappen.

Leiden.

Nederlandsche Dierkundige Vereeniging.

Rijks Observatorium.

Middelburg.

Zeeuwsch Genootschap van Wetenschappen.

Rotterdam.

Bataafsch Genootschap der Proefondervindelijke Wijsbegeerte.

Utrecht.

K. Nederlandsche Meterologisch Instituut.

Provinciaal Utrechtsch Genootschap van Kunsten en Wetenschappen.

Zwolle.

Overijsselsche Vereeniging tot Ontwikkeling van Provinciaale Welvaart.

NORWAY.

Bergen.

Bergens Museum.

Christiania.

K. Norske Frederiks Universitet.

Trondhjem.

K. Norske Videnskabernes Selskab.

Tromsö.

Tramsö Museum.

PORTUGAL.

Lisbôa [Lisbon].

Academia Real das Sciencias.

Sociedade de Geographia.

Porto [Oporto].

Academia Polytechnica.

ROUMANIA.

Bukarest.

Academia Românǎ.

"Buletinul Societath de Sciinte Fizice."

RUSSIA.

Derpt [Dorpat].

Derptskoie Obshchestvo Iestestvo-Ispytatelei. (*Society of Naturalists.*)

K. Livländische Oekonomische Gesellschaft.

Naturforscher Gesellschaft.

Russia — *Continued.*

Helsingfors.

Sällskap pro Fauna et Flora Fennica.

Kazan.

Imp. Kazanskii Universitet.

Kief.

Kiefskoie Obshchestvo Iestestvo-Ispytatelei.
(*Society of Naturalists.*)

Moskva [Moscow].

Imp. Moskofskoie Obshchestvo Iestestvo-Ispytatelei.
(*Society of Naturalists.*)

Meteorological Observatory of the Agricultural Academy.

Odessa.

Novo-Rossiiskoie Obshchestvo Iestestvo-Ispytatelei.
(*Society of Naturalists.*)

Riga.

Obschestvo Iestestvo-Ispytatelei.
(*Society of Naturalists.*)

Sankt-Peterburg [St. Petersburg].

Imp. Akademia Nauk.
(*Academy of Sciences.*)

Imp. Biblioteka.

Imp. Russkoie Geograficheskoie Obshchestvo.
(*Geographical Society.*)

Imp. Sankt-Peterburgskii Botanicheskii Sad.
(*Botanical Garden.*)

Imp. Sankt-Peterburgskoie Mineralogicheskoic Obshchestvo.
(*Mineralogical Society.*)

Institut Impérial de Médecine Expérimentale.

Tiflis.

Magnitnaia i Meteorologicheskaia Observatoria.
(*Magnetic and Meteorological Observatory.*)

Spain.

Barcelona.

Academia de Ciencias, Artes, y Oficios para la Mujer.

Córdoba.

Academia Nacional de Ciencias Exactas.

Madrid.

Observatorio de Madrid.

R. Academia de Ciencias Exactas, Fisicas y Naturales.

Sociedad Española de Historia Natural.

SWEDEN.
Lund.
K. Universitet.
Stockholm.
Biologiska Förening.
" Entomologiska Tidsskrift."
K. Svenska Vetenskaps Akademie.
National Historical Museum.
Upsala.
K. Vetenskaps Societet.
SWITZERLAND.
Aarau.
Aargauische Naturforschende Gesellschaft.
Mittelschweizerische Geographisch-Commercielle Gesellschaft.
Basel.
Naturforschende Gesellschaft.
Bern.
Naturforschende Gesellschaft.
Schweizerische Naturforschende Gesellschaft.
Chur.
Naturforschende Gesellschaft Graubündens.
Frauenfeld.
Thurgauische Naturforschende Gesellschaft.
Fribourg.
Société Fribourgeoise des Sciences Naturelles.
Genève.
Institut National Genevois.
Société de Physique et d' Histoire Naturelle.
Lausanne.
Bibliothèque Cantonale et Universitaire.
Musée d' Histoire Naturelle.
Société Vaudoise des Sciences Naturelles.
Neuchâtel.
Société des Sciences Naturelles.
St. Gall.
Naturwissenschaftliche Gesellschaft.
Zürich.
Eidgenossensche Polytechnische Schule
Naturforschende Gesellschaft.
Schweizer Alpen-Club.
Schweizerischer Forst-Verein.

THE ACADEMY OF SCIENCE OF ST. LOUIS.

ORGANIZATION.

The Academy of Science of St. Louis was organized on the 10th of March, 1856, in the hall of the Board of Public Schools. Dr. George Engelmann was the first president.

CHARTER.

On the 17th of January following, a charter incorporating the Academy was signed and approved, and this was accepted by vote of the Academy on the 9th of February, 1857.

OBJECTS.

The act of incorporation declares the object of the Academy to be the advancement of science and the establishment in St. Louis of a museum and library for the illustration and study of its various branches, and provides that the members shall acquire no individual property in the real estate, cabinets, library, or other of its effects, their interest being usufructuary merely.

The Constitution, as adopted at the organization meeting and amended at various times subsequently, provides for holding meetings for the consideration and discussion of scientific subjects; taking measures to procure original papers upon such subjects; the publication of transactions; the establishment and maintenance of a cabinet of objects illustrative of the several departments of science, and a library of works relating to the same; and the establishment of relations with other scientific institutions. To encourage and promote special investigation in any branch of science, the formation of special sections under the charter is provided for.

MEMBERSHIP.

Members are classified as active members, corresponding members, honorary members, and patrons. Active membership is limited to persons interested in science, though they need not of necessity be engaged in scientific work, and they alone conduct the affairs of the Academy, under its Constitution. Persons not living in the city or county of St. Louis, who are disposed to further the objects of the Academy by original researches, contributions of specimens, or otherwise, are eligible as corresponding members. Persons not living in the city or county of St. Louis are eligible as honorary members by virtue of their attainments in science. Any person conveying to the Academy the sum of one thousand dollars or its equivalent becomes eligible as a patron.

Under the By-Laws, resident active members pay an initiation fee of five dollars and annual dues of six dollars. Non-resident active members pay the same initiation fee, but annual dues of three dollars only. Patrons, and honorary and corresponding members, are exempt from the payment of dues. Patrons and all active members not in arrears are entitled to one copy of each publication of the Academy issued after their election.

Since the organization of the Academy, 759 persons have been elected to membership, of whom, at the present time, 202 are carried on the active list. One person, Mr. Edwin Harrison, has been elected a patron. The present list of corresponding members includes 204 names.

OFFICERS AND MANAGEMENT.

The officers, who are chosen from the active members, consist of a President, two Vice-Presidents, Recording and Corresponding Secretaries, Treasurer, Librarian, three Curators, and two Directors. The general business management of the Academy is vested in a Council composed of the President, the two Vice-Presidents, the Recording Secretary, the Treasurer and the two Directors.

The office of President has been filled by the following well-known citizens of St. Louis, nearly all of whom have been eminent in some line of scientific work: George Engelmann, Benjamin F. Shumard, Adolphus Wislizenus, Hiram A. Prout, Dr. John B. Johnson, James B. Eads, William T.

Harris, Charles V. Riley, Francis E. Nipher, Henry S. Pritchett, John Green, and Melvin L. Gray.

MEETINGS.

The regular meetings of the Academy are held at its rooms, 1600 Lucas Place, at 8 o'clock, on the first and third Monday evenings of each month, a recess being taken from the second June meeting to the first October meeting, inclusive. These meetings, to which interested persons are always welcome, are devoted in part to the reading of technical papers designed for publication in the Academy's Transactions, and in part to the presentation of more popular abstracts of recent investigation or progress. From time to time, public lectures calculated to interest a larger audience, are provided for in some suitable hall.

LIBRARY.

After its organization, the Academy met in Pope's Medical College, where a creditable beginning had been made toward the formation of a museum and library, until May, 1869, when the building and museum were destroyed by fire, the library being saved. The library now contains some 12,500 books and 8,500 pamphlets, and is open during certain hours of the day for consultation by members and persons engaged in scientific work.

PUBLICATIONS AND EXCHANGES.

Seven octavo volumes of Transactions, averaging 725 pages, have been published since the organization of the Academy, and widely distributed. Two quarto publications have also been issued, one from the Archaeological section, being a contribution to the archaeology of Missouri, and the other a report of the observations made by the Washington University Eclipse Party of 1889. The Academy now stands in exchange relations with 550 institutions or organizations of aims similar to its own.

MUSEUM.

Since the loss of its first museum, in 1869, the Academy has lacked adequate room for the arrangement of a public museum, and, although small museum accessions have been received and cared for, its main effort of necessity has been concentrated on the holding of meetings, the formation of a library, the publication of worthy scientific matter, and the maintenance of relations with other scientific bodies, through its active membership, which includes many business and professional men who are interested in the work and objects of the Academy, although not themselves investigators.

December 31, 1897.

RECORD

From July 1, 1894, to December 31, 1897.

October 15, 1894.

Vice-President Gray in the chair, fifty-two persons present.

The Corresponding Secretary reported on a very interesting meeting of the Royal Society at Oxford, which he attended as a delegate of the Academy.

Professor William Trelease gave an informal account of a recent visit to the Azores, describing briefly the customs of the people, and the natural history and especially the botany of the islands.

Mr. E. T. Olshausen, of St. Louis, was elected an active member.

One person was proposed for active membership.

November 5, 1894.

Vice-President Gray in the chair, thirty-two persons present.

Mr. Allerton S. Cushman gave an account of his recent visit to the laboratory of Professor Dewar, of the Royal Institution, describing Professor Dewar's experiments in his search for the absolute zero of temperature, and the process by which he has succeeded in liquefying and even solidifying air.

Professor H. A. Wheeler exhibited a specimen of lignite obtained from excavations in Baden (in the northern suburbs of St. Louis), the cracks of which were filled with sulphide of zinc, which was held to corroborate the theory that decomposing organic matter produces the precipitate.

Mr. E. H. Semple, of St. Louis, was elected an active member.

Three persons were proposed for active membership.

NOVEMBER 19, 1894.

Vice-President Baumgarten in the chair, thirty-one persons present.

Professor Otto Heller read an interesting paper entitled Words and their growth. Apropos of the paper, Dr. Kinner offered an explanation of the myth of the Phoenix, which he connected with the transits of Mercury.

The following persons, resident in St. Louis, were elected active members: — H. C. Frankenfield, John R. Fordyce, John J. Taussig.

DECEMBER 3, 1894.

Vice-President Gray in the chair, eighteen persons present.

Mr. Arthur Winslow read a paper on the geologic history of Missouri.

Mr. Frank Leverett made a few remarks on glacial drift, speaking of two invasions of the ice, one from the northwest, in the direction of Manitoba, and the other from Labrador, in the northeast. The question was raised as to any evidence of the northeastern glaciation having crossed the Mississippi river into St. Louis county.

Mr. Robert Moore, Dr. E. Evers and Professor H. A. Wheeler, were elected a committee for the nomination of officers for the year 1895.

One person was proposed for active membership.

DECEMBER 17, 1894.

Vice-President Gray in the chair, twenty-five persons present.

The nominating committee reported the following nominations for officers for the year 1895:—

President	John Green.
First Vice-President	M. L. Gray.
Second Vice-President	William Trelease.
Recording Secretary	A. W. Douglas.
Corresponding Secretary	E. C. Runge.
Treasurer	Enno Sander.
Librarian	G. Hambach.

Curators	Arthur Winslow,
	Julius Hurter,
	G. Hambach.
Directors	E. A. Engler,
	H. W. Eliot.

The following additional nominations were made from the floor: —

Corresponding Secretary	A. S. Cushman.
Director	Robert Moore.
Curator	H. A. Wheeler.

Professor J. H. Kinealy presented some notes on the ventilation of rooms, illustrating by experiments one of the tests for the presence of carbon dioxide in the atmosphere of an apartment, this being taken as an index of the degree of contamination by respiration. In the discussion of the paper, the point was made that chemically pure carbon dioxide is not of itself harmful, save in unduly large proportions.

Dr. Elisha H. Gregory, Jr., of St. Louis, was elected an active member.

One person was proposed for active membership.

January 7, 1895.

Vice-President Gray in the chair, thirty-seven persons present.

The Treasurer's report, an abstract of which follows, was submitted, and, after having been audited by a committee appointed for that purpose, was approved.

RECEIPTS.

Balance from 1893	$ 709 19	
Sundry collections	11 47	
Interest on invested money	360 00	
Membership dues	1,155 00	$2,235 66

EXPENDITURES.

Rent	$500 00	
Moving library, etc	337 05	
Current expenses	354 56	
Publication of Transactions	847 30	2,038 91
Balance to 1895		$196 75

The Corresponding Secretary reported, and, in commenting on recent literature, read extracts from the publications of Lord Kelvin, President of the Royal Society, and Dr. Armstrong, President of the Chemical Society of London, regarding the discovery of a new constituent of the atmosphere.

The Librarian reported that during 1894 exchanges had been received from 187 foreign and 62 American societies, of which 20 had this year been added to the exchange list. In all, 1,132 numbers were reported as having been added to the library, an increase of 451 over the preceding year. It was reported that during the year the Transactions of the Academy had been distributed to 542 societies or institutions, chiefly by exchange or donation.

Professor F. E. Nipher read a paper on the electrical capacity of bodies and the energy of an electrical charge.

The nominating committee reported that 123 ballots had been counted, and the following officers for 1895 were declared elected:—

President	John Green.
First Vice-President	M. L. Gray.
Second Vice-President	William Trelease.
Recording Secretary	A. W. Douglas.
Corresponding Secretary	A. S. Cushman.
Treasurer	Enno Sander.
Librarian	G. Hambach.
Curators	G. Hambach, H. A. Wheeler, Arthur Winslow.
Directors	E. A. Engler, Robert Moore.

On taking the chair, Dr. Green made a short address, appropriate to the occasion.

Dr. Arthur E. Ewing, of St. Louis, was elected an active member.

JANUARY 21, 1895.

President Green in the chair, twenty-eight persons present.

Dr. H. C. Frankenfield spoke of weather forecasts, describing the causes of atmospheric disturbances and enumerating the general principles governing the United States Weather Bureau in forecasting changes of the weather.

The President briefly outlined the present status of the Academy, as regards finance, membership and aims, and urged the desirability of taking such steps as would increase its sphere of usefulness.

February 4, 1895.

President Green in the chair, ten persons present.

Professor J. H. Kinealy gave the results of a series of experiments made by him to determine the volume of air passing through a heating register in a given time, showing that the average velocity of the air, as indicated by an anemometer, multiplied into eighty-five per cent. of the total area, gave a mean approximation to the volume of air passing.

Professor Engler gave an illustration of a new method of summing series of numbers consisting of two factors.

Four persons were proposed for active membership.

February 18, 1895.

President Green in the chair, forty-four persons present.

Dr. E. C. Runge read a paper on the birth and growth of scientific medicine,— a historical sketch, with special reference to our present notions on immunity.

Professor Angelo Heilprin spoke briefly on glacial phenomena in Greenland, stating that his experience led him to believe that the phenomena presented by these glaciers and the mountain or alpine type are identical, although the belief is prevalent among geologists that the glaciers of the Ice Age were of a different type from the alpine glaciers of the present time. He further stated his belief that the erosive action of glaciers has materially modified the configuration of Greenland.

The following persons, resident in St. Louis, were elected active members:— H. C. Scott, Paul Wittenberg, H. N. Davis, W. D. Simmons.

March 4, 1895.

President Green in the chair, fifty-five persons present.

In exhibiting a photograph of the late Professor Helmholtz, presented to the Academy by Professor Pritchett, the President briefly reviewed the life and labors of Helmholtz, noting especially his great work on physiological optics and his invention of the ophthalmoscope. Professor Nipher also spoke of the researches of Helmholtz in the domain of physics.

Professor C. R. Sanger delivered an address on argon, reviewing the history of atmospheric study from the time of Cavendish, in the last century.

Three persons were proposed for active membership.

March 18, 1895.

President Green in the chair, eight persons present.

The following persons, resident in St. Louis, were elected active members: — John Alden, Wm. C. Teichmann, Philip Gruner.

One person was proposed for active membership.

April 1, 1895.

President Green in the chair, eight persons present.

One person was proposed for active membership.

April 15, 1895.

President Green in the chair, twenty-nine persons present.

Miss Mary E. Murtfeldt read a paper on the habits of certain seed-feeding insects, giving the results of her observations and experiments on insects which feed on the seeds of weeds and other injurious plants. The conclusion was stated that these insects exercise a very pronounced effect in preventing the spread of weeds,—and in some instances almost exterminate them.

The following persons, resident in St. Louis, were elected active members: — Edward Mallinckrodt, Charles Espenschied.

MAY 6, 1895.

President Green in the chair, sixteen persons present.

Professor J. H. Kinealy gave the results of some tests of ventilation made for the Board of Public Schools, which showed great lack of uniformity in the ventilation of the various schoolrooms and demonstrated the presence of an undue amount of carbon dioxide in the air of these rooms.

MAY 20, 1895.

President Green in the chair, eleven persons present.

The Corresponding Secretary reported on a recent experiment by Professor Ramsay, who, in boiling a rare mineral, cleveite, with dilute sulphuric acid, obtained a gas which showed the same spectrum as the helium line in the solar spectrum.

Dr. John Green read a note on the variation in the power and in the astigmatism of thin spherical, toric and cylindrical lenses, in principal cases of oblique centrical refraction through the lens; this was followed by a general discussion of the nature and correction of astigmatism in the eye.

JUNE 17, 1895.

President Green in the chair, twenty-five persons present.

Professor C. R. Sanger discussed the chemistry of photography, with respect to the formation and development of the latent image, the fixation of the developed image, and the printing and toning of the positive.

The following persons, resident in St. Louis, were elected active members:— Christoph. Winkelmeyer, Rudolph Hartmann.

OCTOBER 21, 1895.

President Green in the chair, nineteen persons present.

Professor Trelease read a paper by L. H. and Emma Pammel, on the gases produced by certain bacteria.

The President announced the death of Professor C. V.

Riley, and on motion Professor Nipher was appointed as a committee to prepare a suitable memorial of Professor Riley.

One person was proposed for active membership.

November 4, 1895.

President Green in the chair, thirty-three persons present.

Professor F. E. Nipher read the following memorial of the late Professor C. V. Riley:—

To the President and Members of the Academy of Science of St. Louis:

Gentlemen: At your request I have tried to give some account of the work which our lately deceased associate Charles V. Riley did while actively engaged among us.

I can give only the impressions of one unfamiliar with the details of his work. It was, however, evident to anyone who knew him twenty years ago, that he was a man of great ability, full of energy and of enthusiasm for his work, and ambitious to accomplish great things in his chosen field.

His connection with the Academy began April 20, 1868, soon after he had been made State Entomologist of Missouri. On January 16, 1871, he was elected Recording Secretary, a position which he held until January 3, 1876, when he became President of the Academy. He served as President until January 7, 1878. At about this time he removed to Washington, and became connected with the Department of Agriculture.

The first paper presented by him for publication in the Transactions of the Academy was read September 2, 1872. It marked the beginning of his work on the fertilization of the *Yucca*. Dr. Engelmann had drawn attention to the fact that the plants of this genus must rely upon insect agency for fertilization, and Riley at once took up the study of this subject. The results were perhaps the most interesting of any reached by him, and attracted world-wide attention among botanists and entomologists. Volumes III. and IV. of our Transactions contain in all seventeen papers written by Riley, while actively at work among us. All of this material is also to be found either in the form of reprints or rewritten in connection with other matter, in the nine annual reports which as State Entomologist he made to the State Board of Agriculture.

Riley undoubtedly accomplished his greatest work in the field of economic entomology. His reports are full of information of value to the farmer and the horticulturist. He always sought to impress upon the people of our State the importance of distinguishing friends from enemies in the insect world, and his continued aim was to show the farmer how he might take an active and effective part in the war of extermination, the results of which should determine whether the farmer should lose or save the fruits of his labor. He thought it proper that the Governor should appoint a day of fasting and prayer during the great locust invasion, but he was emphatic in recommending the value of a ditch two feet wide and two feet deep as an effective auxiliary measure. It is difficult to exaggerate the educational value to a State of an active student such as Riley was, devoting his entire time to such work as is represented in the nine annual reports which he made to the State Board of Agriculture.

He enlisted everyone whose interest could be aroused. He made them his correspondents and taught them to collect the information he sought. He taught many a farmer's boy to appreciate the advantage of country surroundings in the study of Nature. It was to many the discovery of a new world. When we reflect that men who have been raised on farms have done most of the great things that have been done in this country, the educational value of Riley's work becomes apparent.

The money value of the service he rendered during the great locust invasion probably exceeded manyfold the entire cost of his service during nine years. Many who were about to abandon their farms in despair were by him encouraged to believe, what the subsequent results verified, that the damage, although seemingly overwhelming, was in fact only temporary, that late crops could be raised after the scourge had departed for the year, and that the enormous multiplication of insect enemies would destroy the plague in a few years. But there were many well-meaning men in political life at that time, whose names I do not now remember, who were anxious to do something effective, and who convinced themselves that such work was not of sufficient value to justify the expense, and the work was stopped.

Professor Riley was too serious in his address and manners to win many warm and cordial friends. He could never forget his work. He talked with men with a view of obtaining their co-operation and assistance in advancing the interests which were placed in his keeping. But we all learned to admire and respect his personal worth and his great ability. For many years the work of the Academy was largely the work of Riley and Engelmann. It is very fitting, therefore, that we should thus record our high appreciation of the service he has rendered to our Academy and to the State.

Professor H. S. Pritchett presented a resumé of certain studies of the satellite system of Saturn, calling attention to the remarkable similarity between this system and the solar system, and mentioning the frequent eclipses to which the satellites of Saturn are subjected. An interesting exposition was given of the effect of the attraction of the large satellite Titan upon the smaller one Hyperion, resulting in great eccentricity of the orbit of the latter. Mention was also made of the phenomenon of greater brightness of one side of the satellite Iapetus, and of the coincidence of the revolution of this satellite on its axis with its revolution around the planet.

Professor Nipher presented a paper on the law of minimum deviation of light by a prism.

Mr. Carl Kinsley, of St. Louis, was elected an active member.

Two persons were proposed for active membership.

NOVEMBER 18, 1895.

President Green in the chair, twenty-two persons present.

Dr. N. M. Glatfelter read a paper on the relations of *Salix Missouriensis* to *S. cordata.*

Mr. F. W. Duenckel presented a model of a meteorological instrument invented by Mr. Leonard Hunt and himself, called "the electric sunshine annunciator," briefly explaining its mode of operation in accurately recording the amount of sunshine each day.

The following persons, resident in St. Louis, were elected active members: — Frank B. Gallivan, H. von Schrenk.

One person was proposed for active membership.

DECEMBER 2, 1895.

President Green in the chair, twenty-three persons present.

Dr. H. C. Frankenfield presented a communication on hot and cold waves, and on the deficit in rainfall during the past three years. He spoke of hot waves as being due to low pressure areas first appearing in the Northwest and moving east and south, causing warm winds from the South, and disappearing on the development of high areas in the Northwest. The accompanying phenomenon of hot winds in the Southwest and West, moving, as a rule, in narrow belts, from one hundred feet to half a mile in width, was discussed, and the statement made that their cause and limitation were somewhat obscure, but that they were evidently of dynamic origin. With respect to cold waves, it was stated that, as a rule, a low area is followed by a high one, bringing a cold wave with it, but that this is not invariable, a cold wave occasionally not following a low area, and sometimes not attending a high one. The theories as to the source of the cold air were considered, and it was also stated that the most severe cold waves are those in which the preceding low area extends in a long and narrow trough-shaped depression from the northeast to the southwest. In the discussion of droughts, the phenomena were regarded as purely those of the distribution of rainfall, which might reach the normal amount during a year, although attended by a severe drought at certain seasons, the rainfall being excessive in some months and deficient in others.

Mr. A. S. Cushman spoke informally on the present state of our knowledge of helium, stating that it has been definitely proved that this is not a simple element, but in all probability a composition of two or more elementary gases.

Professors M. S. Snow, H. S. Pritchett and F. E. Nipher were elected a committee to nominate officers for the year 1896.

December 16, 1895.

President Green in the chair, twenty-eight persons present.

The committee elected to nominate officers for the ensuing year reported the following nominations:—

President	M. L. Gray.
First Vice-President	E. A. Engler.
Second Vice-President	Robert Moore.
Recording Secretary	William Trelease.
Corresponding Secretary	A. S. Cushman.
Treasurer	Enno Sander.
Librarian	G. Hambach.
Curators	Julius Hurter,
	H. A. Wheeler,
	George R. Olshausen.
Directors	John Green,
	Adolph Herthel.

Professor J. H. Kinealy exhibited a new instrument of his device, for testing the purity of air in buildings, and explained the method of using it.

Dr. Chas. R. Keyes, of Jefferson City, Missouri, was elected an active member.

Two persons were proposed for active membership.

January 6, 1896.

President Green in the chair, eighteen persons present.

The Treasurer's report, an abstract of which follows, was submitted, and, after having been audited by a committee appointed for that purpose, was approved.

RECEIPTS.

Balance from 1894	$ 196 75	
Interest on invested money	300 00	
Membership dues	1,132 00	$1,628 75

EXPENDITURES.

Rent	$ 500 00	
Insurance	100 00	
Library	36 62	
Publication of Transactions, and notices of meetings	543 70	
Sundries	65	$1,180 97
Balance to 1896		$ 447 78

The Librarian reported that during 1895 exchanges had been received from 239 societies, of which eleven had this year been added to the exchange list. In all, 701 numbers were reported as having been added to the library, a decrease of 431 from the preceding year. It was reported that during the year the Transactions of the Academy had been distributed to 551 societies or institutions.

The retiring President made a brief address, touching on the needs and prospects of the Academy.

The nominating committee reported that 112 ballots had been counted, and the following officers for 1896 were declared elected: —

President	M. L. Gray.
First Vice-President	E. A. Engler.
Second Vice-President	Robert Moore.
Recording Secretary	William Trelease.
Corresponding Secretary	A. S. Cushman.
Treasurer	Euno Sander.
Librarian	G. Hambach.
Curators	G. R. Olshausen, H. A. Wheeler, Julius Hurter.
Directors	A. Herthel, John Green.

On assuming the chair, President Gray made a short address, thanking the members of the Academy for his election and expressing his wish to serve the Academy at all times, to the best of his ability.

Professor C. R. Sanger made brief mention of the methods used in the determination of atmospheric carbon dioxide.

Professor Engler indicated a simple graphical method of drawing a normal to a parabola from a point outside the curve.

On motion, the Council was requested to arrange for a session of the Academy commemorating the services to science of Dana, Helmholtz, Huxley and Pasteur, all of whom had passed away during the past year.

Mr. Charles Espenschied exhibited several samples of sisal hemp fiber obtained by him in the island of Nassau, and explained the method of preparing the fiber. The bearing life of each plant was stated to be about six years, after which it flowers and dies. He also exhibited a sample of cordage in several stages of preparation, a hand-braided sieve, a braided whip-lash, and a plaited fruit basket, made from palm fiber in the West Indies. A coil of chew-stick (*Gouania Domingensis?*), a saponifying fiber used for cleansing the teeth in Nassau, was exhibited, and also a walking stick made from the arborescent *Opuntia* of New Mexico. The specimens were given to the Academy.

The following persons, resident in St. Louis, were elected active members:— Dr. Sidney P. Budgett, Dr. George W. Cale, Jr.

JANUARY 20, 1896.

President Gray in the chair, twenty-two persons present.

Mr. C. H. Thompson exhibited specimens of two minute aquatics rare in the United States,— *Wolffia gladiata*, var. *Floridana*, and *W. lingulata*, both belonging to the subgenus *Wolffiella*,— and presented the principal results of some recent studies which he had made on them. For purposes of comparison, other Lemnaceae of the United States were exhibited in a living condition.

Professor E. A. Engler, in continuation of his remarks at the last meeting, spoke of certain properties of the parabola, from which conclusions were drawn as to the number of normals which can be drawn through any given point.

Dr. A. C. Bernays exhibited under the microscope a specimen of the epidermis of *Fritillaria*, showing unusually large and beautiful karyokinetic figures.

February 3, 1896.

President Gray in the chair, twenty-two persons present.

Professor William Trelease exhibited several specimens of a curious silk tapestry which had been received in 1894 and 1895 from Dr. Francis Eschauzier, of San Luis Potosi, Mexico, stating that the larger specimen, nearly three feet square, had been cut from a piece over twenty yards wide and about four times as long, covering the ceiling of a corn-storing loft. These specimens, having much the appearance and feeling of a soft-tanned piece of sheepskin, were composed of fine silk threads crossing at every conceivable angle, and were stated to be evidently the work of lepidopterous larvae which feed upon grain.

One person was proposed for active membership.

February 17, 1896.

President Gray in the chair, seventy-five persons present.

Dr. Adolf Alt spoke of the anatomy of the eye, and by aid of the projecting microscope exhibited a series of axial sections representing the general structure of the eye in thirty-one species of animals, comprising two crustacea, the squid, three fish, two batrachians, two reptiles, ten birds and eleven mammals.

Professor F. E. Nipher gave an account of the Geissler and Crookes tubes and the radiant phenomena exhibited by each when used in connection with a high-tension electrical current of rapid alternation, and detailed the recent discoveries of Professor Röntgen, showing that certain of the rays so generated are capable of affecting the sensitized photographic plate through objects opaque to luminous rays. Attention was also called to the experiments of Hertz and Lodge with discharges of very high tension alternating currents, which showed that by the latter certain invisible rays are produced, which, like the Röntgen rays, are capable of passing through opaque bodies, such as pitch, but differ in their refrangibility by such media, and, so far as present experiments have shown, in their inability to affect the photographic plate during ordinary exposures.

Mr. James Gurney, of St. Louis, was elected an active member.

February 24, 1896.

President Gray in the chair, forty-five persons present.

The President announced that this had been called as a special meeting in commemoration of the services rendered to science by four distinguished men who had died in the past year, men who had contributed greatly to the advancement of knowledge, and who, as it happened, represented four of the great nations of the earth. Addresses on their work were then read, as follows: —

Hermann von Helmholtz, by Professor H. S. Pritchett.

Louis Pasteur, by Dr. A. N. Ravold.

James Dwight Dana, by Mr. Arthur Winslow.

T. H. Huxley, by Dr. S. P. Budgett.

March 2, 1896.

President Gray in the chair, twenty-one persons present.

Mr. F. W. Duenckel presented a comparison of the records of the United States Meteorological Observatory, located at the government building in the city, with the record for the Forest Park Station, showing that the daily minimum averaged decidedly lower at the Forest Park Station than in the city, while the wind averaged decidedly higher at the city station.

Professor E. A. Engler spoke on the summation of certain series of numbers.

March 16, 1896.

Vice-President Engler in the chair, twelve persons present.

Professor William Trelease stated some of the results of a recent study of the poplars of North America, and exhibited specimens of the several recognized species. Specimens were also exhibited of an apparently undescribed poplar from the mountains of northern Mexico, which he proposed to characterize shortly; and, for comparison, specimens of the two other species of poplar known to occur in Mexico, and of the European allies of the supposed new species, were laid before the Academy.

In accordance with a recommendation of the Council, the following resolutions were adopted by the Academy, and a copy thereof ordered transmitted to the secretary of the Joint Commission of the Scientific Societies of Washington:—

Whereas, The work of the Department of Agriculture in the discovery, exploration, development, conservation, and proper utilization of the resources of our country, is of the utmost importance; and whereas the Department's capacity for originating, procuring, and disseminating knowledge of vital importance to farming and other interests, though already large, is capable of much extension in the future; and whereas the results accomplished through the system now in existence have been exceedingly great, and the one thing above all others necessary to increase the efficiency of this organization is a permanent policy with regard to its work and personnel:—

Resolved, That the Academy of Science of St. Louis heartily approves the proposition to create the office of "Director-in-Chief of Scientific Divisions in the Department of Agriculture," to be filled by a broadly educated and experienced scientific administrative officer, holding office during good behavior;

Resolved, That the plan of having a permanent officer in charge of the scientific and technical work, under the executive head of a Department, represents a distinct advance in good government and is therefore not only of national importance, but certain to have a beneficial effect upon the scientific standing of Government work in all its relations.

April 6, 1896.

President Gray in the chair, forty persons present.

Professor C. R. Sanger spoke on the commercial synthesis of acetylene, illustrating the flame procurable from this gas when burned with a proper proportion of air. Professor Sanger further presented the results of a preliminary biological and chemical examination into the ice supply of St. Louis, and exhibited a device for melting ice in such examinations without danger of contamination from atmospheric ammonia, etc.

The Secretary presented a paper by Mr. Charles Robertson, entitled Flowers and insects.

Mr. William H. Roever presented a paper on the geometry of the lines of force from an electrified body.

April 20, 1896.

President Gray in the chair, seventeen persons present.

Professor C. M. Woodward presented the results of a study of certain statistics of school attendance, from which it appeared that the average age of withdrawal from the public schools in three cities compared was as follows: —

Boston 15.8; Chicago, 14.6; St. Louis, 13.7.

Professor J. H. Kinealy exhibited and gave a mathematical discussion of the Stang planimeter.

May 4, 1896.

President Gray in the chair, thirty-five persons present.

Professor F. E. Nipher read a preliminary paper on a rotational motion of the cathode disk of a Crookes tube.

Dr. E. C. Runge gave the history of an interesting case of insanity which had remained undetected for twenty-eight years.

The President announced the death on April 22, 1896, of Dr. C. O. Curtman, and on motion Drs. Evers, Alt and Bremer were appointed a committee to prepare a suitable memorial of Dr. Curtman.

May 18, 1896.

Vice-President Engler in the chair, nineteen persons present.

Professor C. M. Woodward presented a critical examination of some of the mathematical formulae employed by Herbart to represent mental phenomena, in which these formulae were criticised as inadequate. Though not considering any formulae likely to be satisfactory, from the nature of the case, the speaker offered a substitute for the Herbart formulae pertaining to the bringing into consciousness of a sublatent concept through the suggestion of another concept similar in some respects but different in others.

Dr. Amand Ravold reported on the use in St. Louis of diphtheria antitoxine, prepared by the Health Department of the city. During the past winter, 342 cases of diphtheria had been treated with this serum, by ninety-three physicians. Doses of from 2.5 to 100 cc. had been administered. As a rule, the recovery was far slower when the number of units used was small than when a larger quantity was employed. Usually the serum was administered only once. In about half the cases a decided change for the better was noticeable within twenty-four hours, and these cases were practically cured within forty-eight hours, although attention was called to the fact that for some weeks the throat of a convalescent is a breeding-place for the diphtheria bacilli, the virulence of which did not seem to be diminished by the serum treatment. Of the cases reported on, only 9.06 per cent. died, and, as a considerable number of cases were hopeless when treatment was administered, the patients dying within twenty-four hours thereafter, it was considered fair to deduct these deaths from the total, which reduced the mortality to 4.6 per cent. when the serum was administered in the earliest stages of the disease. The injurious consequences of administering the serum were fully considered, but held to be practically insignificant. It was also stated that when used on persons who had been exposed to but had not manifested the disease, the serum proved an unfailing means of conferring immunity for a certain period of time. Among the advantages in the use of this serum was mentioned that of lessening the chances of secondary infection, so frequent after an attack of diphtheria.

On behalf of the committee appointed at the last meeting, Dr. Evers presented the following report, which was ordered spread on the records of the Academy: —

IN MEMORIAM: DR. CHARLES O. CURTMAN.

In the death of Dr. Charles O. Curtman, the Academy of Science of St. Louis has been bereft of one of its illustrious members. He was one of the select few who combined great learning, the faculty of original research and teaching, with a happy, jovial disposition and the modesty of the true scientist. The St. Louis Academy of Science, which has many times had occasion to listen to his brilliant discourses, will find the void in its membership, due to his death, irreparable.

His memory will not only live in the minds of those whose fortune it was to know him personally, and in the archives of the Academy of Science of St. Louis, but it is graven indelibly on the leaves of the eternal book of science. Though dead, he still lives.

One person was proposed for active membership.

June 1, 1896.

President Gray in the chair, eight persons present.

Professor Milton Updegraff read a paper on the flexure of telescopes.

Professor J. M. Stedman, of Columbia, Missouri, was elected an active member.

Three persons were proposed for active membership.

October 19, 1896.

President Gray in the chair, twenty persons present.

The President briefly addressed the members of the Academy, welcoming them after the summer recess.

Professor William Trelease exhibited a Tropical American orchid, *Catasetum Gnomus*, which he had brought from the Botanical Garden, explaining that this genus presents in its flowers one of the most remarkable instances of irritability known in the vegetable kingdom, inasmuch as each of the staminate flowers is provided with two appendages, or tentacles, so placed that an insect, in entering the flower to gnaw the fleshy labellum, must of necessity touch one tentacle or the other, the result of a slight touch on either being propagated through its length to the upper portion of the column, where it induces the rupture of a membrane by which the elastically bowed pollen mass is retained in place, the release being followed by the prompt and forcible propulsion of the pollen mass, the anterior end of which is heavy and very viscid, so that it will adhere to the body of the insect causing the discharge. This action was demonstrated to the Academy by the use of a lead pencil, a slight touch from the point of which on either antenna was promptly followed by the emergence of the pollen mass, which accurately attached itself to the pencil at a distance of about half an inch from its point. Reference was made to the studies of Darwin, Crüger and others on the pollination of this genus, and the three very dissimilar forms under which its flowers occur were mentioned.

Mr. J. B. S. Norton presented a paper embodying the results of a study of the Kansas Ustilagineae, especially with reference to their germination.

The Anti-Vivisection Bill, now pending before the United States Senate, was read in abstract by Mr. H. von Schrenk, and, after a discussion by members of the Academy, on motion the President was requested to appoint a committee of three to prepare resolutions expressing the views of the Academy concerning the bill, for presentation at the next meeting of the Academy. The President appointed as such committee Messrs. Baumgarten, Budgett and von Schrenk.

The following persons, resident in St. Louis, were elected active members: — Frederick W. Frerichs, George P. B. Jackson, Andrew J. O'Reilly.

Three persons were proposed for active membership.

November 2, 1896.

President Gray in the chair, twenty-five persons present.

The Corresponding Secretary having removed from the city, on motion the President was requested to appoint an acting Corresponding Secretary for the remainder of the year. The President appointed Mr. Ernst P. Olshausen.

Mr. Colton Russell spoke of what an entomologist can find of interest about St. Louis, illustrating his remarks by numerous pinned specimens of insects, giving particular attention to the butterflies, and speaking at some length of the phenomena of periodicity, migration, polymorphism, etc., as illustrated by these insects, his paper embodying the result of a large amount of field work performed during the last ten years.

On behalf of the committee appointed at the last meeting, Mr. H. von Schrenk presented the following report, the adoption of which by the Academy was recommended by the committee.

WHEREAS, There is a bill at present before Congress intended to restrict experimentation upon animals; and

WHEREAS, Restrictive legislation is in our opinion unnecessary, and moreover detrimental to the progress of scientific investigation; and

WHEREAS, The provisions of the bill must necessarily operate to altogether suppress scientific investigation by means of experimentation upon animals; and

WHEREAS, Such experimentation has been of great practical value to man and animals, and indispensable to the progress of science; and

WHEREAS, Those engaged in earnest scientific investigation are the least likely to inflict unnecessary pain, and least of all should be subject to the supervision of persons who are not trained in the proper understanding of the problems to be solved; and

WHEREAS, The passing of a bill which gives evidence both of ignorance of the methods pursued in conducting experiments upon animals, and an utter disregard of those sufferings to the alleviation of which such experiments are directed, would be a reproach to a civilized and humane community; therefore, be it: —

Resolved, That the members of the Academy of Science of St. Louis unanimously and earnestly protest against the passage of Senate Bill No. 1552, entitled "A Bill for the Further Prevention of Cruelty to Animals in the District of Columbia," or any modification of this bill;

Resolved, That copies of these resolutions, attested by the signature of the President and officers of the Academy, be sent to each member of the Committee on the District of Columbia in the House of Representatives and the Senate of the United States, the District Commissioners, and the United States Senators from the State of Missouri.

On motion, the preamble and resolutions were unanimously adopted, and copies certified by the officers of the Academy ordered transmitted as directed in the resolutions.

The following persons, resident in St. Louis, were elected active members :— Fred. J. Taussig, Albert Taussig.

Professor P. H. Rolfs, of Lake City, Florida, was elected an active member.

Two persons were proposed for active membership.

November 16, 1896.

President Gray in the chair, fifteen persons present.

Dr. Charles R. Keyes read a paper entitled, How shall we subdivide the Carboniferous?

Professor J. H. Kinealy exhibited a chart for determining the number of square feet of low pressure steam-heating surface required to keep a room at 70° F., and gave a description of the method of making the chart.

The Council having recommended that, in view of Mr. Edwin Harrison's numerous donations to the Academy during the period of his active membership, extending over nearly forty years, he be elected a patron, on motion Mr. Harrison was unanimously elected a patron of the Academy.

The following persons, resident in St. Louis, were elected active members:—Ellis Warren Lazell, Lewis Olivar Atherton.

One person was proposed for active membership.

December 7, 1896.

President Gray in the chair, twenty-four persons present.

Professor H. S. Pritchett presented a paper giving the results of measures of double stars, mostly close binaries, made with the twelve-and-one-half-inch equatorial of the Glasgow Observatory. These observations, compared with similar ones made by him fifteen years earlier, showed some remarkable changes, particularly in the case of 70 Ophiuchi, in which the companion had described an arc of 102.° Others, as Σ 2120, showed that the motion of the companion star was in dependent of the brighter one. The speaker gave a general statement of the method of measuring double stars and the method of determining the apparent and true orbits.

Mr. William H. Roever presented an abstract of a paper on the geometrical properties of lines of force proceeding from electrical systems.

Mr. A. W. Douglas, Dr. G. Baumgarten, and Professor Otto Heller, were elected a committee for the nomination of officers for the year 1897.

Mr. Colton Russell, of St. Louis, was elected an active member.

December 21, 1896.

Dr. John Green in the chair, in the absence of the President and Vice-Presidents, twenty persons present.

The nominating committee reported the following nominations for officers for the year 1897:—

President	M. L. Gray.
First Vice-President	E. A. Engler.
Second Vice-President	Chas. R. Sanger.
Recording Secretary	William Trelease.
Corresponding Secretary	E. C. Runge.
Treasurer	Enno Sander.
Librarian	G. Hambach.
Curators	Julius Hurter,
	J. H. Kinealy,
	E. Evers.
Directors	M. H. Post,
	Joseph Grindon.

Mr. H. von Schrenk made some remarks on the parasitism of lichens, in which he showed that it has been asserted by some persons that lichens growing on trees may do considerable injury to such trees, possibly by taking sap from them, but that this did not seem probable, as no portion of the lichen thallus penetrates beyond the outer periderm layer. The lichen, however, by covering a large area, may prevent access of light and air. In the long hanging forms of *Usnea barbata*, growing on *Juniperus* on Long Island, New York, the lichen closely envelops leaves and branches, and appears to be capable of killing both by suffocation. Pieces of this lichen are carried from branch to branch by wind and birds, and in the new stations grow without attachment, spreading very rapidly over adjacent areas. In its habit this lichen resembles *Tillandsia usneoides*, which is likewise capable of killing branches by suffocation and of growing without attachment, according to Schimper.

One person was proposed for active membership.

January 4, 1897.

President Gray in the chair, twenty-seven persons present.

The President addressed the Academy as follows: —

I take pleasure in congratulating the Academy of Science of St. Louis on its comparatively prosperous condition at the beginning of the fortieth year of its corporate existence.

It has convenient and comfortable quarters for its meetings and property, at a rent of $500.00 a year, payable quarterly under a lease for one year from the 15th of the present month. Its library is valuable and growing, containing many excellent works and the proceedings of most of the learned scientific societies of the civilized world. Its museum is a creditable nucleus to which, it is hoped, from time to time, valuable additions will be made.

We have two hundred and six active members, of whom twenty-one are non-residents, nine of whom have been elected during the year just closed; and in the same period fourteen have resigned and three have died, namely, Dr. C. O. Curtman, Judge Charles Speck and O. B. Wheeler.

We have, besides, quite a large list of corresponding members, a number of whom are residents of foreign countries.

We exchange our publications with one hundred and thirty-nine scientfic institutions in the United States, four of which were added to the list during the last year. We also exchange with three hundred and ninety-seven foreign societies, and by these means we are kept in touch with the latest scientific work and discoveries throughout the world.

Our income is derived from the interest on $6,000.00 invested on real estate security, and from annual dues from members, the amount of which will appear from the report of the Treasurer.

Our meetings during the past year have been interesting and instructive. Meritorious papers have been read, and our Transactions are being published from time to time, and they maintain the high character of former years.

In order to increase our income, it is highly desirable that the number of active members should be increased. In a city of the population of St. Louis, there ought to be more than two hundred persons who, if properly approached, would be willing to join our ranks and aid and promote the objects we have in view.

The present arrangement of having, at each meeting, one or more papers read that treat, in a popular manner, subjects of scientific interest, and of new discoveries and their application to practical uses, is, I think, in the right direction and should be continued. It seems to me that if our meetings and the topics that are to be discussed were publicly advertised, a general interest might be awakened and strengthened that would result in larger audiences and membership, and a consequent increase of income, and I suggest that an earnest and active effort be made to effect this.

We have long dreamed of raising a sufficient fund to erect a suitable fire-proof building in which to shelter our library and cabinet, and to the present time it is a dream, and yet not all a dream, for we have toward it the sum of $6,000.00. As long as the public is ignorant of the existence of the society and its work, we cannot expect funds to flow in; but by bringing its aims and work before the people, securing their interest, educating them up to its importance and usefulness, we will at least be in the way of making supporters and friends that may grant the aid we need. San Francisco, (and possibly other cities), much younger and smaller than St. Louis, has for its Academy of Science a large and commodious home of its own, and a large museum. We cannot expect to attain such a home without a strong pull and a pull all together; and when times improve, I recommend that such a pull be made.

The Treasurer's report, an abstract of which follows, was submitted, and, after having been audited by a committee appointed for that purpose, was approved.

RECEIPTS.

Balance from 1895	$ 447 78	
Collections (membership dues, etc)	1,086 00	
Interest on invested money	465 00	
Rebate on insurance	166 70	$2,165 48

EXPENDITURES.

Rent	$ 500 00	
Current expenses	155 13	
Insurance	350 00	
Publication of Transactions	393 33	1,398 46
Balance to 1897		$ 767 02

[INVESTED FUND.

As shown by President's Report.

Investment on security.................................$ 6,000 00]

The Librarian reported that during 1896 exchanges had been received from 255 societies, of which 4 had this year been added to the exchange list. In all, 856 numbers were reported as having been added to the library, an increase of 155 over the preceding year.

The nominating committee reported that 105 ballots had been counted, and the following officers for 1897 were declared elected :—

President	M. L. Gray.
First Vice-President	E. A. Engler.
Second Vice-President	Chas. R. Sanger.
Recording Secretary	William Trelease.
Corresponding Secretary	E. C. Runge.
Treasurer	Enno Sander.
Librarian	G. Hambach.
Curators	Julius Hurter,
	J. H. Kinealy,
	E. Evers.
Directors	M. H. Post,
	Joseph Grindon.

Dr. Amand Ravold gave a microscopic demonstration of Widal's test for typhoid fever, demonstrating that after the disease has existed for four days or more, the blood of typhoid patients, probably because of some contained antitoxine, possesses the power of inhibiting the motion and causing a peculiar clumping of typhoid bacilli from a pure culture introduced into it, within a period of one hour or less, whereas, in normal blood, similar bacilli retain their power of locomotion for an indefinite length of time. It was stated that typhoid blood possesses this property even after having been dried for a period of four weeks or more, so that a few drops obtained from a person suspected of having the disease may be sent to suitable places for applying the test, thus rendering comparatively easy the early diagnosis of a disease which in its early stages presents many clinical difficulties.

Professor F. E. Nipher gave preliminary results of partially completed experiments, made through the courtesy of the Burlington and Illinois Central Railroads, to determine the frictional effect of trains of cars on the air near them. His apparatus consists of a cup collector supported on a bar capable of sliding in guides on a clamp attached to the window sill of the car. The bar is thrust out to varying distances up to thirty inches. The mouth of the collector is turned in the direction of motion of the train. The pressure due to the motion is conveyed through a rubber tube attached to the rear of the collector and passing lengthwise through the bar to a water manometer. The manometer has a tube with a rise of four or five in one hundred, and is provided with a pivotal mounting and a level. The pressure near the train is comparatively small, and increases as the collector is thrust further out, where it approaches a limit corresponding to the train velocity at the instant. Professor Nipher finds the relation between the limiting pressure and velocity to agree exactly with the formula—

$$P = \frac{\delta}{2} v^2$$

where v is the train velocity in centimeters per second, P is the pressure in dynes to the square centimeter, and δ is the density of air in C. G. S. units at the temperature and pressure of the observations. He finds the pressure a maximum when the axis of the collector is parallel to the direction of motion with the mouth to the wind. Turning the collector until its axis makes an angle of about 60° with this position, the pressure reduces to zero. At greater angles the pressure becomes less than atmospheric pressure by an amount which reaches a maximum at an angle of 90°, and passes through a minimum at an angle of 180°, when the collector is in a trailing position. The sum of the coefficients for the two positions of maximum and minimum exhaust is almost exactly the same as Langley obtained with a pressure board when exposed normally to the wind. The result shows that a large amount of air is dragged along with the train, the motion being communicated to air many feet away. This air is a source of danger to one standing too near the train when it is at full speed. One is likely to be toppled over, and the blow of the air communicates a motion of rotation which may cause one to roll under the train if the nature of the ground does not prevent such result. It was remarked, however, that where trains have a right to run at any speed, no prudent person would stand so near a train as is necessary in order to be in danger from this source.

Mr. Alfred Clifford, of St. Louis, was elected an active member.

Two persons were proposed for active membership.

January 18, 1897.

Vice-President Sanger in the chair, a large number of members and guests present.

Professor H. S. Pritchett presented some results of observations on the recent sun-spots, prefacing his remarks by a general account of our present knowledge of the constitution of the surface of the sun, and of sun-spots in general, and illustrating them by the use of lantern slides.

The following persons, resident in St. Louis, were elected active members: —H. A. Hunicke, Julius C. Strauss.

February 1, 1897.

President Gray in the chair, thirteen persons present.

A philosophical paper by Mr. S. H. Emmens, which the Council had ordered preserved in the library of the Academy, was laid upon the table.

Professor L. H. Pammel read a paper embodying ecological notes on some Colorado plants, observing that botanists who have studied the Rocky Mountain flora have frequently commented on the interest attached to the plants from an ecological standpoint, but most perplexing to the systematist. It is not strange that this should be the case, since there are great differences in altitude and soil, and the relative humidity of the air varies greatly. This is a most prominent factor in the development of plant life. A cursory glance at the plains flora of eastern Colorado shows that there are representatives of a flora common from Texas to British America and east to Indiana. We should not for a moment suppose that the species are identical in structure, since the conditions under which they occur are so different. Attention was called to the great abundance of plants disseminated by the wind, as *Cycloloma*, *Salsola*, *Solanum rostratum*, *Populus*, *Cercocarpus*, "Fire-weeds" (*Epilobium spicatum* and *Arnica cordifolia*), *Hordeum jubatum*, *Elymus Sitanion*, etc. Plant migration may be studied to better advantage in the irrigated districts of the West than elsewhere, partly because the water carries many seeds in a mechanical way, and partly because the soil is very favorable for the development of plants. Instances were cited where several foreign weeds are becoming abundant, as *Tragopogon porrifolius* and *Lactuca Scariola*. The latter, known as an introduced plant for more than a quarter of a century, is common at an altitude of 7,500 feet in Clear Creek Cañon. Once having become acclimated, it is easy to see how Prickly Lettuce is widely disseminated. Collectors appreciate the importance of giving more attention to conditions under which plants thrive, such as phases of development, soil, climate and altitudinal distribution. Structures of plants are produced to meet certain conditions. Under extreme conditions protective devices are more pronounced.

In discussing some of the plants, Warming's classification into Hydrophytes, Xerophytes, Halophytes and Mesophytes was adopted. The Mesophytes of eastern Iowa were compared with some of the Xerophytes of western Iowa, such as *Yucca angustifolia*, *Mentzelia ornata*, *Liatris punctata*, etc. These increase in abundance in western Nebraska, and attain a maximum development in northern Colorado. In the foot hills and mountains the Mesophytes constitute a large class, although the Xerophytes are common in dry, open, sunny places. The photosynthetic system is reduced to guard against excessive transpiration which would otherwise take place at high altitudes. The thick rootstock of alpine plants in dry open places is an admirable protection against drouth and cold. In cañons where snow remains on the ground, plants do not need this protection. Halophytes are not numerous in species and genera. Hydrophytes are abundant at higher altitudes, where they occur in marshes and along streams.

FEBRUARY 15, 1897.

President Gray in the chair, ten persons present.

Professor J. H. Kinealy presented a preliminary discussion of the Pohle air-lift pump, a device for pumping water from artesian wells by injecting into the pump tube, at a considerable depth below the surface of the water, bubbles of air from an air-compressor. Provisional means of determining the efficiency of the pump were indicated. In the discussion of the communication a comparison was made with the action of an inverted Sprengel pump.

Professor William Trelease exhibited two hair balls removed from the stomach of a bull in Mexico, and showed that they were composed of the pointed barbed hairs of some species of prickly pear upon which the animal had unquestionably fed. Attention was called to similar balls from the stomachs of horses, but composed of the calyx hairs of crimson clover, which had been described in 1896 by Mr. Coville, of the United States Department of Agriculture.

March 1, 1897.

President Gray in the chair, eighteen persons present.

Mr. W. H. Rush gave some demonstrations illustrating the formation of carbon dioxide and alcohol as a result of intramolecular respiration by plant tissues grown in an atmosphere containing no free oxygen. For the demonstration of the liberation of carbon dioxide, germinating seeds were used, the atmosphere in the apparatus being replaced by hydrogen, and the usual barium hydrate test being applied for the presence of carbon dioxide. For the alcohol, a distillate was exhibited, obtained from peas and also from fresh grapes, which, after being superficially disinfected by corrosive sublimate, had been allowed to remain for a period of some weeks in a hermetically sealed vessel, the oxygen in which was very quickly exhausted, leaving the atmosphere quite destitute of this element in an uncombined state. On removal, the seeds or grapes were crushed with water, and the alcohol removed by distillation and demonstrated by the usual tests. It was explained that intramolecular respiration was supposed to result from a breaking down of the living proteid molecules, as a result of which dead molecules of two classes were formed, nitrogenous and non-nitrogenous, the latter again splitting into carbon dioxide, alcohol, and some organic acid, with occasionally a certain amount of hydrogen. With free oxygen, the speaker stated, the same disintegration of the living molecules occurred, but with this difference, that the non-nitrogenous portion again split into carbon dioxide, water, and some carbohydrate. The nitrogenous product was stated to be in part asparagin, which, uniting with some carbohydrate like glucose, was believed to form anew the living proteid molecule. Owing to its prompt exhaustion in this manner, asparagin was stated to acumulate in quantity only when carbohydrates were absent, as, for instance, in seedlings grown in the dark.

Mr. H. von Schrenk exhibited drawings and presented a preliminary notice of an oedema of the roots of *Salix nigra* which he had observed in the early part of the winter, along the edges of a body of water in Forest Park. The swellings were observed near the tips of actively growing roots, shortly after the fall of the leaves. The epidermis was found to be burst, and the periblem cells, greatly enlarged, protruded. The speaker referred to previous studies of plant oedemas, and compared the specimens here described, particularly, with some oedematous apple twigs which had been made the subject of investigation at Cornell University. The latter were observed in the early spring, before the expansion of the leaves, but after the roots had been stimulated into premature activity, and it was suggested that possibly the oedematous willow roots might have similarly resulted from an unseasonable root activity, while the plants were in a leafless condition.

Professor J. H. Kinealy exhibited a simple glass model very clearly illustrating the mode of action of the Pohle air-lift pump, of which he had spoken at the last meeting.

One person was proposed for active membership.

March 15, 1897.

President Gray in the chair, thirty-five persons present.

A portrait of Dr. Enno Sander, which had been secured through the efforts of friends of the Academy, was presented, on their behalf, by Professor F. E. Nipher, who said:—

Mr. President and Members of the Academy:

It sometimes happens that occasions arise in the history of our Academy when our thoughts are directed back over our past record. Sometimes these occasions have been full of sorrow, when some one of our number has rested from his labors. To-night we seek to honor one of our number who is still with us, and who still carries his full share of the responsibilities of active membership. From the earliest year of its existence, forty-one years ago, he has been a worthy member of the Academy. He was the associate of Engelmann, Eads, Shumard, Harris, Holmes, Riley, and a host of worthy citizens of St. Louis, who are no longer here, and most of whom have finished their labors. Dr. Enno Sander has been a most important element in the life of the Academy. There have been times when its future was anything but promising. It has passed through the turmoil of civil war, it has suffered irreparable loss from fire, it has had seasons of financial trouble which have put its affairs in serious straits. As Recording Secretary, and continuously for the last thirty-five years as our Treasurer, Dr. Sander has never failed us in any emergency.

There has never been any self-seeking on the part of members of our Academy. There has been always only a worthy and honorable devotion to those great things which the Academy represents as an element of modern life. I have seen bodies of this kind divided into contending factions until there was nothing left which was worthy of contention. In our Academy each member has always held other considerations secondary to the work of widening the boundaries of human knowledge. It is not given to any one of us to do much of this work, but that is the cause which, as an organization, we represent, and no other. All other things are subordinate. This was the direction which the wise men who represented science in our midst gave to the Academy in its early days. And it is largely due to Dr. Sander that the Academy has been able to maintain this high ideal. As his old friends and associates have, one by one, departed and new faces have taken their places, he has known how to welcome them and to be one of them. We are all his juniors in membership, and nearly all are his juniors by a quarter of a century.

A record such as his is certainly worthy of honorable recognition. I am asked to represent a number of gentlemen of our Academy who have interested themselves in securing a portrait of Dr. Sander for presentation to the Academy. He has been induced to submit to their wishes, and has enabled them to secure a likeness of him as we have known him in these latter years of hearty good-fellowship. And I know that I represent every member of the Academy when I express the warmest appreciation of the services which he has rendered to our Academy. We do not need to assure him of our personal esteem. He has made it impossible for us to feel for him anything but the highest esteem. And we hope that time will continue to deal gently with him, and that he may be spared to us yet many years.

Mr. President and members of the Academy, I now present this portrait to the Academy, in behalf of those whom I represent.

On behalf of the Academy, President Gray accepted the portrait with thanks.

Dr. Sander, being called upon, responded happily to the expressions of good will which had accompanied the presentation and receipt of the portrait, and expressed his pleasure at having his portrait placed with those of his esteemed friends, Doctors Shumard and Engelmann, on the walls of the Academy rooms.

Dr. G. Hambach gave an account of the more striking geological features of St. Louis, exhibiting specimens of the principal fossils and minerals which characterize the local formations, and indicating the best localities for the collection of certain specimens.

On recommendation of the Council, the following preamble and resolutions were unanimously adopted:—

WHEREAS, The admission of natural history specimens to the international mails is at present restricted to such as are sent in sealed packages, at letter rates of postage, which are practically prohibitory; and

WHEREAS, It is understood that the question of admitting such specimens to the mails at merchandise rates is to be considered by the next International Postal Congress, which is announced to meet in Washington in May next:—

Resolved, That the Academy of Science of St. Louis favors the adoption of an amendment to the present regulations which shall admit to the international mails

"Objects of natural history, dried or preserved animals and plants, geological specimens, etc., of which the transmission has no commercial interest, and the packing of which conforms to the general conditions concerning packages of samples of merchandise;"

Resolved, That the Postmaster General of the United States be and he is hereby respectfully requested to instruct the delegates from the United States to vote for the above or some similar amendment.

Mr. P. C. Compton, of St. Louis, was elected an active member.

APRIL 5, 1897.

Vice-President Engler in the chair, eighteen persons present.

Professor Frederick Starr spoke briefly of the Academy and its work, stating that the duties of an organization like the Academy of Science were threefold: first, to its members; second, to the scientific world; and, third, to the community at large; and with a minuteness of detail which showed a thorough knowledge of the past history of the Academy, Professor Starr reviewed what the Academy had thus far accomplished in each of these three directions.

A paper by Mr. Charles Robertson, on North American bees—descriptions and synonyms, was read by title.

Mr. H. C. Irish spoke on the relations of the unfolding of plants in spring to meteorological conditions, giving a historical resumé of the principal work in phenology thus far done in this country and in Europe, and presenting charts on which the vegetable periodicity for a series of years was contrasted with the temperature variations for the same years.

APRIL 19, 1897.

President Gray in the chair, twenty-one persons present.

Dr. C. Barck read an interesting address on Helmholtz—his life and work.

Dr. C. R. Keyes presented in abstract papers on the relations of the Devonian and Carboniferous systems of the Upper Mississippi basin, and on the distribution of Missouri coals.

The President announced the death of Dr. J. M. Leete, and, on motion, a committee composed of Dr. Grindon, Mr. Harrison and Professor Nipher was appointed to prepare suitable resolutions for presentation at the next meeting of the Academy.

May 3, 1897.

President Gray in the chair, twenty persons present.

Mr. H. von Schrenk spoke of the respiration of plants, with special reference to the modification of those growing with their roots submerged in water. The lecture was illustrated by a demonstration of the liberation of carbon dioxide in respiration, from the roots of an ordinary flowering plant and from freshly gathered fungi, and the more usual aerenchyma structures were made clear by the use of lantern slides.

Professor F. E. Nipher described a simple means of measuring the resistance of a tube to a current of air, when compared with an accepted standard, by the use of a device similar in principle to the Wheatstone bridge used in electrical instruments. The apparatus, in the present instance, consisted of parallel tubes filled with air, connected by a tubular bridge, in the middle of which a drop of water was placed, so as to change position with the variations in the pressure of air on the opposite sides of the drop.

May 17, 1897.

President Gray in the chair, twenty-five persons present.

The committee appointed at the meeting of April 19 presented the following memorial of the late Dr. J. M. Leete.

The St. Louis Academy of Science is once more called upon to record the death of one of its valued members. Dr. James M. Leete was born in Lockport, New York, in the year 1832. At the close of his early studies, he removed to Hines County, Mississippi, where he taught school for some time, thus broadening his knowledge and sympathies by contact with his fellow-man in widely separated portions of our country, which breadth of sympathy was not lessened by four years' active participation in the war, and was in later life a prominent trait of his character. Returning to the North, he took up the study of medicine, was graduated from the University of Pennsylvania, and served two years in Blockley Hospital, Philadelphia, as an interne under the late Samuel D. Gross and other men whose names have become illustrious in the annals of medicine. He gained their respect by his close attention to and proficiency in his studies, and devotion to duty.

At the breaking out of the war, he entered the Federal army as assistant surgeon. His ability and conscientiousness procured his promotion, and he became medical director of Crooke's Corps in Hunter's Division (the Sixth).

At the close of the war he chose this city for his home, and soon after joined himself to this Academy, remaining one of its most faithful and esteemed members until the end.

In 1871, he married Miss Cordelia Harrison. Two daughters, with their mother, survive him.

Three years since, his failing health induced him to seek another place of residence, and he died on April 17, 1897, at Mineral Point, Wisconsin.

Dr. Leete's personality was of that purposeful and energetic sort which leaves an impression on its surroundings. Public-spirited to an unusual degree, he harbored no selfish thought when the common weal was concerned, and, without expectation of remuneration or demand for recognition, gave much labor, time, and even occasional pecuniary assistance to objects which were of equal importance to all.

The St. Louis Academy of Science herewith tender to his bereaved family and friends their heartfelt sympathy in this our common loss.

Professor Nipher stated that he desired to add that Dr. Leete had furnished the means for carrying on the magnetic survey of Missouri during the years 1881–1882, expressing a desire that his name should not at that time appear in connection with the reports of the work done, which were published in Volume IV., No. 3, of the Academy's Transactions.

Mr. J. B. S. Norton read a paper embodying the results of an examination into the effects of the tornado of May, 1896, on trees about St. Louis, in which it was shown that, while ordinary winds have some influence on the form and strength of trees, in strong winds uprooting is caused by wet soil, weak spreading roots, and a large surface exposed to the wind. If the roots hold, breaks may occur in the trunk or branches, depending on the strength of the wood, the form of the tree, the mode of branching and the weight and resistance of foliage. While the edge of dry leaves presented to the wind offers little resistance, when foliage is wet and massed this may be very different. Local variations in these several factors make a comparison of different species difficult. It was shown that *Acer dasycarpum* was badly broken on account of its brittle wood and heavy foliage, while the weak-wooded *Tilia* and *Liriodendron* were also broken. Spreading-topped trees, like *Ulmus Americana*, as a rule, were broken and uprooted, though the branches were only bent in the tougher-wooded individuals. As a general thing, conical trees, like *Ulmus campestris*, *Liquidambar* and most conifers, and the strong-wooded oaks, were little injured. *Taxodium distichum*, from its slender form, strength and elasticity, was injured least of all. It was shown that after the tornado, which occurred early in the vegetative period, most of the trees continued the summer's growth by producing new foliage shoots. While a few died from the inability to secure food, others indicate injury by flowering and fruiting more profusely than usual. It was shown that some of the trees which were broken have already begun to show serious decay where the branches were removed, so that the final injury can hardly yet be measured. The results observed here were compared by the speaker with those which have been reported from time to time in connection with severe storms elsewhere.

In the discussion of Mr. Norton's paper, Mr. von Schrenk submitted some interesting specimens, slides and drawings illustrating the formation of a double ring of wood in 1896, resulting from the refoliation of the branches, denuded shortly after the season's growth had begun.

The Secretary presented a paper by Frank C. Baker, entitled Critical notes on the family Muricidae.

June 7, 1897.

President Gray in the chair, twenty persons present.

A paper by Robert Combs, entitled Plants collected in the District of Cienfuegos, Province of Santa Clara, Cuba, in 1895–1896, was presented, and the introduction was read by Mr. W. H. Rush.

Professor F. E. Nipher made some remarks on the difficulties yet involved in the theories of the ether.

OCTOBER 18, 1897.

Vice-President Engler in the chair, twelve persons present.

The Secretary presented in abstract a paper by Frank Collins Baker, entitled The molluscan fauna of Western New York.

Professor H. A. Hunicke gave an informal account of recent progress in our knowledge of the constitution of steel, treating the subject from a chemical and microscopical standpoint.

NOVEMBER 1, 1897.

President Gray in the chair, twenty-six persons present.

Dr. G. Hambach gave an interesting account of his impressions of the Hawaiian Islands, which he visited last summer, exhibiting a number of photographs, and some specimens of lava.

Dr. C. Barck gave a description of the volcano Haleakala and an account of his ascent of it.

NOVEMBER 15, 1897.

Vice-President Engler in the chair, six other members and one guest present.

Professor F. E. Nipher presented informally some of the results of his recent experiments on the stability of a pivotally mounted sheet in an air stream. He stated that he had used two surfaces, each having a vertical dimension of one foot, pivotally mounted on a vertical axis, the horizontal dimension of one surface being one foot and of the other forty-six and one-half inches. These pressure planes were exposed on the roof of a moving box car. It was stated that the results reached were very satisfactory, since the two planes gave nearly identical results when the distance of the pivots from the center was expressed in per cent. of the horizontal dimension.

Mr. Trelease presented notice of a proposal to amend

Article IV. of the Constitution so as to read "Three Curators" instead of "Board of Curators," the amendment to be submitted to ballot at the time of the approaching annual elections.

One person was proposed for active membership.

December 6, 1897.

President Gray in the chair, fifty persons present.

Mr. Julius Hurter exhibited a number of reptiles and batrachians now first reported as occurring in Missouri, and read an interesting account of his studies of these animals.

Mr. H. von Schrenk presented a paper on the trees of St. Louis as influenced by the tornado of May, 1896, illustrating his remarks by drawings, cross sections of tree trunks, and slides under the microscope.

Dr. G. Baumgarten, Professor F. E. Nipher and Dr. John Green were elected a committee for the nomination of officers for the year 1898.

Judge Warwick Hough, of St. Louis, a corresponding member of the Academy since December, 1856, was elected an active member.

One person was proposed for active membership.

December 20, 1897.

President Gray in the chair, twenty-five persons present.

The nominating committee reported the following nominations for officers for the year 1898:—

President	E. A. Engler.
First Vice-President	Robert Moore.
Second Vice-President	D. S. H. Smith.
Recording Secretary	William Trelease.
Corresponding Secretary	Joseph Grindon.
Treasurer	Enno Sander.
Librarian	G. Hambach.
Curators	G. Hambach, Julius Hurter.
Directors	M. H. Post, Amand Ravold.

Dr. R. J. Terry exhibited several specimens of the human humerus, showing a supra-condylar process, associated with high division of the brachial artery, which was contrasted with similar processes observed in the anthropoid apes and the lower monkeys, and with a similarly situated formamen of the arm of the Felidae.

Professor F. E. Nipher presented a paper describing experiments made to determine the distribution of pressure over a pressure board, illustrating his remarks by diagrams and by exhibiting the apparatus employed by him.

Dr. John A. James James, of St. Louis, was elected an active member.

One person was proposed for active membership.

Reports of Officers for the Year 1897.

Submitted January 3, 1898.

The President addressed the Academy as follows :—

Gentlemen of the Academy of Science of St. Louis:

To review the work of this Academy prior to the year just closed would be a repetition of what has been ably said by my predecessors. Therefore, I shall only refer to what has been done during the year now closing. In 1897 the Academy has published Numbers 12 to 19, both inclusive, of its Transactions, which, with previous numbers and one now ready and soon to be published, will complete the seventh volume of our Transactions. The work of the year has been, I think, up to the average of what has been accomplished in previous years. Interesting and instructive meetings have been held, a variety of subjects have been discussed, and valuable papers have been presented, some of which will form a part of a new volume, constituting the eighth of our Transactions.

Abstracts of papers read are in the records of the Academy, and will show that good work has been accomplished. There has been, generally, a good attendance at our meetings, and a growing interest has been manifested that is highly encouraging. We have had frequent applications from similar bodies elsewhere for our publications, and exchanges with us have been sought for. There is evidence that the Transactions of our Academy are read and appreciated by other learned societies, and this is a matter of just pride. Yet we are sensible that we have not that general and popular support at home that our plans and aims are justly entitled to. A project has been inaugurated that aims to create a more general and public local interest that shall add to our members and increase our finances. A circular has been prepared, to be sent to public-spirited citizens, in the hope that their co-operation can be secured that shall bring us nearer to the ability to build a suitable and permanent home for our library and museum. It is much to the credit of our members that courage has been kept up and that we do not despair of ultimately reaching that desirable result. I believe this object will be attained, though it comes slowly. Milton, in one of his sonnets, says, "They also serve who stand and wait," and we have a proverb that all things come to those who wait. I do not interpret this proverb to mean that success comes to those who idly wait, but rather to those who eagerly wait and watch and seize opportunities to accomplish what they desire. It may be that the time is not yet ripe for an effort of this kind, but it is well to be educating the public mind on the subject so that, when business is prosperous and remunerative, the people may be ready to act and come to our aid.

A desire to see and know those who have achieved deserved reputation in any line of human effort is natural and commendable, and it was therefore a great pleasure to us to meet and entertain Dr. Nansen, the great Norwegian Arctic explorer. His wisdom and foresight in planning and equipping his expedition, his courage, patience, cheerfulness and heroism in braving the perils and terrors of the icy plains of the frozen North, have placed him in the front rank of Arctic travelers, and our meeting with him will long linger in our memories as one of the red-letter days of the year's experience.

Mingled with the pleasant emotions connected with this visit is an undertone of sadness from the loss of one of our colaborers, Professor Pritchett, who has left us to enter upon an important field of labor, under the Government, where, it is believed, he will be useful and will do credit to himself, to this Academy, and to the Government that, unsolicited on his part, has placed him in a position of honor and responsibility.

You, gentlemen of the Academy, have elected, to-night, officers either young or in the prime of life, active and enthusiastic workers in different fields of scientific study, with high ideals and aims, with faces set toward the future, with energy, zeal and courage to meet and solve the many problems that are springing into life; and under their guidance and leadership, I believe this Academy will achieve, in the time to come, all that its founders hoped and struggled for. That it may be so is my wish and prophecy.

The Treasurer reported as follows:—

RECEIPTS.

Balance from 1896	$767 02	
Sundry collections	6 49	
Donation (for portrait)	200 00	
Interest on invested money	363 66	
Membership dues	958 00	$2,295 17

EXPENDITURES.

Rent	$500 00	
Portrait	200 00	
Current expenses	457 91	
Publication of Transactions	533 85	1,691 76
Balance to 1898		$ 603 41

[INVESTED FUND.

Investment on security .... $ 6,000 00]

The Librarian reported that during 1897 exchanges had been received from 248 societies, of which 7 had this year been added to the exchange list. In all, 837 numbers were reported as having been added to the library, a decrease of 19 from the preceding year. It was reported that during the year the Transactions of the Academy had been distributed to 520 societies or institutions, chiefly by exchange or donation.

A STUDY OF THE UNIONIDÆ OF ARKANSAS, WITH INCIDENTAL REFERENCE TO THEIR DISTRIBUTION IN THE MISSISSIPPI VALLEY.

By R. Ellsworth Call, M. Sc., M. A., M. D.

There exists very little published information concerning the abundance, varieties, and geographic distribution of the great molluscan family of *Unionidæ*, within the limits of the State of Arkansas. A few forms were originally accredited to it; some of these have not since been found in the State, nor have some others ever occurred outside its boundary. Of the mollusks of no other one State in the Union is less known.

During the progress of the investigation the results of which are herein recorded, opportunity to consult a number of original types has been afforded with some very interesting results connected with the nomenclature of this great group of mollusks. To those who have not had access to original publications and to original specimens, much of the synonymy herein developed will, perhaps, prove a matter of surprise. The task which one thus assumes is not without its share of responsibility. To do strict justice to those most excellent early investigators, who so completely have rendered all successive students their debtors, is no easy task. That each one did the best he could, or knew, we scarcely can doubt; measured by the faulty notions of species that prevailed during their time they could, perhaps, for the most part, have done little better. A half century spent upon this great family by the veteran Dr. Isaac Lea must, in itself, entitle his opinions to confidence and to weight. But authority may never stand in place of Nature and in place of fact. If so be a more modern notion of what constitutes specific value, coupled with proper regard for environmental factors, has necessitated the reduction to synonymic rank of very many forms it is only because the facts justify the reduction, and the interests of sound scientific reasoning require it. Of so much synonymy as grew out of personal differences between former students it were better not to speak. It will always stand as a reproach that the best interests of science have thus suffered.

Most of the opinions herein expressed, regarding the specific value of very many forms, are based upon an extensive private collection of *Unionidæ*, which is geographically and numerically all but complete. Added thereto are very many facts gleaned during an engagement of some months in the Smithsonian Institution, at Washington, the time of which was largely devoted to the *Unionidæ*, which had previously been studied by my old friend and preceptor, the competent and painstaking Dr. James Lewis. Many facts, chiefly, however, connected with geographical distribution, were thus collated.

A considerable number of American *Unionidæ*, most of which are represented in the fauna of Arkansas, were originally described by the great French naturalist, Lamarck. Concerning these species there has been much difference of opinion, and even yet, in certain cases, opinions are divergent. To facilitate a correct understanding of Lamarck's species his original descriptions are herein reproduced, and fuller and more complete descriptions added, of forms which are believed to be authentic. These descriptions are accompanied by drawings in the several plates; some of these were executed by the careful hand of Mr. Harry A. Pilsbry and are duly accredited to him on the plates; the remainder were drawn by the writer. Added to the data thus assembled will be found, for Lamarck's species, most of the synonyms which have been erected as species upon his older described forms. The determination of these synonyms was in no sense a patriotic matter, but proceeded on the hard lines recognized in science as just and right. The great naturalist made serious errors, but these could not well be avoided with scanty material and not too full locality references. It is hoped that this rather full synonymy,— which is not complete, we too well know, — will eliminate from the trade-lists of amateurs species names which should no longer burden our faunal lists. In the matter of other bibliographic references the rule adopted has been to give the volume, page, plate, figure and date reference where the form was first described; added to these are occasional references to well-known and easily accessible works. There has been made no attempt, in the case of the greater number of forms listed, to exhibit but a moiety of the bibliographic matter. Beginning with *Unio elegans* Lea, references have been made to Reeve's great work, the Conchologia Iconica; this has been done in the hope that those to whom access is given to that work will find the critical notes, which are sometimes appended, of service. Many American shells are therein wrongly named but the fault lies in the sending abroad of misnamed specimens of American *Unionidæ*. Some of these errors are corrected by Reeve in the addenda to the Genus *Unio;* the rest remain to puzzle the naturalist. The opportunity to examine and use this great and costly work was afforded by the generous courtesy of Mr. Truman H. Aldrich, of Cincinnati, who kindly loaned me these volumes for a long period of time.

Not the least interesting fact connected with the study of the *Unionidæ* is the one that numerous species have been duplicated by describing the forms assumed by the sexes as of specific value. This has occurred in a number of instances, and is responsible for a considerable number of synonymic names. Among the forms so described, the following may stand as examples: —

Unio donaciformis Lea is the female of *Unio zigzag*, Lea.

Unio ater Lea is a synonym of *Unio purpuratus* Lamarck, and is based on the female form.

Unio patulus Lea is based on the female of *Unio clavus* Lamarck.

Unio lens Lea and *Unio leibii* are both synonyms of *Unio circulus* Lea and are based on the female form. *Unio leibii* is a dwarfed form of *U. circulus*.

Unio brevidens Lea is a male form of a species the female of which was afterwards described as *Unio arcæformis* Lea.

Unio subovatus Lea was based on the male of Say's *Unio ovatus.*

This list, illustrating what appears to have been the misinterpretation of sexual differences, might be extended indefinitely; when extended to its limits the student of the *Unionidæ* will be astonished at the results which he will reach.

Aside from personal collections, made in the intervals of field work in geology, and which were made in the St. Francis, Ouachita and Saline rivers, help has been derived from specimens collected by Professor R. T. Hill, in the Ouachita, by Mr. L. S. Griswold, in the Ouachita well up toward its source, and by Mr. F. A. Sampson, in the White river and in other portions of northern Arkansas. Dr. John C. Branner, State Geologist, has furnished an occasional specimen. Other shells have been sent, for identification, from the Little Red river. It is a matter of regret that more full and exhaustive collections could not be made preliminary to a final paper; it would better represent the wealth of the State in this group of natural objects. It will be noticed that three streams and as many localities furnish the major portion of the species here listed. Reasoning from this fact it is fair to assume that very many forms yet remain to be added to the list on complete examination of the State.

REGISTER OF SPECIES.

UNIO ABERTI Conrad.

Proc. Phila. Acad. Nat. Sci., p. 10, (1850); Jour. Phila. Acad. Nat. Sci., 2d series, Vol. II, Plate XXVI, Fig. 1, (1851).

Unio lamarckianus Lea. Trans. Am. Philos. Soc., 2d series, Vol. 10, Pl. 17, Fig. 20, (1852).

Unio popenoi Call. Bull. Washburn Coll. Lab'y of Nat. Hist., No. II, pp. 48–49, Pl. II, (1885).

This form was described by Lea from the Caddo river, under the name of *Unio lamarckianus*, the specimens of which were submitted to him by Dr. Byrd Powell. Additional examples were submitted by Dr. Hale who collected them in the Ouachita river, near the Hot Springs. The specimen figured by Doctor

Lea is a young one and is by no means a fair illustration of the shell. In the description of the species he mentions the numerous small nodules found over its surface but the figure shows the shell as smooth. The very young shells are nearly as triangular as the well known *Unio elegans* Lea.

In 1885 the writer, without then having access to the complete bibliography of the species, and misled by the great size of the specimens submitted to him, described the form as new, giving it the name of its Kansas discoverer. Later the error was discovered by him and the facts fully stated.* In this last named paper the remarkable character of the ctenidium was made known and illustrated from specimens collected in the Verdigris river, Kansas, by Mr. J. R. Mead.

This species has thus far been only found in the Arkansas and Red river drainage basins. It has not occurred to us in our collecting in the State.

UNIO ALATUS Say.

Nicholson's Encyc., Am. ed., Vol. IV, Pl. IV, Fig. 2, 1816. Also figured in the Am. Jour. of Science and Arts, 1st series, Vol. XIV, Fig. 17*a* and 17*b*. Another good figure may be found in Conrad's Monograph of Unio, Plate XXXI. A figure has recently appeared, in Bull. U. S. Fish Commission, Vol. XIII, Pl. 36, 1893, that is characteristic in all respects, except its alate features. Both alæ are broken in the specimen figured.

This species has not been found abundantly in Arkansas. Its sole occurrence to us was in the St. Francis river, near Wittsburg, in Cross county. It has been seen by the writer from the Ouachita river, Indian Territory, and without doubt will be found in the Arkansas portion of that stream. It is not readily confounded with any other known *Unio* being, when perfect, easily separated from other symphynote species by its dark purple coloration within and its flattened disk. I have received it under the name of *Unio purpuratus* from which species, however, it is entirely distinct.

From the Cedar river, Iowa, were secured very large and

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* See American Naturalist, September, Vol. xxi, 1887, p. 860.

fine specimens of this form. One of these measures in length 175 mm., in height 105 mm., in breadth 51 mm.

UNIO ANODONTOIDES Lea.

Trans. Am. Philos. Soc., Vol. IV, Pl. VIII, Fig. 11, 1830.

Unio teres Rafinesque, *vide* Conrad's Monograph, Pl. XXVIII.

St. Francis river, at Wittsburg and Madison; Saline river, at Benton.

This species is very widely distributed over the United States from western New York to Alabama and Texas, ranging north to Indiana, Minnesota, and Kansas. It is well marked and is distinct from *Unio luteolus* Lamarck, with which it is often confounded. The St. Francis specimens are very large and fine.

Conrad's figure of *Unio teres* is said by him to be based upon a specimen in Mr. Poulson's cabinet, which was said to have been labeled by Rafinesque himself, who collected it "in the west."

UNIO ARKANSASENSIS Lea.

Jour. Phila. Acad. Nat. Sci., 2d series, Vol. V, Pl. XXX, Fig. 275.

The only Arkansas specimens seen came from the Saline river, near Benton. One is quite imperfect while the other, of the two, is a good representative of the female of the species. The original specimens came from "Hot Springs" and presumably from the Ouachita river.

UNIO BREVICULUS Call.

Plate XVII.

Proc. U. S. Nat. Mus., Vol. 10, p. 499, Plate XXVIII, 1887.

White river, Carroll county; Little Red river, Clinton, Van Buren county, Arkansas. Jack's Fork of Current river, Missouri; Big Creek, tributary to Jack's Fork, Texas county, Missouri.

Shell smooth, ovate elliptical, inequilateral, subinflated, biangular posteriorly, circularly rounded before, somewhat incrassate; umbones slightly elevated, so much eroded that minute characters are indeterminate; ligament large, thick, black, or dark brown; epidermis yellowish horn-color, smooth, polished, rayed with dark green over the whole disk, the rays often interrupted by the lines of growth, which are numerous, but somewhat indistinct; umbonal slope rounded, depressed in the male, slightly elevated in the female; posterior outline emarginate in the female ventrad of the siphonal area, dorsal outline rounded; cardinal teeth double in the left and single in the right valve, short, erect, triangular, solid, smooth, or scarcely crenulate; plate connecting laterals with cardinal teeth thick, somewhat arched; lateral teeth rather short, thick, slightly curved, smooth; anterior cicatrices distinct, large, deeply impressed; posterior cicatrices confluent, well impressed, that of the *retractor pedis* muscle at tip of base of lateral tooth but not on it; dorsal cicatrices numerous and deeply impressed in the cavity of the umbones; nacre salmon colored, occasionally white. Length 71.00 mm.; breadth 27.20 mm.; height 45.50 mm.

Animal dirty, yellowish white; labial palps short, ovately triangular, adherent at base, laterally united so as to form an oval groove, midway from the extremities of which is placed the mouth. In the specimens examined only the anterior one-third of the external branchiæ contained ova. This portion was characterized by the heavy deposit of pigmentary matter at the apex of the chambers, while the remaining margins of the branchiæ were uniform in coloration with the mass of the animal. The posterior borders of the mantle were, as usual, differentiated into a series of tentacular folds; those surrounding the incurrent and excurrent orifices were yellow and brown, the remainder were black.

While the females sustain a general resemblance to *Unio clarkianus* Lea and *Unio gerhardtii* Lea the emarginate character of the female form is utterly unlike anything exhibited by the females of Lea's types.

The above description is repeated from the original, that this form, which has recently been found abundantly near Clinton, Arkansas, may not remain unknown to those persons in that State who take any interest in its natural objects.

UNIO CALIGINOSUS Lea.

Trans. Am. Philos. Soc., 2d series, Vol. 10, Plate VII, Fig. 21, 1845.

St. Francis river, Wittsburg; White river, Carroll county; Ouachita river, Malvern; Saline river, Benton. These localities all furnished numbers of this form and of great perfection. Among the Uniones with which it groups are *Unio intercedens* Lea, *Unio fallax* Lea, and *Unio subrostratus* Say. The group is widely distributed in the southern States and is characterized by the emargination of the female, on the ventral border.

UNIO CAPAX Green.

Described by Dr. Green in "Cabinet of Natural History and American Rural Sports," Vol. II, p. 290, Phila., 1832.

Figured as *Symphynota globosa* Lea, in Trans. Am. Philos. Soc., Vol. V, Pl. IV, Fig. 12, 1832.

Dr. Green's description has priority by some weeks, though these authors published their diagnoses in the same year. Green's specimens came from the Falls of St. Anthony, and Bayou Teche, La., the localities being widely separated. Dr. Lea's specimens came from the Ohio river, about 150 miles below Louisville.

The species has occurred in our collections from Arkansas only in the St. Francis river at Wittsburg and is represented by two fine examples. It has the habit of *Unio occidens*, with which it groups, preferring muddy bottoms and still waters. It is fairly common throughout the Mississippi valley, in the larger streams that flow into the main river.

A closely related form, from the Altamaha river, Georgia, was described by Dr. Lea under the name of *Unio dolabræformis*, *vide* Trans. Am. Philos. Soc., 2d series, Vol. VI, p. 103, Pl. XXIV, Fig. 113, 1838. It is probably synonymous.

UNIO CASTANEUS Lea.

Trans. Am. Philos. Soc., Vol. IV, p. 91, Pl. XI, Fig. 21, 1830,. Described from the Alabama river, Alabama. Numerous examples of this shell have been taken in the

Little Red river, in Van Buren county, one fine example of which we have seen, together with a poorer one. It came to us under the name of *Unio arkansasensis* Lea. From Claiborne Parish, Louisiana, we have seen about fifty good examples. The large and old shells resemble much some forms of *Unio ellipsis* Lea.

UNIO CERINUS Conrad.

Monograph of Unio, p. 95, Plate LII, 1838. Reeve, Conchologia Iconica, Vol. XVI, *Unio*, Plate LXXXVII, Fig. 468.

The only Arkansas example which we have seen was taken in the Little Red river, and was loaned to us for examination by Mr. W. A. Marsh. It is a fine female and a very characteristic form. Mr. Lea makes this shell a synonym of his *Unio rubiginosus*, but does so wrongly. Before us are forty or more specimens from Louisiana, the original home of the species, some of which are sufficiently perfect to disclose undulations on the beaks such as no *rubiginosus* ever possessed. They rather ally Conrad's shell to those peculiarly marked Mexican and Central American forms that have similar beaks. No shell with which I am acquainted so well presents similar characters as the common Texan form to which Gould gave the name of *Unio petrinus*, the original examples of which came from Mexico. This species will certainly not fall under *rubiginosus* whatever else may become of it.

UNIO CLAVUS Lamarck.

Plate I.

This shell is one of those prolific sources of synonymy with which the descriptive matter of American fresh-water conchology has become so burdened. In the hope that it will subserve a useful purpose the original description of Lamarck follows, and the synonymy as now understood, excepting only those names which have not been accompanied by figures.

The following description is taken from Volume VI, "Historie Naturelle des Animaux sans Vertebres," page 537, 1838.

"*U. testa sublongitudinali, oviformi, inferne tumida, obtusa; postico latere brevissimo; dente laterali prælongo.*

Var. testa versus extremitatem lateris antici sensim depressa, magis attenuata.

Unio modioliformis Say, Amer. Conch.

Habite dans le lac Erie. Michaud fils. * * * *Test tres blanc. Longueur apparente 72 millimetres. La variete b vit dans la riviere de la Nouvelle-Ecosse.* * * * *Longueur apparente 53 millimetres.*"

Lamarck's brief description is no doubt responsible for very much of the confusion which attends the separation of this form. To aid in its correct determination the following description has been drawn, from specimens collected in the Duck river, Tennessee. The specimen figured is one of those employed in this diagnosis.

Shell smooth, somewhat elliptical, most of its mass posterior to a line drawn vertically from the umbones, laterally subcompressed, somewhat pointed posteriorly, circularly rounded before; umbones prominent and pointed anteriorly, apiculate; ligament large, thick, light brown; epidermis honey-yellow, smooth, often polished, rayed from the tips of the umbones with green lines over the first formed half of the disk, the rays broadening downward, occasionally interrupted by the lines of growth which are numerous and strongly impressed giving to the lower third of old specimens a striate appearance; umbonal slope rounded anteriorly but compressed posteriorly; in the female, the posterior slope is rather less flattened than in the male, while the outline of the disk is less pointed; cardinal teeth single in the right, double in the left valve, rather short and incrassate, crenulate; plate connecting laterals with the cardinal teeth disposed to folding in the left and pitted in the right to correspond, thick, slightly arched; lateral teeth long-lamellar, curved ventrad, striate; anterior cicatrices confluent, deeply impressed, that of the *retractor pedis* impression very deep and circular and at the end and lower margin of the lateral teeth and partly on them; dorsal cicatrices numerous, small and impressed in an irregular line on the under side of the plate between the cardinal and lateral teeth; nacre pure white, with a very marked iridescence posteriorly between the pallial cicatrix and the margin.

Animal not observed.

Length, 53.00 mm.; breadth, 18.50 mm.; height, 30.00 mm.

The synonymy of this species has been but partially worked out, but it is certain that it will include the following forms:

Unio patulus Lea. 1829. Trans. Am. Philos. Soc., Vol. III, p. 409, Pl. XII, Fig. 20.

Unio decisus Lea. 1830. Trans. Am. Philos. Soc., Vol. IV, p. 92, Pl. XII, Fig. 23.

Unio chattanoogaensis Lea. 1858. Jour. Acad. Nat. Sci. Phila., 2d series, Vol. IV, 1859, p. 209, Pl. XXV, Fig. 90.

Unio consanguineus Lea. 1861. Jour. Acad. Nat. Sci. Phila., 2d series, Vol. V, p. 67, Pl. VII, Fig. 217.

Unio pallidofulvus Lea. 1861. Jour. Acad. Nat. Sci. Phila., 2d, series, Vol. V, pp. 83–85, Pl. XI, Fig. 232.

Unio interventus Lea. 1861. Jour. Acad. Nat. Sci. Phila., 2d series, Vol. V, p. 84, Pl. XI, Fig. 233.

Unio concolor Lea. 1861. Jour. Acad. Nat. Sci. Phila., 2d series, Vol. V, p. 89, Pl. XII, Fig. 237.

Unio anaticulus Lea. 1861. Jour. Acad. Nat. Sci. Phila., 2d series, 1862, Vol. V, p. 92, Pl. XIII, Fig. 240.

Unio crebrivittatus Lea. 1861. Jour. Acad. Nat. Sci. Phila., Vol. VI, 1866, p. 43, Pl. XV, Fig. 41.

Unio curtus Lea. 1859. Jour. Acad. Nat. Sci. Phila., 2d series, Vol. V, 1861, pp. 92–103, Pl. XVII, Fig. 253.

Both this last named form and *Unio anaticulus* were based on deformed specimens of *Uniones* and are, in a certain sense, pathologic forms. To this synonymy must be added those other names under which Say described this species a leading term of which will be *Unio modioliformis*, as had been noted by the editors of Lamarck, in 1838. Other great groups of *Uniones* there are which exhibit a far larger synonymy than does that group which this species of Lamarck heads.

So far as known this form does not occur west of the Mississippi, nor has any member of the group been found which may be located west of that stream. It has its greatest development in the mountain regions of Georgia, Alabama, Kentucky, and Tennessee, though it ranges, as specimens at hand prove, from western New York to Ottawa river, Canada, thence west to Illinois and south to middle Alabama, where some of its forms are exceedingly abundant in the streams of north-central Alabama, notably in the Coosa, Alabama, and Cahaba rivers.

A good illustration of this form may be found in Conrad's Monograph, Pl. III, fig. 1. Also in Tenney's Zoölogy, Manual, edition of 1872, p. 492, Fig. 460. Reeve, Conchologia Iconica, Plate LXIX, Fig. 354, also well exhibits its chief features, but the beaks are represented to be more decurved than in any specimen we have ever seen.

Unio cornutus Barnes.

Am. Jour. of Sci. and Arts, 1st series, Vol. VI, p. 122, Fig. 5*a*, 5*b*, 1823;

Unio reflexus Rafinesque, in Conrad's Monograph, Pl. IV, Fig. 1, 1838.

This species has been seen by us from only one Arkansas locality. That one was the St. Francis river, at Wittsburg, in Cross county. It has a wide range in its geographical distribution since it occurs from western New York to Kansas and south to Alabama and Texas.

Unio crassidens Lamarck.

Plate II.

Unio niger Rafinesque, in Conrad's Monograph of Unio, Pl. XXVI, 1836.

Unio incrassatus Lea. Trans. Am. Philos. Soc., 2d series, Vol. VIII, Pl. XVI, Fig. 34, p. 217, 1840.

Unio cuneatus Barnes, Am. Jour. of Sci. and Arts, 1st series, Vol. VI, p. 263, 1823.

Lamarck's description included several varieties, some of which were improperly included in the species as limited. Such, for instance, is his variety *a* which is said by Dr. Lea, who saw the type in Paris, to be his *Unio trapezoides* and which is entirely distinct from *crassidens*. The original description here follows from the *Animaux sans Vertebres, 2d Edition*, Vol. VI, p. 532, 1838.

" *U testa ovali, tumida, crassa, postice rotundata, antice, angulis binis ternisve subsinuosa, dente cardinali crassissimo lobato, angulato, striato.*

Habite l'Amerique septentrionale, dans le Mississippi, l'Ohio, et plusieurs lacs. * * * "

The remainder of the description is concerned with the diagnoses of the varieties which Lamarck considered as belonging to this form. Variety *a* is from the Mississippi; variety *b* from Lake Erie, variety *c* from the Ohio. But each variety appears to be a distinct species.

The following description is based upon specimens obtained from the Cumberland river, at Nashville, Tennessee, where the species is very abundant; also facts are included from characters exhibited by abundant material from the Etowah and Oostanaula rivers, in Georgia. The species is likewise abundant in the Cahaba, Alabama, and Coosa rivers, in Alabama.

Shell smooth, elliptical, compressed, incrassate anteriorly, biangular and much thinner posteriorly; epidermis rather thick, black in old specimens and deep reddish brown in young ones, striate, often with curved, dark green rays extending ventrad from the umbones, in the young shell; the dorso-posterior margin much and quite regularly-curved; posterior umbonal slope eradiate, somewhat flattened, separated from the lateral slope by a marked angle, with a prominent raised line, sometimes two, extending from the umbones and joining the posterior margin at the angles, the whole posterior slope is, commonly, strongly and coarsely striate; umbones small, scarcely prominent, slightly incurved; ligament long, thick, curved with dorsal margin, black; cardinal teeth short, heavy, triangular, striate, single in the right, double in the left valve, the posterior portion of the double left tooth nearly equal in size and shape to the single right tooth; lateral teeth long, thick, straight or nearly so, crenulate, in old specimens this is strongly marked; dorsal plate connecting the lateral with the cardinal teeth scarcely marked, smooth, rounded; anterior cicatrices distinct, deeply impressed, that of the adductor muscle much roughened and pitted with numerous small pits arranged in a row near the edge of the plate forming its upper margin; pallial cicatrix well impressed anteriorly and markedly crenulate throughout; posterior cicatrices distinct, that of the adductor deeply impressed and extending to the posterior end of lateral teeth, striate, that of the *retractor pedis* muscle deep, pit-like, sometimes confluent with that of the adductor; cavity of the beaks shallow, with a row of minute pit-like dorsal cicatrices some distance within the margin of the plate; nacre rich purple, light, iridescent, the latter feature especially marked posteriorly.

Animal not observed.

Length, 111.25 mm.; breadth, 40.00 mm; height, 69.00 mm.

In very good specimens, not too old, small and well marked foldings, disposed at an angle with the umbonal angle and increasing in number towards the umbones, may be noticed. These are characteristic, and serve to indicate the possible affinities of this species and *Unio incrassatus* Lea, from the Chattahoochee, Oostanaula, and other Georgia streams.

The figure given herewith is drawn from a fine specimen obtained in the Cumberland river, Tennessee, at Nashville, where the form is very abundant. Larger but less perfect specimens are common. In nearly all the great rivers of the south, west of the Appalachian system, this form occurs and usually in great abundance. It has not yet been obtained west of the Mississippi, so far as present information extends.

UNIO CUNEUS Conrad.

Monograph of Unio, Pl. LVIII, Fig. 1, 1836.

Four specimens were found in the Saline river, at Benton. The species was described from the Little Red river, Arkansas, by T. A. Conrad. It has long been properly regarded as identical with *Unio coccineus* Hildreth and should no longer be distributed under its Conradian name. Doctor Ward, of Ohio, many years ago distributed the white-nacred variety of this form under the manuscript name of *Unio gouldianus* Ward, but never described it. The name was adopted by Dr. John Jay, of New York, and published by him in his "Catalogue of Shells in the Jay collection."

The typical forms have a warm pink nacre but are not so common as the white-nacred variety. The range of the species is from western New York to North Alabama and west to central Kansas. In the rivers of Iowa it is both abundant and fine.

In further history of the form it may be stated that the real author of the species was Dr. Hildreth, of Marietta, Ohio, who sent it to Mr. Lea with the manuscript name of *Unio coccineus*. Hildreth did not describe it under that name, even in manuscript, and Mr. Lea, adopting the proposed name, described the species as new in the Trans. Am. Philos. Soc., Vol. VI, Pl. V, Fig. 12, 1834. A good figure may also be found in Conrad's Monograph, Pl. XIII, Fig. 1. The white-nacred variety is figured by Conrad, on the same plate, under the name of *Unio catillus*, from the Scioto river, Ohio.

UNIO CYLINDRICUS Say.

Plate XI.

Unio cylindricus Say, in Nicholson's Encyc. Am. Ed. Article Conchology, Pl. 4, Fig. 3, 1816.

Unio naviformis Lamarck. Deshayes Encyc. Meth. Vers ,Tome II, p. 580, No. 5, 1830.

Unio naviformis Lamarck. Animaux sans Vertebres, Tome VI, p. 537, No. 20, edition of 1838. From the Ohio.

Unio cylindricus Say, Barnes, in Am. Jour. of Sci. and Arts, 1st series, Vol. XIV, Pl. I, Figs. 13a, 13b.

This species is abundant in the St. Francis, Saline, and Ouachita rivers, Arkansas, from which localities many specimens have been seen. In the Cumberland and Harpeth rivers of Tennessee, the largest and finest specimens noticed have been taken. In geographical range the species extends from western New York to Indiana, Kansas, and Texas, and south to Central Alabama, in the Alabama river, at Selma. The specimen figured is from the White river, Indiana, and was contributed by Professor Barton W. Evermann.

UNIO DONACIFORMIS Lea.

Trans. Am. Philos. Soc., Vol. III, p. 266, Pl. IV, Fig. 3, 1827. Described from Ohio.

Unio zigzag Lea. Trans. Am. Philos. Soc., Vol. III, p. 409, Pl. XII, Fig. 19, 1829. Described from Ohio.

This species is abundant in the St. Francis river, at Wittsburg. It is reported also from the Ouachita river, near the boundary of the Indian Territory, but we have seen no specimens from that stream. The probable identity of these forms, as given in the above synonymy, was suspected by Mr. Lea himself; it seems, therefore, now more than useless longer to attempt their specific distinction.

UNIO EBENUS Lea.

Trans. Am. Philos. Soc., Vol. IV, p. 84, Pl. IX, Fig. 14, 1830.

Unio subrotundus Lea. Trans. Am. Philos. Soc., Vol. IV, p. 117, Pl. XVIII, Fig. 45, 1831.

Unio lesueurianus Lea. Trans. Am. Philos. Soc., Vol. VIII, p. 195, Pl. VIII, Fig. 6, 1840.

Unio globatus Lea. Jour. Phila. Acad. Nat. Sci., 2d Series, Vol. VIII, p. 5, Pl. I, Fig. 1, 1874.

Unio subglobatus Lea. Jour. Phila. Acad. Nat. Sci., 2d series, Vol. VIII, p. 7, Pl. I, Fig. 3, 1874.

Specimens have been studied from the following Arkansas localities: St. Francis river, Wittsburg; Ouachita river, Malvern. The geographical range of the species is from western New York to Texas, north to Kansas and Minnesota. The species is very abundant in the Mississippi river, at Moline, Illinois; in the Cumberland, at Nashville, Tennessee, in the Alabama, at Selma, and is a common form in the larger rivers west of the Mississippi. This shell is peculiar, though it shares this feature with several other forms, in occurring only in large streams. It is a mud-loving form and commonly abounds in muddy localities, where it occurs at all. The synonymy indicated above is illustrated by specimens in the cabinet of the writer and identified by Dr. Lea. Some of them are from the original localities of the various types.

UNIO ELEGANS Lea.

Trans. Am. Philos. Soc., Vol. IV, p. 83, Pl. IX, Fig. 13, 1830–1. Described from the Ohio river.

Conchologia Iconica, Reeve, *Unio*, Plate LXXIV, Fig. 380, 1868.

Unio truncatus Rafinesque, Say in American Conchology, Pl. 67.

The only Arkansas locality where this form has been found is the St. Francis river, at Wittsburg. It is there a very common shell, preferring rather muddy bottoms. The illustration given by Reeve is a fairly good one, but presents certain artistic effects that are not to be seen in the shell itself. It is a member of a group of which *Unio donaciformis* Lea may be considered a leading term.

UNIO GIBBOSUS Barnes.

Am. Jour. Sci. and Arts, 1st series, Vol. VI, Pl. XI, Fig. 12, 1823.

Unio arctior Lea. Trans. Am. Philos. Soc., Vol. VI, p. 10, Pl. IV, Fig. 10, 1834; Conchologia Iconica, Reeve, *Unio* Plate LXXXV, Fig. 454, 1868.

Unio dilatatus Rafinesque, so Conrad in Monograph, Plate XXI, 1838.

Unio stonensis Lea. Trans. Am. Philos. Soc., Vol. VIII, p. 195, Pl. VIII, Fig. 5, 1840; Conchologia Iconica, Reeve, *Unio* Plate LXXXV, Fig. 453, 1868.

Unio gibbosus Barnes, so Reeve in Conchologia Iconica, Pl. LXXIII, Fig. 377.

The figures of all these forms, as given by Reeve, are poor and do not well represent the shells. *U. stonensis* Lea is from Stone river, Tennessee, from which original locality the writer has specimens, and these are part of the original lot, identified by Mr. Lea, and still with the name in his handwriting. They formerly belonged to Dr. Troost, of Nashville, and were donated by Dr. J. Berrien Lindsley, into whose hands many of the shells of the Troost collection passed. There is no question that the form from the Ohio, which Mr. Lea called *Unio arctior*, is a white-nacred variety of *gibbosus*, a form which is commonly marked by a purple nacre. The white-nacred form, or *arctior*, is common in the Saline river, at Benton; it is abundant also in the Piney river, Missouri. Typical *gibbosus* was obtained in the St. Francis, at Wittsburg.

The geographical range of this form is from western New York to Minnesota and Kansas, south to Texas, and east to Georgia. In the Mississippi and Cumberland rivers it is both abundant and variable. There are few shells among the *Unionidæ* that present so great a range of variation as this one.

UNIO GLANS Lea.

Trans. Am. Philos. Soc., Vol. IV, 1830, p. 82, Pl. VIII, Fig. 12. From the Ohio river; Conrad's Monograph, Pl. IX, Fig. 2, 1836.

Unio pullus Conrad. Monograph of Unio, 1838, p. 100, Pl. LIV, Fig 2. From the Wateree river, South Carolina.

Unio granulatus Lea. 1861. Jour. Acad. Nat. Sci. Phila., Vol. VI, 2d series, 1866, p. 48, Pl. XVI, Fig. 46. Big Prairie creek, Alabama.

Unio germanus Lea. 1861. Jour. Acad. Nat. Sci. Phila., Vol. VI, 1866, p. 49, Pl. XIX, Fig. 54. From Coosa river, Alabama.

Unio cromwellii Lea. 1865. Jour. Acad. Nat. Sci. Phila., 2d series, Vol. VI, 1868, p. 258, Pl. XXXI, Fig. 73. From Kiokee creek, Albany, Georgia.

Unio cylindrellus Lea. Jour. Acad. Nat. Sci. Phila. 1868, 2d series, Vol. VI, p. 308, Pl. XLVIII, Fig. 121. From Tennessee, north Georgia, and north Alabama.

Unio corvunculus Lea. Jour. Acad. Nat. Sci. Phila., 2d series, 1868, Vol. VI, p. 314, Pl. L, Fig. 127. From Swamp creek, Whitfield county, Georgia.

The localities at which this species has occurred, in collecting in Arkansas, are all in Carroll county, and presumably from the same portions of the White river. The three specimens submitted were kindly furnished by Mr. F. A. Sampson, of Sedalia, Missouri, by whom they were collected. The synonymy indicated above is based upon very large series of specimens which comprise materials from every one of Lea's localities. The species was also figured by Reeve, in 1868, *Unio* Plate XXXVI, Fig. 190. The specimen figured by him shows the emarginate character of the female, which sex he had before him. The shell is usually abundant in warm, shallow water, near the margin, and on gravelly bars; it also occurs commonly in muddy stations having the habit of *Unio parvus* Barnes which heads the group of which *Unio glans* is a member. *Unio ellipsiformis*, Conrad (Monograph of *Unio* Plate 34, Fig. 1, p. 60), 1838, described from Michigan, is also a synonym.

UNIO GRACILIS Barnes.

Described in the Am. Jour. Sci. and Arts, 1st series, Vol. VI, 1823.

Unio fragilis Rafinesque, so Conrad, in Monograph of Unio, Plate XXX, 1836.

Unio dolosus Lea. 1860. Jour. Acad. Nat. Sci. Phila., Vol. V, 1861, p. 75, Pl. IX, Fig. 224. Also Conchologia Iconica, Reeve, *Unio* Plate XLI, Fig. 228. This is a poor figure of an immature specimen.

Unio gracilis Barnes. Reeve, Conchologia Iconica, 1868, *Unio* Plate XXXIX, Fig. 215. This is a figure of an old specimen but does not show the characteristic alation of the dorsal margin.

This species has occurred to us in the Saline river, at Benton, and in the St. Francis river, at Wittsburg. It does not differ in any material respect from the forms found so abundantly in the sloughs along the Mississippi river farther to the north, and in all the larger streams which are tributary to it, except, perhaps, the Missouri river alone. Lea's *dolosus* is very abundant in the Coosa river at Wetumpka, and in the Alabama at Selma. It was also found in numbers in the Cahaba, at Lily Shoals, in Bibb county. There can be no doubt of its identity with the older form described by Barnes.

The typical form of the group that it heads, this species ranges from the Ottawa river, Canada, to Minnesota, Iowa, and Kansas, and south to Central Alabama and to Texas.

UNIO GRANDIDENS Lea.

Jour. Acad. Nat. Sci. Phila., 2d series, 1862, Vol. V, p. 205, Pl. XXX, Fig. 274. Also Reeve, in Conchologia Iconica, 1868, *Unio* Plate LXXXIII, Fig. 439.

This species has not been found by us in Arkansas nor do we know of the existence of any specimens other than the types. It was collected by Dr. Byrd Powell, near Hot Springs, Arkansas, and was described from two unmatched valves belonging to old individuals. Reeve gives a very good figure, probably copied from Lea, but is hopelessly confused on the relations of the form. He does not recognize the name of Lea, save as a synonym, but places it under *Unio nodulosus* Wood. He suggests that it has an aspect very much like that exhibited by certain Chinese shells, and thinks that both "may prove to be the *Chama plumbea* of Chemnitz." It is hardly necessary to say that there is no relation to *Chama*, and no question but that the shell is properly credited to Arkansas. It is a member of the pustulate group and is not far removed from *Unio cooperianus*, which it closely resembles.

Unio irroratus Lea.

Trans. Am. Philos. Soc., Vol. III, 1827, p. 269, Pl. V, Fig 5. Described from Ohio.

Unio irroratus Lea, Reeve, in Conchologia Iconica, *Unio* Pl. XII, Fig. 44, female. 1868.

Unio stegarius Rafinesque, so Conrad, in Monograph of Unio, p. 83, Pl. XLVI, Fig. 1, 1838. Also Reeve, in Conchologia Iconica, *Unio* Plate XII, Fig. 45, male. 1868.

This species occurred in the St. Francis river, at Wittsburg, and in the Saline, at Benton. In the first mentioned locality it is very abundant and specimens of all ages were found. The very young have the outline of *Unio elegans*, but they are somewhat longer than the young of that species at a corresponding age. The resemblance of very many of the young to the form described by Conrad as *Unio aberti* is also marked. The triangular outline is lost with age, and the circular form becomes more and more marked. Closely allied to it is the common *Unio dromas* Lea, of the Cumberland river.

Unio hydianus Lea.

Trans. Am. Philos. Soc., 2nd series, Vol. VI, 1834, p. 14, Pl. VI, Fig. 14.

This species was described from the Bayou Teche, Louisiana; it occurs abundantly in the St. Francis river, at Wittsburg, and in the Saline river at Benton. It is a synonym of *Unio luteolus* Lamarck, to which the reader is referred.

UNIO LACHRYMOSUS Lea.

Transactions Am. Philos. Soc., 2nd series, 1827, p. 272, Pl. VI, Fig. 8. Described from Ohio. Also Reeve, in Conchologia Iconica, 1864, *Unio* Pl. IX, Fig. 33.

Unio asperrimus Lea. Trans. Am. Philos. Soc., 2d series, Vol. IV, p. 71, Pl. V, Fig. 3. 1830–1.

Unio quadrulus Rafinesque, so Say, in Am. Conch., Pl. 53, 1834.

Unio quadratus, Rafinesque, so Reeve, in Conchologia Iconica, *Unio* Plate VI, Fig. 24, 1864.

Unio lunulatus, Pratt. Proc. Davenport Acad. Sci., Vol. I, Pl. XXXI, Fig. 1, (1870?).

Obtained by us in the St. Francis river, at Wittsburg, and in the Saline river, at Benton. *Unio lachrymosus* was described from a small and immature specimen; *Unio asperrimus* from an old and well-worn shell. Yet the resemblances are so close that one might easily have recognized their identity. From the Little Arkansas river, Kansas, come the largest and finest specimens of this species that we have ever seen. In geographic range the form extends from western New York to Kansas and Minnesota, and south to Texas and Alabama.

UNIO LÆVISSIMUS Lea.

Trans. Am. Philos. Soc., Vol. III, Pl. XIII, pp. 444–445.

Specimens of this form were taken by Dr. J. C. Branner, in the Little Red river, at Fulton. The shell is somewhat more globose than the same form reported from other localities; the specimens have a slight tendency to vary toward *Unio hermannii* Lea, described originally from Texas. The types of Lea's *Unio lævissimus* came from the Ohio, in which stream it is by no means uncommon. The range of this form is from Western or middle Ohio to Kansas and Nebraska; southward it ranges to Trinity river, Texas. It is a member of the bi-alate group, the leading term of which is *Unio alatus* Say.

UNIO LIGAMENTINUS Lamarck.

Plate XXI.

Animaux sans Vertebres, Ed. 1838, Vol. VI, p. 533.

Described as follows:—

U. testa ovali tumida, sub epiderme candida; ligamento subduplici: unico externo detecto; altero intra natem et cardinem obtecto.

"*Habite la riviere de l'Ohio. A. Michaud. La coquille a sur chaque valve un angle obtus au cote anterieur. Son test est tres blanc. Son corselet est un peu eleve en carene. Dent cardinale fort epaisse. Largeur, 77 millimetres.*"

It is quite possible that the very extensive synonymy that is exhibited by this species is due largely to the incomplete description which Lamarck gave to this form. It is widely distributed over the United States from western New York to Michigan, Minnesota, Dakota, and Kansas; south to Texas, Louisiana, Alabama, and Tennessee. In this vast range, throughout which it is common or abundant, it has a wonderfully diversified environment. Its home may be in sluggish and muddy bayous, where it delights to dwell in mud and sand; in rapidly flowing mountain streams, like the upper Cumberland and the Holston rivers, where it may be found on gravel bars or wedged in between the larger rocks in the middle of the channels; in the muddy or gravelly rivers of the western prairie States, as in Iowa and Illinois, where it dwells indifferently in mud or gravel. It follows therefore, that these great differences in environment will be influential in determining its coloration and its form. So it is among the most variable, in minor details, of any of the common river-mussels of the western States, sharing in this regard the changes in form incident to *Unio luteolus* Lamarck and *Unio complanatus* Solander, the last named being a form which has never yet been found in any stream west of the Appalachians, outside the drainage of the Great Lakes. These very variable shells have been described many times by those who look for differences rather than resemblances, and so the great burden of synonymy has arisen. A partial list of the most evident synonyms is given below, a list which does not exhaust, by any means, this fruitful mine.

Unio crassus Say. Nich. Encyc. Am. Ed., Article Conchology, Plate I, Fig. 8, 1816; American Conchology, Pl. VIII, 1831; Reeve, in Conchologia Iconica, *Unio* Plate XCV, Fig. 520, 1868. This is a fine figure of a well-rayed female.

Unio carinatus Barnes. Am. Jour. of Sci. and Arts, 1st series, Vol. VI, 1823, pp. 126 and 259, Fig. 10, Plate 11. From Fox river, Illinois.

Unio ellipticus Barnes. Am. Jour. Sci. and Arts, 1st series, Vol. VI, 1823, Pl. 13, Fig. 19, in outline only. From Fox river, Illinois.

Unio crassus Say, so Conrad, in Monograph of Unio, 1836, Pl. XVI; Reeve, in Conchologia Iconica, *Unio* Plate XL, Fig. 220, 1866. This is a fine figure of a large male specimen.

Unio fasciatus Rafinesque, so Conrad, in Monograph of Unio, 1836, Plate I, p. 3.

Unio powellii Lea. Trans. Am. Philos. Soc., 2d series, Vol. X, Pl. XIX, Fig. 25, p. 270, 1852. From the Saline river, Arkansas, where the writer obtained it in large numbers, in 1891.

Unio pinguis Lea. Jour. Acad. Nat. Sci., 2d series, Vol. IV, 1858, p. 78, Pl. XV, Fig. 58. This is a deformed specimen of *Unio ligamentinus* from the St. Peter's, Minnesota, river. The species was based on a single specimen found in the cabinet of Dr. Budd; no other specimens are known.

Unio upsoni Marsh. Ms. Described in a paper read before the Mercer county, Illinois, Historical Society. The types came from Kishwaukee river, Winnebago county, Illinois. The author of the species thinks he has also recognized it from the White river, Indiana. Having seen the original types, no hesitation is felt regarding this disposition of the form.

Additional to these references little will be needed to understand this species. It may be better understood, however, if a full description of the form be given, and such description follows, drawn from a large series of specimens from the Des Moines river, Iowa, and supplemented by very large numbers from nearly every considerable stream within the geographic range of this form.

Shell large, elliptical, compressed, rounded before, subbiangulate behind, smooth or striate, thickened anteriorly, thin and iridescent posteriorly; epidermis yellowish-straw color, rayed with numerous, broad, green rays, extending from the umbones ventrad; the rays are indistinct or wanting anteriorly; lines of growth numerous and often, especially in old specimens, raised into ridges which are concentric with the ventral margin; ligament long, thick, black, nearly straight; umbones scarcely prominent, approximating, with many very fine, concentric folds, apparent only in young specimens with perfect epidermis; from the posterior edge of the umbones an obtuse angle extends over the disk posteriorly to the margin where it is apparent at one of the angles which renders the outline biangulate; cardinal teeth double in the left, and disposed to be double in the right valve, triangular, crenulate, roughened; lateral teeth long, lamellar, slightly curved ventrad, crenulate; plate between cardinal and lateral teeth incrassate, arched, smooth; anterior cicatrices large, deeply impressed, distinct; posterior cicatrices large, slightly impressed, confluent, that of the *retractor pedis* muscle impressed at the extreme end of the lateral teeth; dorsal cicatrices in the cavity of the umbones as deep pits disposed in a straight line, which ends near the margin of the plate; pallial cicatrix crenulate, deeply impressed anteriorly; nacre pure white, iridescent, in many specimens with a blush of pink or with decided pink coloration.

Length, 125 mm.; height, 75 mm.; breadth, 52 mm.

The measurements given are those of a large specimen from the Des Moines river, at Des Moines. The species often exceeds these dimensions but is commonly found smaller. In the female the posterior margin is much more rounded than in the male, and the biangulate character quite disappears. The general outline is more flowingly rounded, and the transverse measurements somewhat greater, in the female than in the male shell.

Say's description of *Unio crassus* does not agree with his figure, as has already been pointed out by Dr. Lea. He says his species has waves, while the figure, which shows the interior of the shell only, does not give any hint of that character. It is doubtful that the description and figure were made from the same species. Moreover, it will be noticed, from the dates assigned to these several forms in the synonymy, that Say's species was described long before Lamarck framed his description. But there had already been described from Europe, by Retzius, 1788, a species with the name Say employed. Say's name, therefore, falls into synonymy. This shell is often received from correspondents under the name of *Unio luteolus* Lamarck, which form it very closely, in some respects, resembles.

The Arkansas localities, whence the species has been obtained, are the St. Francis river, at Wittsburg; Ouachita river, at Malvern; and Saline river, at Benton. The last named stream is the original one for the shells which Lea described under the name of *Unio powellii*, the female of which is well figured by Reeve in the volume cited. His specimen was a fair exhibition of the Arkansas form.

UNIO LUTEOLUS Lamarck.

Plate III.

Animaux sans Vertebres, 1818, Vol. VI, p. 79; also, same, edition of 1838, Vol. VI, p. 544.

Unio luteolus Lamarck, Reeve, in Conchologia Iconica, *Unio* Plate LVIII, Fig. 239, female; 239b, female, 1867; also, in same, Plate LXI, Fig. 306, as *Unio multiradiatus* Lea, corrected in *errata*. This is a good figure of the female.

Unio siliquoideus Barnes. Am. Jour. Sci. and Arts, 1st series, Vol. VI, p. 269, Fig. 15, 1823. This is female *luteolus*.

Unio inflatus Barnes. Am. Jour. of Sci. and Arts, 1st series, Vol. VI, 1823, p. 266.

Unio hydianus Lea. Trans. Am. Philos. Soc., Vol. VI. p. 14, Pl. VI, Fig., 14, 1834; Reeve, in Conchologia Iconica, *Unio* Plate XXXVII, Fig. 203, female, 1866.

Unio haleianus Lea. Trans. Am. Philos. Soc., Vol. VIII, p. 247, Pl. XXVII, Fig. 63, 1842. Also a form said to be this is figured by Reeve, *Unio* Plate XXIV, Fig. 116, 1865, in Conchologia Iconica. There is no resemblance to Lea's form.

Unio approximus Lea. Trans. Am. Philos. Soc., Vol. X, Pl. V, Fig. 13, p. 74. Described in 1845 from the Red river, Louisiana; published as above in 1848.

Unio distans Anthony. Am. Jour. of Conchology, Vol. I, p. 156, 1865.

Unio affinis Lea. Trans. Am. Philos. Soc., Vol. X, p. 271, Pl. XIX, Fig. 26; Reeve, Conchologia Iconica, Vol. XVI, *Unio* Plate LXI, Fig. 307, 1868. Described from Alexandria, Louisiana.

Obtained by us in the St. Francis river, at Wittsburg; and in the Saline river, at Benton. The Benton form is *Unio hydianus* Lea and is a very abundant one in the Saline.

The original description of Lamarck was as follows:—

" *U testa oblongo-ovata, tenui subpellucida, luteo-virente, radiata; latere antico majore, latiore, rotundato.*

" *Habite la riviere Susquehana et celle Mohancks, dans les Etats Unis.* * * * *La ligament passe entre le crochet et la charniere. Largeur 69 millimetres.*"

This short and imperfect description was not known to the earlier students of American mollusca, and there is little wonder that considerable synonymy has been established on this shell. It has a very wide range, extending from Winnipeg and Slave Lakes and the Saskatchewan river, British America, to central New York, south to Georgia, Alabama, Texas; west to Kansas, Montana and Dakota. In all this range it is abundant in favorable localities and often attains a great size. Lamarck's original specimens did not approach the maximum dimensions which this shell sometimes reaches.

A very beautiful and somewhat depauperate form occurs in the lakes of northern Indiana. It was a specimen of this sort that constituted the basis of Anthony's description of *Unio distans*. Though sometimes confounded with *Unio ligamentinus* Lamarck there is really no excuse for the confusion of the two forms, since they are more dissimilar than alike. The beaks of the young, and this statement is true as well of old and perfect specimens, are beautifully marked with ridges that are concentric, or better, perhaps, angulated, with the very obtuse angle pointing toward the tip of the umbones. In *Unio ligamentinus* this character is not so marked and differs in the degree of fineness of these ridges.

The following description is based upon a series of shells taken from the Des Moines river, in central Iowa :—

Shell large, elongate, somewhat inflated, rather thin, circularly rounded before, elliptically rounded behind, the male often somewhat pointed posteriorly, female more tumid posteriorly, emarginate ventrally; epidermis light horn color, polished and shining, usually abundantly rayed with narrow, bright, green, crenulate, somewhat curved rays which depart from the beaks and cover more or less closely the posterior three-fourths of the disk, these are often wanting, especially in old specimens; lunule long, narrow; ligament long, thin, light horn color; hinge margin nearly straight or very slightly arcuate; umbones prominent, approximate, concentrically wrinkled, the wrinkles being angulate and the apices of each pointing toward apex of the umbone, light, nearly white, in color when the epidermis is perfect; cardinal teeth double in both valves, equal only in the left valve, rather small, thin, acutely serrate, all directed anteriorly; lateral teeth long, thin, lamellar, striate, nearly or quite straight; dorsal plate smooth, short, rounded, thin; anterior cicatrices distinct, that of the adductor rather deep, large, striate, irregularly impressed, that of the *protractor pedis* well impressed but not deep; posterior cicatrices confluent, very slightly impressed, smooth, iridescent; pallial cicatrix well impressed before, broad and shallow, or scarcely impressed, behind; dorsal cicatrices numerous, impressed as deep pits in an irregular row in the center of the cavity of the beaks; cavity of the beaks rather shallow; nacre pure white, sometimes somewhat iridescent posteriorly.

The swollen outline of the full grown female apparently led to the description of this form under the name of *Unio siliquoideus* by Dr. Barnes. This variety in the Mississippi and its larger tributaries, especially those which enter it from the west, is not only abundant, but is frequently the only form found. It is usually, also, of a darker color, and inhabits muddy portions of the river beds. The female shells are usually found in greater abundance than the male forms, but occasionally the latter are most numerous. The female appears to have formed the basis of nearly every described species that has been erected, and which appears in the synonymy given herewith.

UNIO METANEVRUS Rafinesque.

Plate X.

Obliquaria metanevra Rafinesque, Annales Generales des Sciences Physique, Bruxelles, September, 1820, p. 305, Pl. LXXXI, Figs. 15 et 16. Described from Kentucky.

Unio metanevra Rafinesque, so Reeve, in Conchologia Iconica, *Unio* Plate VII, Fig. 25, 1864. A good figure of outside character.

Unio nodosus Barnes, Am. Jour. Sci. and Arts, 1st series, Vol. VI, 1823, Pl. VI, Figs. 7a and 7b, p. 124. Described from Wisconsin; Hildreth in Am. Jour. Sci. and Arts, 1st series, Vol. XIV, p. 281, Fig. 10, 1828.

Unio rugosus Barnes, Am. Jour. Sci. and Arts, 1st series, Vol. VI, 1823, p. 126, Fig. 9. Described from Ohio; Hildreth in Am. Jour. Sci. and Arts, Vol. XIV, 1st series, p. 282, Fig. 12, 1828.

Our Arkansas specimens came from the St. Francis, at Wittsburg; the Ouachita, at Malvern; the Saline, at Benton.

A small number of related forms, constituting a natural group, are headed by this earliest described member; among them are *Unio tuberosus* Lea; *Unio wardii* Lea, and *Unio cylindricus* Say. The type of the group has a wide distribution from Ohio, south to the Coosa and Alabama rivers, Alabama; Louisiana and Texas; west to the Neosho and Elk rivers, Kansas; and north to Dresbach, Minnesota.

This species is exceedingly variable. In the Alabama, Tennessee, Cumberland, and Mississippi rivers it is usually short, thick, and nodulous, and often exhibits a pinkish tinge within. In the Meramec, White, St. Francis, Saline, and Colorado rivers it is larger, flatter, thinner, less nodulous, or the nodules are less numerous, but the individual ones are much larger and smoother. It is such a shell as this, with absolutely perfect beaks and epidermis, that forms the basis of the figure in the plate. It was collected by Prof. B. W. Everman, in the White river, Indiana, and is among the most perfect full-grown specimens known. The arrow-shaped, green markings are well exhibited in the specimen.

Conrad, in his Monograph, Plate V, Fig. 2, gives a fine figure of this species.

UNIO MULTIPLICATUS Lea.

Trans. Am. Philos. Soc., 2d series, Vol. IV, 1830–31, p. 106, Pl. IV, Fig. 2. Reeve, in Conchologia Iconica, *Unio* Plate II, Fig. 8, as *Unio heros* Say ; Lea figures the animal of his species in Jour. Acad. Nat. Sci. Phila., 2d series, Vol. IV, Pl. 30, Fig. 105.

Unio heros Say. New Harmony Disseminator, Vol. II, p. 291, 1829; Conrad in Monograph of Unio, Pl. LIX.

Unio undulatus Say. American Conchology, 1831, Pl. XVI, figured from the Fox river, Illinois. This is not the *Unio undulatus* Barnes, but Say abandoned his *heros* for the name of Barnes thinking the totally dissimilar forms to be identical.

Unio boykinianus Lea. Trans. Am. Philos. Soc., 2d series, Vol. VIII, 1840, p. 208, Pl. XIII, Fig. 22; Reeve, in Conchologia Iconica, *Unio* Plate I, Fig. 1, 1868. Described from the Chattahoochee river, Georgia.

Unio elliottii Lea. Jour. Acad. Nat. Sci. Phila., Vol. IV, 2d series, 1858, p. 54, Pl. VII, Fig. 37. Described in 1856 from Othcalooga creek, Gordon county, Georgia.

Unio eightsii Lea. Jour. Acad. Nat. Sci. Phila., 2d series, Vol. IV, 1860, Plate LXIV, Fig. 192, p. 367, described from Texas and Mexico.

This is the most ponderous *Unio* found in American waters. It sometimes attains, as in the Ohio river, at Evansville and Louisville, the Cumberland, at Nashville, the Alabama, at

Selma, and the Red river, at Shrevesport, very great development. From all these localities we have seen large examples, some of which are believed to be unrivaled elsewhere.

Though Say's name of *heros* has strict priority, it cannot be used for the following reasons: it was poorly described in the beginning; it was abandoned by its author for the name of *undulatus* which had been given to another and distinct species by Barnes, from which procedure it is clear that Say had no clearly defined view concerning this form. Lea's name and description being the first that was accompanied with figures, and being the first clearly to indicate the limits of the species, must be adopted, and his name is now in common use. Say himself said, in his description of Plate XVI, American Conchology: "I formerly considered this species, with much doubt, as distinct from the *undulatus* of Barnes, and gave to it the name of *heros*, but notwithstanding some differences, I have concluded, after a more mature examination and comparison, that it may be with propriety referred to that species. Barnes drew his description and figure from a specimen then unique, * * * which was so eroded as not to exhibit the ornamental tubercles of the umbo and beak." To all who have seen the perfect forms of *undulatus* Barnes and *multiplicatus* Lea the marked differences in the characters of the beaks will be clear. Say abandoned his name for this form, and another student renamed it.

This shell has occurred to us only in the St. Francis river, so far as collections have been made in Arkansas.

I have not seen a specimen of *Unio gigas* Swainson, but a specimen in the Museum Taylor, England, is figured by Reeve as coming from the Ohio river. *Vide Unio* Plate LVI, Fig. 287, Conchologia Iconica, Vol. XVI, 1867. There can be no question that this is also *Unio multiplicatus* Lea, and that it should be placed under the above synonymy.

Reeve describes and figures a shell under the name of *Unio perplicatus* Conrad, in Conchologia Iconica, Vol. XVI, *Unio* Plate IX, Fig. 35, which had been labeled by J. G. Anthony, but which is most certainly a specimen of *Unio multiplicatus* Lea. The specimen was then in the Museum Cuming.

UNIO OBLIQUUS Lamarck.

Plate IV.

Historie Naturelle des Animaux sans Vertebres, 1818, Vol. VI, p. 72; also same, edition of 1838, Vol. VI, p. 534.

Unio undatus Barnes, *in partim.* Am. Jour. of Sci. and Arts, 1st series, Vol. VI, 1823, p. 121, Fig. 4. From the Wisconsin and Fox rivers.

Unio cordatus Rafinesque, so Conrad, in Monograph of Unio, p. 48, Pl. XXV, 1836; also Reeve, *Unio* Plate LXXIII, Fig. 376, 1868.

Unio obliquus Lamarck, so Conrad Monograph Pl. XLIII, Fig. 2, 1838. Conrad is in error in making *ebenus* Lea a synonym of this form.

Much confusion exists regarding this species, which is a highly characteristic one. Very much more extensive collecting than has hitherto been done by any person or organization throughout the range of the form will be needed to place it properly. Whether *Unio pyramidatus* Lea and *Unio mytiloides* Rafinesque may not also fall under it as synonyms could not now be gainsaid.

Lamarck's original description was as follows:—

"*U. testa sublongitudinali, ovato-rotundata, obliqua, sub epiderme candida; ligamento subduplici; dente cardinali crasso, sulcato, bipartito.*

" * * * *Habite la riviere de l'Ohio. A. Michaud. Distincte de la precedente par sa forme: elle est renflee vers les crochets, deprimee vers l'autre extremite, bisillonnee sur le cote anterieur. Longueur apparente, 61 millimetres.*"

The following description is based upon specimens taken from the Cumberland river, at Nashville, Tennessee, where the species is very abundant, and attains a very large size:—

Shell heavy, sulcate, thick, large, triangularly cordate, wrinkled parallel with the lines of growth, compressed on the posterior umbonal slope, turgid or swollen at the umbones, very solid and thick anteriorly; epidermis rather thick, striate, especially at the margins, black or reddish corneous, olivaceous in the young, eradiate; lines of growth numerous, well impressed, crowded confusedly; dorso-posterior margin arcuate, almost circular in old specimens; posterior umbonal slope rounded, much produced in old specimens, with rather marked angle at junction with posterior margin; ventral margin disposed to be sulcate; anterior margin rounded, scarcely produced, not as far forward as the umbonal tips; umbones large, very thick, turgid, somewhat produced beyond the anterior margin, approximating in perfect specimens, minutely undulated at tips; ligament large, thick, long, black, curved parallel to the dorsal margin; lunule large, cordate, black; cardinal teeth large, heavy, short, bifid in the left and disposed to be trifid in the right valve, rough, striate-crenulate, all segments departing at varying angles from a point immediately under the apex of the umbones, the dorsal division in the left valve the largest and heaviest, and parallel to the cardinal teeth; plate joining cardinal teeth with the laterals short, thick, smooth dorsally, but striate ventrally, margin somewhat crenulate; lateral teeth long, thick, slightly curved ventrad, striate-crenulate, rough; anterior cicatrices deep, rough-pitted, distinct, outline of the adductor somewhat triangular, that of the *protractor pedis* elliptical, behind rather than under the adductor; posterior cicatrices distinct, well and deeply impressed, the adductor concentrically striate; the *retractor pedis* circular, pit-like, impressed just below the ends of the lateral teeth; pallial cicatrix broad, crenulate, well impressed throughout, but not deeply impressed anteriorly; dorsal cicatrices not impressed in the cavity of the beaks, but as a broad row on the posterior margin of plate formed by the cardinal teeth, numerous and rough; nacre white, in some specimens with occasional brownish blotches, iridescent posteriorly; dimensions of average mature specimen: length, 95.56 mm.; breadth, 45.00 mm.; height, 77.40 mm.

The only locality in Arkansas which is represented by this form, so far as our collections extend, is the Ouachita river, at Arkadelphia. A single specimen only was secured, but it compares well with typical specimens from the Cumberland river. Not far removed from the forms which we believe will properly group with this as synonyms are other forms such as *Unio plenus* Lea and *Unio solidus* Lea, the relationships of which are yet somewhat problematical.

UNIO OCCIDENTALIS Conrad.

Monograph of Unio, 1836, p. 64, Pl. XXXVI, Fig. 1.

This is an abundant species in central Arkansas, particularly in the Little Red river, Van Buren county; found also in the White river, Carroll county; Saline river, Benton, Saline county.

There is no other form with which this species will be easily confused. It groups with *Unio phaseolus* Hildreth, but is quite distinct from that form; it is commonly much smaller. It was described originally from the Current river, Arkansas, and is not yet known to occur outside of the State.

UNIO OZARKENSIS Call.

Plate XVIII.

Proc. U. S. Nat'l Mus., Vol. X, p. 498, Pl. XXVII, 1887.

The original description of this species follows: —

Shell smooth, elliptical, somewhat compressed laterally, inequilateral, thick, but thickest anteriorly; epidermis thin, striate toward the margins, yellowish-brown, or olivaceous, marked with numerous, obscure, narrow, green rays disposed regularly over the central portion of the disk; lines of growth rather numerous, dark, well marked; dorso-posterior margin curved; posterior umbonal slopes always eradiate, more or less biaugulate, which angulations continued posteriorly mark the siphonal area and render the posterior margin biangular; umbones small, triangular, scarcely prominent, approximating, marked — in non-eroded specimens — by two or three rather coarse undulations; ligament short, thick, light brown; cardinal teeth disposed to be double in both valves, short, oblique, thick, unequally bifid, striated, the posterior division generally thickest and heaviest; lateral teeth rather short, slender, slightly curved, crenulate at extremities, in general direction forming nearly a right angle with a line drawn through the tip of the umbo and the anterior division of the cardinal tooth; anterior cicatrices deep, pit-like, striate, confluent, though in occasional specimens the *protractor-pedis* impression is distinct from the adductors and deep; posterior cicatrices distinct, that of the *adductor* muscle being usually well impressed, that of the *retractor-pedis* muscle circular, pit-like, impressed at extreme end of lateral tooth; pallial cicatrix well impressed throughout, but especially marked anteriorly; dorsal cicatrices irregularly crowded and placed near the inferior edge of the plate, which connects the lateral and cardinal teeth; nacre usually silvery white, occasionally salmon, or warm pink, iridescent posteriorly. Length, 54.50 mm.; breadth, 15.28 mm.; height, 32.76 mm.

The original localities are the White and Current rivers of Arkansas and Missouri; and Jack's Fork of the Current river, Missouri. A single specimen referable to this form has been seen from the Little Red river, at Clinton.

Unio parvus Barnes.

Am. Jour. of Sci. and Arts, 1st series, Vol. VI, 1823, p. 274, Fig. 18; Lea figures the animal in Jour. Phila. Acad. Nat. Sci., 2d series, Vol. IV, Pl. XXIX, Figs. 102, 102a; Conrad, Monography of Unio, 1836, Pl. IX, Fig. I; Reeve, Conchologia Iconica, Vol. XVI, *Unio* Plate XXXV, Fig. 186, a very poor figure from a specimen in the Museum Cuming.

Unio paulus Lea. Trans. Am. Philos. Soc., Vol. VIII, 1840, p. 213, Pl. XV, Fig. 29. From the Chattahoochee river, Georgia.

Unio minor Lea. Trans. Am. Philos. Soc., Vol. IX, 1843, p. 276, Pl. XXXIX, Fig. 3. From Lakes Monroe and George, Florida.

Unio marginis Lea. Jour. Acad. Nat. Sci. Phila., 2d series, Vol. VI, p. 255, 1868, Pl. XXXI, Fig. 69. From Dougherty county Georgia.

Unio corvinus Lea. Jour. Acad. Nat. Sci. Phila., 2d series, Vol. VI, 1868, p. 310, Pl. XLVIII, Fig. 123. From Flint river, Georgia, and Neuse river, North Carolina.

Unio vesicularis Lea. Jour. Acad. Nat. Sci. Phila., 2d series, Vol. VIII, 1874, p. 37, Pl. XII, Fig. 34. From Lake Ocheechobee, Florida.

The Arkansas localities for this form are the St. Francis river, at Wittsburg; Ouachita river, at Arkadelphia; Saline river, at Benton. It no doubt occurs in abundance in many other streams in the State. It is usually a very abundant shell, preferring the muddy banks of bayous and sluggishly flowing portions of streams, where it may be found most commonly buried in the mud. There is but the minute opening leading from the siphons to indicate its presence.

So few animals of the *Unionidæ* have been described that it may not be amiss to insert at this place a description of the animal of *Unio parvus* based upon the examination of specimens taken in the Des Moines river, in central Iowa.

Animal of *Unio parvus.* Color of the mass whitish ; tentacular portion of mantle dark brown, ending in a caruncle; labial palps large, white, triangular, united at base and partially so over the posterior margin; external ctenidium smaller than the internal, thicker and larger at the posterior extremity, which is rounded, and on the margin, which is marked by a double row of minute, white papillæ; ctenidia united above throughout their entire length; free below; internal ctenidium white, ovate.

The mass of the animal within the cavity of the beaks is light brown owing to the color of the large liver which shows through the thin tissues separating it from the cavity of the branchiæ.

The chief anatomical peculiarity is the presence of the caruncle in the female; this is somewhat separated from the main tentacular mass and is supported by a slender pedicel.

UNIO PHASEOLUS Hildreth.

Am. Jour. Sci. and Arts, 1st series, Vol. XIV, 1828, p. 283, Fig. 14; Say, in American Conchology, 1830, Plate 22; Reeve, in Conchologia Iconica *Unio* Plate LXXIII, Fig. 378, 1868; Lea figures splendidly the soft parts in Jour. Acad. Nat. Sci. Phila., 2d series, Vol. IV, Plate XXIX, Fig. 101.

Unio planulatus Lea. Trans. Am. Philos. Soc., Vol. III, 1829, p. 431, Pl. IX, Fig. 13.

Unio camelus Lea. Trans. Am. Philos. Soc., Vol. V, 1834, p. 102, Pl. XV, Fig. 45. Reeve, in Conchologia

Iconica, *Unio* Plate LV, Fig. 283, 1867. Both Reeve and Dr. Lea had before them, for drawing and description, large and well-worn, very old, specimens.

This form has occurred to us in the Ouachita, at Malvern, and the Saline river, at Benton. From the last named place large and fine examples that would readily pass under the name of *Unio camelus* Lea were obtained. The range of the species is from western New York west to Kansas and south to Texas. It attains a very great size in the Cumberland river, Tennessee, where it is exceedingly abundant. Specimens collected by amateurs have been received under the name of *Unio arctior* Lea.

Unio plenus Lea.

Trans. Am. Philos. Soc., Vol. VIII, 1840, p. 211, Pl. XIV, Fig. 26; Reeve, Conchologia Iconica, *Unio* Plate LXI, Fig. 305, Vol. XVI.

The westernmost range for this form has been determined thus far to be eastern Kansas in the Neosha river. In Arkansas it has occurred to us in collections made in the Ouachita river, at Malvern, and in the St. Francis river, at Wittsburg. It is a very abundant shell in the first named stream. See remarks under *Unio obliquus* Lamarck.

Unio plicatus Lesueur.

Name adopted by Lea from ms name given by Lesueur. *Vide* Trans. Am. Philos. Soc., Vol. III, 1829, p. 409.

Unio rariplicata Lamarck. Historie Naturelle des Animaux sans Vertebres, edition 1818, Tome VI, p. 71. From the Ohio.

Unio hippopæus Lea. Trans. Am. Philos. Soc., 2d series, Vol. X, Pl. I, p. 67, Pl. I, Fig. 1, 1845. From Lake Erie. Reeve, in Conchologia Iconica, Vol. XVI, *Unio* Plate XI, Fig. 40, 1864. This is a depauperate form of *Unio plicatus*.

Unio neislerii Lea. Jour. Acad. Nat. Sci., Phila., Vol. IV, 1859, p. 212, Pl. XXVI, Fig. 93. From the Flint river, Georgia.

Unio brazosensis Lea. Jour. Acad. Nat. Sci. Phila., 2d series, Vol. VI, 1868, Pl. 48, Fig. 122, p. 309. Based upon a young specimen from the Brazos river, Texas.

Unio lincecumii Lea. Jour. Acad. Nat. Sci. Phila., 2d series, Vol. VI, 1868, p. 312, Pl. 49, Fig. 125. Species based upon three specimens from the Brazos river, Texas.

Unio perplicatus Conrad. Jour. Acad. Nat. Sci., Phila., 2d series, Vol. VIII, p. 178.

Unio pauciplicatus Lea. Jour. Phila. Acad. Nat. Sci., 2d series, Vol. VIII, 1874, p. 29, Pl. 9, Fig. 26. Described from specimens obtained in the Colorado river, Austin, Texas.

Reeve also figures, under the MS name of *Unio perlensis* Conrad, with the habitat "North America", a shell contributed to the Museum Cuming by John G. Anthony, which appears to be an abnormal form of this species. *Vide* Conchologia Iconica, Vol. XVI, *Unio* Plate XI, Fig. 42.

This *Unio* occurs in great numbers in the St. Francis river, at Wittsburg, rivaling all others, save, perhaps, *Unio trapezoides* Lea. The form is the short and somewhat ventricose one, which Mr. Conrad called *perplicatus*. It also occurred in some abundance in the Saline river, at Benton.

The form which Mr. Lea called *Unio hippopœus*, from Lake Erie, is without question a depauperate *plicatus* and is not entitled even to varietal distinction. Throughout the great geographical range of this species almost every possible variety of environment is to be found, and it would be strange indeed if the shells did not in some measure respond to these factors. It is usually abundant, wherever it occurs at all. In central Iowa it is rare, but in the Mississippi river, on the eastern border of that State, it is both common and large. In the Cumberland river it is a very abundant shell; and is, in short, to be reckoned among the most common of our Unios. In Arkansas, aside from the localities named above, the shell is said to be abundant in the Little Red river, though we have not seen specimens that came from that stream. From the Cedar river, Iowa, was obtained a specimen which presented the following dimensions: length, 135 mm.; height, 98 mm.; breadth, 59 mm.

UNIO PURPURATUS Lamarck.

Plate V.

Animaux sans Vertebres, 2d Ed., Vol.VI, p. 533, 1838. Described from the Mississippi; Reeve, in Conchologia Iconica, Vol. XVI, *Unio* Plate XXIV, Fig. 115, 1865.

Unio ater Lea. Trans. Am. Philos. Soc., Vol. III, 1829, Pl. VII, Fig. 9, p. 426. This is the female and was described from specimens taken in the Mississippi river, below Natchez.

Unio lugubris Say. American Conchology, 1832, Plate XLIII. Described from the Bayou Teche, Louisiana. This name was proposed by Say for Lea's species, he doubtless thinking that Nilsson's name had priority.

Unio poulsonii Conrad. New Fresh Water Shells of the United States, 1834, pp. 25–26, Pl. I; Reeve, in Conchologia Iconica, Vol. XVI, 1866, *Unio* Plate LI, Fig. 270. Conrad described his form from the Black Warrior river, Alabama.

Unio coloradoensis Lea. Jour. Acad. Nat. Sci. Phila., 2d series, Vol. III, 1857, p. 314, Pl. XXXI, Fig. 29. Described in 1856, from specimens obtained in the Colorado river of Texas.

This species is among the most ponderous of North American *Uniones*. Chiefly confined to the streams of the southern United States it yet ranges as far north as middle Kansas, and eastwardly to north Alabama and Georgia. In Mississippi, Louisiana, Arkansas, and Texas it is both common and large, but does not rival the giant forms which have come to our cabinet from the Little Arkansas river, near Wichita, Kansas. Two specimens from that locality, and those not the largest, form the basis of the figures which are given herewith.

Lamarck's description, but not his original one, is given herewith, the bibliographic reference to which appears in the above synonymy.

"*U. testa ovato elliptica, tumida, anterius subbiplicata, intus viridi-violaceo purpureoque tincta; dente laterali crenulato.* * * * *Habite le Mississipi* * * * *Je la crois des grandes rivieres de l'Afrique.* * * * *Belle et grande* *coquille a nacre pourpree avec des taches irregulieres d'un vert violatre, sur-tout sous les crochets. Largeur de mon exemplaire, 139 millimetres. La dent cardinale est epaisse mais de taille mediocre. L'autre dent est tres finement crenelee.*"

The reference of this form to the rivers of Africa is, of course, entirely incorrect; its general resemblance to *Pleiodon* may have caused the statement.

Lea's *Unio ater* is the female of this species, while his *Unio coloradoensis* is based upon a large male. Conrad's *Unio poulsonii* is also a male. Again Say described, for his form, the female.

The shell may be described as follows from the appearances presented by mature and large specimens taken in the Little Arkansas river, Kansas, by Mr. J. R. Mead.

Shell large, heavy, smooth, striate, posteriorly elliptical, convex, thick, very thick anteriorly, rounded before, obtusely biangulate behind; epidermis thick, black, striate towards the margin, and on the posterio-dorsal slope, umbonal slope shining, eradiate or obscurely rayed, the rays seen only on the thin margins of the old specimens, in the young as many capillary lines over the whole disk of the umbones; lines of growth conspicuous, numerous and crowded, in old specimens forming slightly raised ridges, which are parallel to the margins but which, posteriorly, form imbrications, these are often broken and give the shell an exceedingly rough appearance; dorso-posterior margin slightly curved; posterior, umbonal slope marked by two carinæ, one of which is very prominent, the other but slightly indicated, these, at the posterior margin, indicate the positions of the incurrent and excurrent orifices and render the margin biangulate; umbones large, prominent, rounded, always so eroded in the old shell as not to disclose the character of the undulations, but nearly perfect, young specimens present indications of apiculate folds; ligament long, thick, black, scarious, rough; cardinal teeth single in the right and double in the left valve, of young specimens, but disposed to be trifid in the right valve, in large and old specimens, erect, dentate, rough, triangular, the anterior portion, in the left valve, the larger; lateral teeth long, straight, thick-lamellar, smooth, but often slightly crenulate on the margin, separated entirely from the cardinals, there being no connecting plate, forming an angle of 130° with a line drawn through the tips of the umbones to the tip of the anterior division of the cardinals; anterior cicatrices distinct, very large, and very deeply impressed, striate, sometimes roughened, deepest close to the base of the cardinal teeth; pallial cicatrix very deep anteriorly, crenulate, and lightly impressed behind; posterior cicatrices large, confluent, not at all impressed, concentrically striate, the *retractor pedis* impression neither on nor very near the end of the lamellar laterals; dorsal cicatrices disposed variously, and always irregularly, in the cavity of the beaks, sometimes quite central; nacre always rich purple, commonly roughened with numerous small pear-like masses studding the body cavity.

Dimensions of large male: length, 165.00 mm.; breadth, 66.00 mm.; height, 116.50 mm. Dimensions of large female: length, 141.50 mm.; breadth, 68.15 mm.; height, 96.76 mm.

Unio pustulatus Lea.

Trans. Am. Philos. Soc., Vol. IV, 1830, p. 79, Pl. VII, Fig. 9. Described from the Ohio.

Unio nodulatus Rafinesque. So Conrad, Monography of Unio, Pl. XLV, Fig. 1, 1838; Reeve, in Conchologia Iconica, Vol. XVI, *Unio* Plate XIII, Fig. 51, 1864.

This form is easily distinguished from the related species which follows, by the fewer pustules which are larger than in *Unio pustulosus* Lea, and are besides differently disposed over the disk. Moreover, its quadrate outline is dissimilar to that presented by any other of the pustulate Uniones.

In the St. Francis river, at Wittsburg, the species occurs in very great numbers, and is well developed and perfect; it was also found, sparingly, at Benton, in Saline river. It is so well marked that very few synonyms have been made from this shell, a fact that few other species will illustrate.

Unio pustulosus Lea.

Plates XIII–XV.

Trans. Am. Philos. Soc., Vol. IV, 1830, p. 64, Pl. VIII, Fig. 7, from the Ohio and Alabama rivers; Reeve, in

Conchologia Iconica, Vol. XVI, *Unio* Plate XII, Fig. 43, as *Unio bullatus*, Rafinesque, 1864; *Unio bullatus* Rafinesque; so Conrad, in Monograph of Unio, Pl. XL, Fig. 2, 1838. This is probably the form intended by Hildreth as his *Unio verrucosa alba*. *Vide* Am. Jour. Sci. and Arts, 1st series, 1828, Vol. XIV, p. 289.

Unio schoolcraftensis Lea. Trans. Am. Philos. Soc., Vol. V, 1832, p. 37, Pl. III, Fig. 9, from Fox river, Wisconsin. This name, for grammatical reasons, was subsequently changed to *schoolcraftii*. Reeve also figures this form, Conchologia Iconica, Vol. XVI, *Unio* Plate I, Fig. 3, 1868. Plates XIII, XIV, Figs. 1–4, herein.

Unio prasinus Conrad. New Fresh Water Shells of the United States, 1834, p. 44, Pl. III, Fig. 1. An immature shell from Fox river, Wisconsin. Reeve, Conchologia Iconica, Vol. XIV, *Unio* Plate VII, Figs. 26a, 26b, 1864; these two figures are excellent, and are taken from specimens presented to the Museum Cuming by John G. Anthony.

Unio turgidus Lea. Trans. Am. Philos. Soc., Vol. VI, 1834, p. 11, Pl. V, Fig. 11; Reeve, Conchologia Iconica, Vol. XVI, *Unio* Plate III, Fig. 10, 1864. Described from near New Orleans, Louisiana.

Unio dorfeuillianus Lea. Trans. Am. Philos. Soc., Vol. VI, 1836, p. 73, Pl. XVII, Fig. 54; Reeve, Conchologia Iconica, Vol. XVI, *Unio* Plate X, Fig. 38, 1864. A poor figure. Described from the Ohio river, at Cincinnati. Plate XV, Figs. 1–2, herein.

Unio mortoni Conrad. Monograph of Unio, p. 11, Plate VI, Fig. I, 1836. Described from the Bayou Teche, Louisiana. This is Lea's *Unio turgidus*.

Unio pernodosus Lea. Trans. Am. Philos. Soc., Vol. X, 1845, p. 71, Pl. III, Fig. 8; Reeve, Conchologia Iconica, Vol. XVI, *Unio* Plate XII, Fig. 46, 1864. Described from North Carolina.

Unio asperatus Lea. Jour. Acad. Nat. Sci. Phila., 2d series, Vol. V, 1861, p. 68, Pl. VII, Fig. 218; Reeve, Conchologia Iconica, Vol. XVI, *Unio* Plate LXXXV,

Fig. 450, 1868. Described from the Alabama river, at Claiborne.

Unio vallatus Lea. Jour. Acad. Nat. Sci. Phila., 2d series, Vol. VI, 1868, p. 315, Pl. L, Fig. 128. Described from Alabama.

Unio refulgens Lea. Jour. Acad. Nat. Sci. Phila., 2d series, Vol. VI. 1868, p. 317, Pl. LI, Fig. 130. Described from Lauderdale county, Mississippi. Plate XV, Figs. 3–4, herein.

Unio sphæricus Lea. Jour. Acad. Nat. Sci, Phila., 2d series, 1868, Vol. VI, p. 319, Pl. LI, Fig. 132. Described from the Pearl river, Mississippi.

Unio cahabensis Lea. Jour. Acad. Nat. Sci. Phila., 2d series, Vol. VIII, 1874, p. 17, Pl.V, Fig. 14. Described in 1871 from the Cahaba river, Alabama.

This is an abundant form in the St. Francis, at Wittsburg, and a common one in the Saline, at Benton. It is, no doubt, quite generally distributed over the State, and the various names above listed are represented by many of the varying forms which the species exhibits. It will be noticed, in the above synonymy, that several of the so-called species come from the same stream or drainage area, and their descriptions are separated from one another by the interval of a few years. Specimens of every form listed in this synonomy, Lea's species all having been named by himself, have been seen and studied in the course of the past ten years. With the exception of *Unio turgidus* Lea examples of every species is before the writer at this time. No hesitation is felt in regarding this series of forms as one species, varying only in those trivial matters which should not, at most, constitute varietal value and which are the expression of different geographic factors.

The plates given herein show certain of the forms of this widely distributed shell, in some of its most marked phases. Recently, from Louisiana comes a form of *pustulosus* that is very like *sphæricus*, as it is found in Texas ; from the Ouachita, at Arkadelphia, come excellent specimens of *refulgens* which, in large series, approach the Louisiana forms. The St. Francis river presents the typical specific form, and with it *sphæricus* and *dorfeuillianus*, all intergrading in so marked a manner that identity must be regarded as established. From the Little Arkansas, at Wichita, Kansas, come numbers of magnificent examples of *schoolcraftii*, some entirely covered with pustules, others absolutely devoid of even a semblance of one; indeed, the writer's collection contains some fifty examples from that stream, exhibiting every phase of nodulation from absolutely smooth specimens to those showing great numbers of small pustules. The characters of the cardinal teeth alone would have sufficed, in the hands of species mongers, to make a dozen "extremely characteristic" species.

The Des Moines river, in central Iowa, presents only the form to which Mr. Lea gave the name of *Unio schoolcraftii*. From this form of the shell a number of the figures given have been made. As in typical *pustulosus* so here there is every degree of nodulation and even of rotundity of form. *Unio vallatus* from Alabama, which was collected by the writer in great numbers in Alabama a few years ago, much resembles the form from Iowa even in the numbers and disposition of the pustules. The female is often somewhat emarginate, but does not approach *Unio pustulatus* Lea in that respect. In *refulgens* the truncated posterior is the most marked differential feature. Plates XII to XIV represent *schoolcraftii* in its various phases.

UNIO RECTUS Lamarck.

Plate VII, (male in outline.)

Historie Naturelle des Animaux sans Vertebres, 1819, Vol. VI, p. 74; described from Lake Erie. Same, 2d edition, Vol. VI, p. 537, 1838; Reeve, in Conchologia Iconica, Vol. XVI, *Unio* Plate XIX, Fig. 86, 1865, the figure is that of a large and old male; Conrad, Monograph of Unio, Pl. XV, 1836.

Unio prælongus Barnes. Am. Jour. of Sci. and Arts, 1st series, Vol. VI, No. 1, p. 261, Fig. 11, 1823.

Unio sageri Conrad. Monograph of Unio, 1836, p. 53, Pl. XXIX, from the Detroit river.

Unio leprosus Miles. Annual Report of the Geological

Survey of Michigan, 1861, p. 240. From the Huron river.

Arkansas specimens have been seen only from the St. Francis, at Wittsburg, and the Saline, at Benton. It doubtless occurs in nearly all the large streams in that State.

Lamarck's description of *Unio rectus* runs as follows:—

"*U. testa transversim elongata, angusta, convexa, anterius, subangulata; latere antico striis longitudinalibus obliquis, remotis obsoletis.* * * * *Habite le lac Erie, Michaud. Elle a presque la forme du mytilus lithophagus, Son test est blanc, recouvert d' un epiderme brun noiratre. Largeur, 100 millimetres.*"

The figures here given in the plate are of shells collected in the Des Moines river, and upon similar shells the description of the species, given below, is based: —

Shell large, smooth, elongate, compressed laterally, thick, very thick anteriorly, rounded before, pointed posteriorly, epidermis thick black, or reddish corneous, shining, obscurely rayed with dark green, the broad rays not very apparent in old specimens, lines of growth numerous, well marked, imbricated posteriorly, and often so on ventral margin; dorso-posterior margin straight, or nearly so; posterior umbonal slopes gently rounded, becoming more angular near the beaks, much imbricated towards posterior margin; umbones small, scarcely approximating, marked, in non-eroded specimens, by many minute, fine, concentric crenulations or folds; ligament long, thick, black, sometimes dark brown; cardinal teeth double in the left, and disposed to be double in the right valve, the larger portion erect, sometimes sharp, sometimes blunt, and commonly gently posteriorly recurved, the characters of the double portion in left valve various, sometimes sharp, often blunt, or smooth rounded; lateral teeth long, lamellar, straight, finely crenulate on margins; anterior cicatrices very large, deep, striate, distinct, that of the *protractor pedis* impression considerably above the lower margin of the large and deep adductor cicatrix; posterior cicatrices not deeply impressed, confluent, very large, pallial cicatrix very deep anteriorly, irregularly impressed throughout, crenulate; dorsal cicatrices impressed deeply in the center of the cavity of the beaks, large, often pit-like, in old shells exhibiting two or three large scars, circular in outline, and as deep as the *protractor pedis* impression, though the posterior one is commonly oval; plate connecting the cardinal and lateral teeth not well developed; nacre usually dark purple, often pink, white, or salmon; frequently the coloration is confined to the region of the cardinal and lateral teeth, the remainder of the interior being pure white.

Length, 171 mm.; breadth, 60 mm.; height, 70 mm.

These are the dimensions of very large shells collected in the Cedar river, Iowa.

This species ranges from New York to Minnesota, Nebraska, Kansas, Indian Territory and Texas, to Georgia, and is common throughout all that vast area.

UNIO RETUSUS Lamarck.

Plate VIII.

Historie Naturelle des Animaux sans Vertebres, 1819, Vol. VI, p. 72; also, 2d edition, 1838, Vol. VI, p. 534. Described as from Nova Scotia. Reeve, in Conchologia Iconica, Vol. XVI, *Unio* Plate LXXI, Figs. 363a, 363b, 1868.

Unio torsa Rafinesque. Annales Generales des Sciences Physiques, Bruxelles, 1820, Vol. V, p. 311, Plate LXXXII, Figs. 1, 2 et 3. Described from the Ohio. See also Conrad, in Monograph of Unio, Plate VIII, 1836, p. 19.

Unio obtusa Say. So Deshayes, in Cuvier's Regne Animal, *teste* Lea. I have been able to find no work in which Say uses this name for any *Unio*.

Lamarck described this shell in the following terms:—

"*U. testa rotundata, tumida, intus violacea; natibus retusis, erosis; dente laterali breviusculo.* * * *

Habite les rivieres de la Nouvelle-Ecosse. A. Michaud. Test epais; epiderme d' un vert jaunatre; dent cardinale grossiere, sillonnee, divisee en deux. Longueur apparente, 47 millimetres."

The range of this species is rather more restricted than is common for Unios of this type. It has been found only in the drainage of the Ohio, and the Mississippi river itself, but is not yet known from streams beyond. South it ranges to the Holston river, in east Tennessee, and to the Cumberland, at Nashville. It is there quite abundant. There is certainly an error in assigning to this species the distant habitat of Nova Scotia, as was done by Lamarck in originally describing it. The great traveler and naturalist, Michaud, had secured this form, with numerous others, during his visit to the New World, and from material furnished by him Lamarck drew his description. The localities were either confused by Lamarck, or what would be more natural under the circumstances, had been confounded by the collector. However this may be, the original shells were most certainly obtained elsewhere than in the region named by Lamarck.

From specimens furnished by Professor Barton W. Evermann, and taken in the White river, Indiana, the following description is drawn:—

Shell rotund, large, smooth, convex, heavy, rounded before, circular behind; epidermis rather thin, polished, striate, disposed to imbrication towards the margins, olivaceous, lines of growth numerous, crowded, darker; dorso-posterior margin curved and rounded; postero-dorsal umbonal slope lighter horn-colored, with numerous capillary rays of green, which are especially marked near the beaks, this slope is separated from the lateral umbonal slope by a rather well marked angle, it has also two slightly marked carinæ; umbones large, prominent, approximating closely, curved anteriorly, and projecting slightly beyond the antero-ventral margin, smooth; ligament short, thick, curved with dorsal margin, light horn-color; lunule large, cordate, scarious; cardinal teeth single in the right, double in the left valve, multi-tuberculate, striate, crenulate, the folds all originating at a common point immediately under the tip of the umbone, as a whole the segments are triangular, massive, thick, short; lateral teeth long, curved, commencing well toward the dorsal margin, and nearly on a line with the anterior portion of the cardinals, lamellar, somewhat thick, double in both valves, crenulate on the margins; the plate connecting the cardinal with the laterals has several folds or plications, rather thin; anterior cicatrices distinct, deep and pit-like, not very large, the adductor roughened, the *protractor pedis* striate; posterior cicatrices deeply impressed, large, confluent, that of the *retractor pedis* at the tip of lamellae of lateral teeth; dorsal cicatrices numerous, pit-like, often confluent, placed on the plate formed by the base of the cardinal teeth; pallial cicatrix well impressed throughout, but deepest and most crenulate anteriorly; nacre rich purple, lighter to white on the margins, beyond the pallial line.

Length of a mature specimen, 70.75 mm.; breadth, 43.50 mm.; height, 74.56 mm.

The species has not yet been found, to our knowledge, in Arkansas; the conditions which obtain in the bayous along the Mississippi are such, however, that it may reasonably be expected to occur since it is common in the Mississippi river farther to the north.

UNIO ROTUNDATUS Lamarck.

Plate IX.

Animaux sans Vertebres, in Historie Naturelle, 1819, Vol. VI, p. 75; also, same, edition of 1838, Vol. VI, p. 538. From unknown locality.

Unio suborbiculatus Lamarck, Historie Naturelle Animaux sans Vertebres, Vol. VI, p. 81; also 2d edition, 1838, Vol. VI, p. 546. From locality unknown.

Unio glebulus Say. Transylvania Journal of Medicine, Vol. IV, p. 526, 1831; also American Conchology, 1832, Plate 34, female; Reeve, Conchologia Iconica, Vol. XVI, *Unio* Plate LXXIV, Fig. 384, young and not characteristic female. Described from the Bayou Teche, Louisiana.

Unio subglobosus Lea. Trans. Am. Philos. Soc., Vol. V, 1837, p. 30, Pl. II, Fig. 3; Reeve, Conchologia Iconica, Vol. XVI, Plate *Unio* LXIV, Fig. 321, 1868. Described from the Bayou Teche, Louisiana. Reeve's figure is that of an old male.

Reeve also figures, as this form, a shell on Plate XXIII, Vol. XVI, figure 106, which is certainly some other species. Correcting the error in the addendum to *Unio* he quotes Conrad, who thinks that the shell may be *Unio kienerianus* Lea. It is certainly much like it.

This is a rare species, and will probably always be so considered. It has not occurred to any collector outside of Louisiana, though it has been found in other than the original locality. There is a fine specimen in my collection which was recently obtained in Crass Lake near Shrevesport, Louisiana, by Mr. Wayland Vaughan, that is very characteristic indeed. Besides, there is before us a suite of three specimens that formerly belonged to Dr. Gerard Troost, of Nashville, Tenn., a warm personal friend of Thomas Say, and a member, for a time, of the singular community which sprang up at New Harmony, Indiana. To him Say gave these examples of his *glebulus*, the original label of which is still treasured with the specimens. They came into my hands through the kind liberality of Dr. J. Berrien Lindsley, of Nashville, who became the owner of Troost's collection, or of most of it. The history is complete, and there is no question that this lot has passed nnder the inspection of the great naturalist who described it as new. The suite is from the Bayou Teche, Louisiana.

Lamarck described this shell in the following terms:—

"*U. testa elliptico-rotundata, inferne ventricosa, sub epiderme splendide margaritacea; cardine arcuato. Habite* * * * . *Coquille rare, d'une forme singuliere pour le genre, et dont la nacre est argentee, legerement teinte de rose, irisee et tres brillante. Largeur, 78 millimetres. Elle a un pli sur le cote anterieur.*"

The "silvery nacre" indicated by Lamarck has been exhibited by but one specimen which has come to our notice. The original description of *Unio suborbiculatus* Lamarck comes nearer to the conditions exhibited by this shell, but the example must have been a very large one. To connect the two better, in the mind of the reader, it is only necessary to add that Lamarck himself gives Say's *glebulus* as a synonym, that is to say, this has been done by Deshayes, who edited the second edition of the Animaux sans Vertebres. Lea, who saw the original example of *Unio rotundatus*, in the collection of the Baron de Ferussac, surrendered his species to Lamarck.

From the examples in our cabinet, formerly belonging to Troost, the following description is made: —

Shell subcircular in outline, globose, convex, the longitudinal about twice the lateral diameter, the male somewhat compressed, rounded before, and angular behind, the female somewhat emarginate posteriorly; epidermis thin, olivaceous, greener over the umbones, eradiate, striate towards the margin, velvety; lines of growth numerous, and crowded, especially so near the region of the margin, often broad and darker colored; posterior-umbonal slope separated from the lateral slope by a well-marked angulation, with two rather faint carinæ; umbones small, scarcely rounded, depressed, without undulations; ligament short, rather thin, scarious, light brown, curved with the dorsal margin; cardinal teeth short, thick, erect, slightly inclined forwards, double in the left, and disposed to be trifid in the right valve, the central mass of the right tooth far the largest; the plate connecting the cardinals with the laterals is poorly developed, thin, rounded, smooth; lateral teeth short, distant from the cardinals, straight, single in the right and double in the left valve, crenulate, rather thin; naterior cicatrices distinct, deep, and pit-like, roughened, somewhat excavated under the plate formed by the cardinal teeth; pallial cicatrix faintly impressed throughout; posterior cicatrices very large, confluent, that of the *retractor pedis* at extreme tip of lateral teeth; dorsal cicatrices small, arranged in a more or less regularly disposed row within the cavity of the beaks, pit-like and deep; nacre purplish or rose-tinted, — this coloration is most marked on the teeth and extends as a mere blush of pink or rose over the balance of the shell. One specimen, from Shreveport, is pure white except a portion of the lateral teeth and the tips of the cardinals, approaching most nearly Lamarck's description of the silvery nacre. Dimensions of mature male: length, 61.60 mm.; breadth, 31.32 mm.; height, 45.58 mm.; of mature female: length, 54.20 mm.; breadth, 32.70 mm.; height, 41.02 mm.

This species will doubtless yet be found in southeastern Arkansas, in muddy bayous. Its close resemblance to a

Cyrena or to a *Cyprina* in color, and general character of the epidermis, will serve to readily distinguish it from all related forms.

UNIO SECURIS Lea.

Trans. Am. Philos. Soc., Vol. III, 1829, p. 437, Pl. XI, Fig. 17; embryo figured in Jour. Acad. Nat. Sci. Phila., 2d series, Vol. IV, p. 47, Pl. V, Fig. 6, 1858; Reeve, Conchologia Iconica, Vol. XVI, *Unio* Plate LXI, Fig. 304, 1868. Described from the Ohio.

Unio lineolatus Rafinesque. So Say, in American Conchology, Plate XLVIII. This part, VII, is undated and was published by Mr. T. A. Conrad, after Mr. Say's death.

The only occurrence to us, in Arkansas, of this shell was in the St. Francis river, at Wittsburg, where it is commonly found on the muddy bottoms in great numbers and of large size. Its cuneiform shape separates it readily from all others likely to be found in Arkansas.

UNIO SPECIOSUS Lea.

Jour. Acad. Nat. Sci. Phila., 2d series, Vol. V, p. 207, Pl. 31, Fig. 276; Reeve, Conchologia Iconica, Vol. XVI, *Unio* Plate LXXXIV, Fig. 447, 1868. Described and figured from Texas.

This shell has not been found by us in Arkansas nor have we seen more than one specimen, said to have been taken in the Ouachita river, near the Indian Territory boundary. If this is its real habitat it properly belongs in this list and will, besides, be found at other localities within the State of Arkansas.

UNIO SUBGIBBOSUS Lea.

Jour. Acad. Nat. Sci. Phila., 2d series, Vol. IV, 1858, Pl. VI, Fig. 36, p. 53. Described from the Oostanaula and Etowah rivers, Floyd county, Georgia.

In the remarks accompanying this form's characterization Mr. Lea says that he has specimens received from Dr. Hale, from the Red river, Arkansas. On this statement the shell is listed in this register. Recently a large set of some twenty specimens was received from Carney Bayou, Claiborne Parish, Louisiana, rendering it very likely that the shell will yet be found abundantly in favorable localities in Arkansas. Some years since the writer collected it, in large numbers, in Piney river, Texas county, Missouri. It groups with Barnes form, along with *Unio sublatus* Lea, though the specific value of all the forms is doubtful, the point cannot be settled now. The specimens from Louisiana and Missouri have been compared with large suites from the Oostanaula river, collected in 1881. They differ in no respect.

UNIO SUBROSTRATUS Say.

New Harmony Disseminator of Useful Knowledge, January 15, 1831; reprint by Say, p. 6. From the Wabash river. The shell which Reeve figures for this species, Conchologia Iconica, Vol. XVI, *Unio* Plate XVII, Fig. 78, is *Unio iris*, and was drawn from a specimen communicated by John G. Anthony, who, evidently, did not know the species.

Unio nashvillianus Lea. Trans. Am. Philos. Soc., Vol. V, 1834, p. 100, Pl. XIV, Fig. 43; Reeve, Conchologia Iconica, Vol. XVI, *Unio* Plate XXX, Fig. 158. Described from specimens communicated by Dr. G. Troost from the Cumberland river, at Nashville. See below.

Unio mississippiensis Conrad. Jour. Acad. Nat. Sci. Phila., 2d series, 1850, p. 277, Pl. XXXVIII, Fig. 11; Reeve, Conchologia Iconica, Vol. XVI, *Unio* Plate XIX, Fig. 85. Described from the lower Mississippi.

Unio nigerrimus Lea. Trans. Am. Philos. Soc., Vol. X, 1852, p. 268, Pl. XVIII, Fig. 23. From Alexandria, Louisiana.

Unio rutersvillensis Lea. Jour. Acad. Nat. Sci. Phila., 2d series, Vol. IV, 1860, p. 356, Pl. LX, Fig. 181. Described from Rutersville, Fayette county, Texas.

Unio topekaensis Lea. Jour. Acad. Nat. Sci., 2d series, Vol. VI, 1868, p. 313, Pl. XLIX, Fig. 126. Described from near Topeka, Kansas.

Specimens were secured from the White river, Carroll county; the St. Francis river, at Wittsburg; the Ouachita, at Arkadelphia; the Saline, at Benton.

A specimen of this shell was reported on by Dr. Lea in the Proceedings of the Philadelphia Academy of Natural Sciences for 1860, page 51, to which was assigned the indefinite locality of "Arkansas." It was reported under the name of *Unio nasutus* Say, a species which does not occur west of the Appalachians, outside of the drainage of the Great Lakes. It was peculiar in that the teeth were reversed, being single in the left and double in the right valve.

In some MS notes left by Dr. G. Troost in his copy of Volume I of Observations on the Genus Unio, now in the library of Dr. J. Berrien Lindsley, of Nashville, the statement is made that the shell which Lea called *Unio nashvillianus* was not originally found in the Cumberland river, but in the Harpeth river, some miles further south. The original locality will, therefore, be the latter river. The original specimen, with Lea's name in MS is now in my possession. The writer has, however, found the species in the Cumberland, at Nashville.

Unio tetralasmus Say.

Plates XIX, XX.

American Conchology, Plate XXIII, 1830. Described from the Bayou St. John, Louisiana. This plate is copied in Plate XX herein, figures 4, 5.

Unio declivis Say. Transylvania Journal of Medicine, Vol. IV, 1831, p. 527; American Conchology, Plate XXXV, 1832; Conrad, Monograph of Unio, p. 45, Pl. XXIII, Fig. 1, 1836. Described from the Bayou Teche, Louisiana.

Unio camptodon Say. American Conchology, 1832, Pl. XLII, Reeve, Conchologia Iconica, Vol. XVI, *Unio* Plate LXX, Fig. 356. From near New Orleans, Louisiana.

Unio geometricus Lea. Trans. Am. Philos. Soc., Vol. V, 1832, p. 38, Pl. IV, Fig. 10. Described from the Bayou Teche, Louisiana.

Unio excultus Conrad. Monograph of Unio, 1836, pp. 99–100, Pl. LV, Fig. 1. Described from near New Orleans, Louisiana. A copy of this figure is given herewith, Plate XX, Figs. 1–3.

Unio sayii Ward. So Tappan in Am. Jour. Sci. and Arts, 1st series, Vol. XXXV, 1839, p. 268, Pl. III, Fig. 1; Conrad, Monograph Plate LVI, Fig. 2, as *Unio sayanus* Ward. These figures are produced herewith, on Plate XIX, figures 3–5. Described from Circleville, Ohio.

Unio symmetricus Lea. Trans. Am. Philos. Soc., Vol. X, 1845, p. 73, Pl. IV, Fig. 11. From the Red river, Alexandria, Louisiana.

Unio subcroceus Conrad. Jour. Acad. Nat. Sci. Phila., 2d series, Vol. II, p. 297, 1854, Pl. XXVI, Fig. 1. Described from a stream in Arkansas, tributary to the Canadian fork of Red river.

Unio manubrius Gould. Proc. Bost. Soc. Nat. Hist. Vol. V, 1855, p. 229. From Chihuahua, Mexico.

Unio jamesianus Lea. Jour. Acad. Nat. Sci. Phila., 2d series, 1858, Vol. IV, p. 52, Pl. VI, Fig. 35. Described from a single specimen obtained at Jackson, Mississippi, and then in the cabinet of U. P. James, of Cincinnati. The specimen is a pathologic representative of *Unio tetralasmus* Say.

This widely distributed species occurs from Ohio, south to central Alabama and through Texas into Mexico. Its most northern and western locality thus far is central Kansas, not far from Wichita. It preserves its specific characters so generally that it is a matter of great surprise that so many synonyms should fall under it. The study of the figures, descriptions, and localities above indicated, will furnish convincing evidence of identity. Of the total number listed, seven came from Louisiana and contiguous territory; of these seven, five are from the same State, and of these five, two are from the same bayou. The pathologic *Unio jamesianus* is not the first shell or the only one which has been projected into specific distinction; the small *Unio liebii* Lea and the *Unio hippopæus* Lea, both from Lake Erie, are further illustrations.

This species occurs in Arkansas in the White and the Black rivers, and in the Red river, near the Louisiana boundary.

Unio trapezoides Lea.

Trans. Am. Philos. Soc., Vol. IV, 1830, p. 69, Pl. III, Fig. 1; Reeve, Conchologia Iconica, Vol. XVI, *Unio* Plate V, Fig. 17, 1864. Described from Lake St. Joseph, Louisiana.

Unio interruptus Say. Transylvania Journal of Medicine, Vol. IV, p. 525, 1831; also American Conchology, 1832, Pl. XXXIII. From Bayou Teche, Louisiana.

Unio atromarginatus Lea. Trans. Am. Philos. Soc., Vol. VIII, 1840, p. 207, Pl. XIII, Fig. 21. From the Chattahoochee river, Georgia. Evidently a junior.

Unio sloatianus Lea. Trans. Am. Philos. Soc., Vol. VIII, 1840, p. 217, Pl. XVI, Fig. 33. From the Chattahoochee river, Georgia.

This is an abundant shell in the St. Francis river, at Wittsburg, at which point very large and fine specimens were secured. It also occurred in the White river, at Augusta, where a single valve was found on the bank; in the Saline, at Benton; and in the Ouachita, at Malvern.

I am not sure that Lea's *atromarginatus* falls into the synonymy of his *trapezoides* but it appears to do so judging from the only specimens which have come to notice. From Louisiana come very numerous and fine specimens of this species, but they do not attain the great dimensions reached by the shells from the St. Francis. The species is a mud-loving one, and delights in sluggishly flowing water. The general transverse form, and the peculiar folds or plications on the posterior margin and slope, will serve to distinguish this species from all others.

Unio trigonus Lea.

Trans. Am. Philos. Soc.,Vol. IV, 1831, p. 110, Pl. XVI, Fig. 40; so, also, Reeve, Concholgia Iconica, Vol. XVI, *Unio* Plate LXXXVI, Fig, 459. From the Ohio river.

Unio chunii Lea. Jour. Acad. Nat. Sci. Phila., Vol. V, 1862, p. 196, Pl. XXVII, Fig. 265. From Dallas, Texas.

Unio riddellii Lea. Jour. Acad. Nat. Sci. Phila., Vol. V, 1862, pp. 197–8, Pl. XXVII, Fig. 267; Reeve, Conchologia Iconica, Vol. XVI, *Unio*, Plate LXXXIII, Fig. 442. From Dallas, Texas.

The geographic range of this heavy and well marked shell is very wide, extending from western New York to Minnesota, and Iowa, and Kansas; to Texas, east to Mississippi and Tennessee. In Arkansas it has been found in the St. Francis river at Wittsburg.

UNIO TUBERCULATUS Barnes.

Am. Jour. Sci. and Arts, last series, 1823, Vol. VI, p. 125, Pl. VII, Figs. 8a, 8b; also, figured as *Unio verrucosus* Rafinesque, in Poulson's translation of "Monograph of the Bivalve Shells of the river Ohio", 1832, frontispiece; same, in Chenu, Bibliotheque Conchyliologique, 1845, p. 17, Pl. II, Figs. 10–12; Reeve, Conchologia Iconica, Vol. XVI, *Unio* Plate 1, Fig. 4; the figure is that of a fine old male.

The range of this form is very great; specimens have been found from western New York to Minnesota, Iowa, and Nebraska; to Kansas, and central Texas; to Georgia, and Alabama. It is commonly abundant wherever found. In the Cahaba river, Alabama, where the shell is very abundant, more than half of those taken have purple nacre. The nacre is usually white, though, in large specimens, it is often blotched with irregularly distributed, brownish spots.

In Arkansas specimens have been taken in the Saline river, at Benton; in the St. Francis, at Wittsburg. Its great length, nodulous anterior portion, striate, posterior slopes, bi-angulate and compressed posterior, will serve to easily separate it from its congeners. The species was originally described from Wisconsin.

UNIO TUMESCENS Lea.

Trans. Am. Philos. Soc., 2d series, Vol X, 1845, p. 71, Pl. III, Fig. 7. Described from Alexandria, Louisiana.

This species was erected on one perfect shell, and one valve of a second specimen. The only locality in Arkansas, from which specimens were secured, is the Ouachita river, at Arkadelphia. It appears to be very rare. It is also credited to the Tennessee drainage of north Alabama and east Tennessee. It is a very tumid shell and bears some points of resemblance to *Unio trigonus* Lea, but is abundantly rayed over the whole disk, and is of a honey yellow color.

UNIO UNDULATUS Barnes.

Am. Jour. Sci. and Arts, 1st series, Vol. VI, p. 120, Fig. 2, 1823; Reeve, Conchologia Iconica, Vol. XVI, Pl. IV, Fig. 16, as *Unio costatus* Rafinesque. Described from Ohio.

Unio latecostatus Lea. Trans. Am. Philos Soc., Vol. X, 1845, p. 68, Pl. I, Fig. 2. Described from the Black Warrior river, at Tuscaloosa, Alabama.

Unio atrocostatus Lea. Trans. Am. Philos. Soc., Vol. X, 1845, p. 70, Pl. II, Fig. 5; Reeves figure 404, Conchologia Iconica Vol. XVI, *Unio* Plate LXXVII is of *plicatus* and not of this shell at all.

Unio quintardii Cragin. Bull. Washburn Coll. Lab'y of Nat. Hist. Vol. II, p, 6, 1887. From Salt Creek. Indian Territory, Sac and Fox Reservation.

Unio pilsbryi Marsh. Nautilus, Vol. V. May, 1891, p. 1; illustrated in The Nautilus, Vol. VII, No. 1, May, 1893, Pl. I, Figs. 7 and 8. Described from the Little Red river, Arkansas. Inspection both of the types, and the published figures confirms this disposition of the form.

Specimens were observed on the bars of the Saline river, at Benton. It occurs commonly in the Little Red river, near Clinton, Van Buren county, from which locality came the shells that were characterized by the name of *Unio pilsbryi*. The species is of wide distribution, ranging from New York to Kansas, Nebraska, Dakota, and to west Central Texas; east to Georgia, Alabama, and intermediate States. It is flatter than *Unio plicatus*, and the undulations are differently disposed; they are commonly more numerous than in Lesueuer's species, and often are interrupted or broken; not infrequently specimens are found in which the undulations cover the entire disk, at other times they are few in number, and almost entirely confined to the posterior slope. This is one of the most common Unios in North America. Conrad figures this shell as *Unio costatus* Rafinesque, on Plate VII of his Monograph.

Unio venustus Lea.

Trans. Am. Philos. Soc., Vol VI, 1834, p. 4, Pl. II, Fig. 4; Reeve, Conchologia Iconica, Vol. XVI, *Unio* Plate LXIV, Fig. 326. Described from Potosi, Missouri.

Unio pleasii Marsh. The Nautilus, Vol. V, No. 1, p. 2, May, 1891. Described from the Little Red river, Van Buren county, Arkansas.

Specimens have been seen from the Little Red river — the lot forming the types of Marsh's supposed new form, and from the White river, Carroll county. While the species does present some features, like those of the young of *Unio ligamentinus* Lamarck, it is entirely distinct from that shell; the comparison was not fortunate, for very many characters that are not allied to those of the Lamarckian form are exhibited; among them may be mentioned the capillary character of the rays, their wavy outlines, their crowding, also the character of the teeth, which are unlike those of young *ligamentinus*, the beaks, which are more elevated, the emarginate character of the female, which is not like the outline of the female *ligamentinus*. The shell which most nearly represents this one is *Unio spatulatus* Lea, but it appears to be distinct from it. Having seen and compared the types of *Unio pleasii* with the real *venustus* there is no hesitation in uniting them.

Unio ventricosus Barnes.

Am. Jour. of Sci. and Arts, Vol. VI, 1st series, 1823, p. 267, Figs. 14a, 14b, 14c; Reeve, Conchologia Iconica, Vol. XVI, *Unio* Plate XLIII, Fig. 235; American Conchology, Say, Plate XXXII. Described from the Wisconsin and Mississippi rivers.

Unio occidens Lea. Trans. Am. Philos. Soc., Vol. III, 1829; p. 435, Pl. X, Fig. 16. Described from the Ohio river.

Unio cardium Rafinesque. So Conrad, in Monograph of Unio, 1834, p. 7.

Unio satur Lea. Trans. Am. Philos. Soc., 2d series, Vol. X, 1852, p. 265, Pl. XVII, Fig. 19; Reeve, Conchologia Iconica, Vol. XVI, *Unio* Plate XCII, Fig. 501. Described from Alexandria, Louisiana.

Unio canadensis Lea. Jour. Acad. Nat. Sci. Phila., Vol. IV, 1859, p. 268, Pl. XLIV, Fig. 148. Described in 1857, from the St. Lawrence river, at Montreal.

Unio subovatus Lea, of Reeve, Conchologia Iconica, Vol. XVI, *Unio* Plate LXXXV, Fig. 456. This is not the true *subovatus* Lea.

Specimens were obtained only in the Saline river, at Benton. The form is very widely distributed, and presents variant features in all its different habitats. Commonly abundant wherever it occurs at all, when perfect specimens are obtainable it constitutes one of the most beautiful of Uniones. It is the type of a great natural group, which includes *Unio ovatus* Say, *Unio subovatus* Lea, *Unio capax* Green *Unio lineatus* Lea, and others. Specimens of the last named, from the original locality in Georgia, indicate that it too must pass into the list of synonyms.

MARGARITANA COMPLANATA Barnes.

Plate XVI.

Alasmodonta complanata Barnes, Am. Jour. Science and Arts, 1st series, Vol. VI, p. 278, Pl. XIII, Figs. 17a, 17b, 1823.

Symphynota complanata Lea. Trans. Am. Philos. Soc., 1829, Vol. III, p. 448. Transferred from *Unio*.

Unio complanatus Lea. So Reeve, Conchologia Iconica, Vol. XVI, *Unio* Plate L, Fig. 266.

This species is rarely found in the St. Francis, at Wittsburg. While it has a wide range it appears to be most abundant in western Illinois, in the Mississippi river, and throughout Iowa. The last named State may, indeed, be said to be its metropolis. The figure is made from a young individual taken in the Des Moines river, and is designed to show the characters of the beaks, which are peculiar to this form.

MARGARITANA CONFRAGOSA Say.

New Harmony Disseminator of Useful Knowledge, Vol. II, No. 22, 1829, p. 339; American Conchology, Plate XXI, 1830. Described from the Wabash river, Indiana.

Unio confragosus Say. So Reeve, Conchologia Iconica, Vol. XVI, *Unio* Plate LX, Fig. 299. A fine figure of the external view of the shell.

This species has occurred only in the St. Francis river, so far as present information extends. It is a form which loves to dwell in the soft mud of sluggishly flowing streams. Just over the Louisiana boundary line, in Claiborne Parish, this shell occurs in numbers. It is not without reason, therefore, that it may be expected to occur in other portions of the State of Arkansas than the one listed.

MARGARITANA RUGOSA Barnes.

Alasmodonta rugosa Barnes. Am. Jour. of Sci. and Arts, 1st series, Vol. VI, 1823, p. 278, Pl. XIII, Figs. 21a, 21b; DeKay Natural History of New York, Vol. V, Mollusca, p. 196, Pl. XIV, Fig. 226. 1843.

Unio rugosus Barnes. So Reeve, Conchologia Iconica, Vol. XVI, *Unio* Plate LX, Fig. 302, 1867. Reeve says this is equivalent to *Unio abducta* Say, a species which we have been unable to find that Say ever characterized.

Specimens were obtained in the White river, Carroll county; and in the Saline, at Benton, where the form appears to be abundant. This shell has a wide range from New England, to west central Kansas, Texas, Louisiana, Alabama, and Georgia; the northernmost range, that is authoritatively known, is the Rideau and Ottawa rivers, Canada.

ANODONTA EDENTULA Say.

Alasmodonta edentula Say. New Harmony Disseminator of Useful Knowledge, Vol. II, No. 22, 1829, p. 340; described from the Wabash river.

Anodonta edentula Say. DeKay Nat. Hist. N. Y., Pt. V, 1843, p. 201, Pl. XVI, Fig. 231; Lea, Trans. Am. Philos. Soc., Vol. IV, 1858, p. 50, Pl. VI, Fig. 37.

Anodonta ferruginea Lea. Trans. Am. Philos. Soc., 2d series, Vol. VIII, 1840, p. 289, Pl. XIX, Fig. 43. Described from Simon's Creek, Indiana.

Anodonta tetragona Lea. Trans. Am. Philos. Soc., 2d series, Vol. X, 1845, Pl. VIII, Fig. 25, p. 82; described from Alexandria, Louisiana.

Anodonta shafferiana Lea. Trans. Am. Philos. Soc., 2d series, 1852, Vol. X, Pl. XXVI, Fig. 50, p. 288; described from Horn Lake creek, Tennessee, and Flat Rock creek, Indiana; Reeve, *Anodon* Plate XXXV, Fig. 143, Conchologia Iconica, Vol. XVII.

Anodonta arkansasensis Lea. Trans. Am. Philos. Soc., 2d series, Vol. X, 1852, p. 293, Pl. XXIX, Fig. 56. Described from Kansas.

Alasmodonta rhombica Anthony. Am. Jour. Conchology, Vol. I, 1865, p. 158.

Anodon annulatus Sowerby. Reeve, Conchologia Iconica, Vol. XVII, *Anodon* Plate XVIII, Fig. 67. This figure and description are based upon a specimen in the Museum Cuming, from an unknown habitat; it shows the characters of the beaks of *edentula*, and is without question that form.

This is the most common and abundant *Anodonta* in the west. The characters of the dorsal margin are such that it is often mistaken for a *Margaritana* as, indeed, was the case when originally described. Subjected to a vast variety of environmental conditions, it is not surprising that very many names have been applied to its differing forms. It is not easily separated, at times, from the form called *Anodonta undulata* Say, which is supposed to be entirely confined to the regions east of the Appalachians, or to waters draining into the Great Lakes.

Reeve's Fig. 60, Vol. XVII, Conchologia Iconica, Plate XVII, is not *Anodonta edentula*, but is something else.

The species has occurred in collections made in the St. Francis river, at Wittsburg, and in the Saline, at Benton; a single imperfect specimen was picked up in a small stream, without a name, in the southeastern part of Craighead county.

ANODONTA GRANDIS Say.

New Harmony Disseminator, Vol. II, 1829, No. 22, p. 341; Reeve, Conchologia Iconica, Vol. XVII, Plate *Anodon* I, Fig. 1, 1870. Described from the Fox river, and the Upper Mississippi river.

Anodonta stewartiana Lea. Trans. Am. Philos. Soc., 2d series, 1834, Vol. V, p. 47, Pl. VII, Fig. 17; Reeve, Conchologia Iconica, Vol. XVII, *Anodon* Plate XXXIII, Fig. 133. Described from the Bayou Teche, Louisiana.

Anodonta plana Lea. Trans. Am. Philos. Soc., 2d series, 1834, Vol. V, p. 48, Pl. VII, Fig. 18, as *palna* in typographic error; Reeve, Conchologia Iconica, Vol. XVII, *Anodon* Plate XXIV, Fig. 94. Described from Bear Grass creek, near Louisville, Kentucky.

Anodonta declivis Conrad. Am. Jour. Sci. and Arts, Vol. XXV, 1st series, p. 341, Pl. I, Fig. 11, 1834. Described from the Flint river, Morgan county, Alabama,

Anodonta corpulenta Cooper. Appendix to "Narrative of an Expedition through the Upper Mississippi to Itasca Lake, etc., under the direction of Henry B. Schoolcraft," p. 153; Reeve, Conchologia Iconica, Vol. XVII, *Anodon* Plate XXXII, Fig. 129. Described from the Lake of the Woods, and the Upper Mississippi.

Anodonta decora Lea. Trans. Am. Philos. Soc., 2d series, Vol. VI, 1836, p. 64, Pl. XX, Fig. 63; Reeve, Conchologia Iconica, Vol. XVII, *Anodon* Plate XXI, Fig. 83, 1869. Described from the Ohio river.

Anodonta gigantea Lea. Trans. Am. Philos. Soc., 2d series, Vol. VI, 1838, p. 1, Pl. I, Fig. 1; Reeve, Conchologia Iconica, Vol. XVII, *Anodon* Plate XXXVII, Fig. 152. Described from Port Gibson, Mississippi.

Anodonta ovata Lea. Trans. Am. Philos. Soc., 2d series, Vol. VI, 1838, p. 2, Pl. II, Fig. 2; Reeve, Conchologia Iconica, Vol. XVII, *Anodon* Plate XXII, Fig. 85, 1869. Described from Marietta, Ohio. Reeve's figure, which is that of a shell without decortication of the beaks, shows well the undulate-apiculate character of the tips.

Anodonta harpethensis Lea. Trans. Am. Philos. Soc., 2d series, Vol. VIII, p. 224, Pl. XIX, Fig. 42; Reeve, Conchologia Iconica, Vol. XVII, *Anodon* Plate XXI, Fig. 82, 1869. Described from the Harpeth river, Tennessee.

Anodonta linnœana Lea. Trans. Am. Philos. Soc., 2d series, Vol. X, 1852, p. 289, Pl. XXVII, Fig. 51; Reeve, Conchologia Iconica, Vol. XVII, *Anodon* Plate XXXV, Fig. 144. Described from Lake Concordia, Louisiana.

Anodonta virens Lea. Trans. Am. Philos. Soc., 2d series, Vol. X, 1852, p. 290, Pl. XXVIII, Fig. 53; Reeve, Conchologia Iconica, Vol. XVII, *Anodon* Plate XXXIV, Fig. 138. This form was described from the Red river, near Alexandria, Louisiana. Through some curious blunder Reeve says "River Euphrates."

Anodonta gesneri Lea. Jour. Acad. Nat. Sci. Phila., 2d series, 1859, p. 231, Pl. XXXI, Fig. 109; Reeve, Conchologia Iconica, Vol. XVII, *Anodon* Plate VII, Fig. 15. Described from the Uphaupee creek, Macon County, Georgia.

Anodonta inornata Anthony. Am. Jour. of Conchology, Vol. II, 1866, p. 145. *Teste* Lea.

This is, without doubt, the most abused American *Anodonta*. Of wide distribution it is one of the most polymorphous shells found on the continent. A number of years ago attention was called to this variant shell, and some of the synonymy here indicated definitely was there hinted at.* There is scarcely a stream in all the great Mississippi Valley but that in it some form of this abundant shell occurs. In outline every one of the forms given above may be found in every lot which numbers forty or fifty specimens, and if the old and the young are taken and compared, all the forms from *gigantea* to *ovata* and *virens* may be obtained. It has fared rather better than the European *Anodonta cygnea*, of which over one hundred and twenty synonyms are known, but by the time it has had attention equal to that of its European congener, it may fare as badly.

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* American Naturalist, Vol. XIV, 1880, pp. 529–530.

The group has received too little attention, and too much reliance has been placed upon authority to fully and correctly understand this shell. Those who collect *Unionidæ* by proxy, and whose acquaintance with streams and lakes is confined to the views from passing train or from study window, will continue to see many species in this polymorphous form.

Specimens were obtained in the St. Francis river, at Wittsburg, and in the Saline, at Benton. It will doubtless be found, in numbers, in the old river beds of all the larger streams, and in most ponds and lakes throughout the State of Arkansas. It ranges to western New York and to central Texas, and north to British America.

ANODONTA IMBECILLIS Say.

New Harmony Disseminator of Useful Knowledge, 1829, Vol. II, No. 23, p. 355; Reeve, Conchologia Iconica, Vol. XVII, *Anodon* Plate XXVII, Fig. 102, as of Lea. Described from the Wabash river.

Anodonta incerta Lea. Trans. Am. Philos. Soc., Vol. V, 1832, p. 45, Pl. VI, Fig. 16; Reeve, Conchologia Iconica, Vol. XVII, *Anodon* Plate XVII, Fig. 59. Described from the Ohio river.

Anodonta hordea Gould. Proc. Bost. Soc. Nat. Hist., Vol. V, 1855, p. 229; Reeve, Conchologia Iconica, Vol. XVII, *Anodon* Pl. XVIII, Fig. 66, as *Anodon hordeum* Gould. Lea says this is Say's *Anodonta imbecillis;* it must be confessed that Reeve's figure bears no resemblance to it as it is generally understood on this side of the Atlantic.

There is no *Anodonta* in American waters so easily determined as this one, and so little likely to be confounded with any other species. It is commonly of a bright green color, and is of very thin texture, resembling nothing else in our waters. In Arkansas it has been found only in the St. Francis river, at Wittsburg, but doubtless occurs elsewhere. We have it from various localities in Louisiana and Texas, whence it ranges to western New York and Canada.

Anodonta opaca Lea.

Trans. Am. Philos. Soc., 2d series, Vol. X, p. 285, Pl. XXV, Fig. 46. Described from near New Orleans, and from near Little Rock, Arkansas.

This is a member of the *grandis* group and it is not sure but that it should have been placed under the synonymy of that species. It has not been seen by us in any collection from Arkansas, and is admitted to this list on the strength of the original description, which credits it to this State.

There have been listed in the foregoing pages fifty-nine species of *Unionidæ*, illustrating the three common North American genera. Had there been recognized the great number of synonymous forms, with which mere collectors seek to enrich their cabinets, the list might have been greatly extended. At present we know, from Arkansas, 52 species of *Unio*, 3 species of *Margaritana*, and 4 species of *Anodonta*.

The *Unionidæ* abound in the streams of Arkansas; varieties or species may be relatively few, but individuals are very abundant. They are to be sought in every conceivable condition of bottom, and other factors of environment. Often certain forms affect stated or well-known sorts of stations in cold and clear, or warm and muddy waters; others will be found on gravelly or sandy bars, ordee ply buried in mud, close to the river's margin. Careful search rarely fails to reveal some form of interest.

Louisville, Kentucky, Nov. 16, 1893.

Issued January 3d, 1895.

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II. Unio crassidens Lamarck.
III. Unio luteolus Lamarck.
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V. Unio purpuratus Lamarck. Male and female
VI. Unio purpuratus Lamarck. Female.
VII. Unio rectus Lamarck.
VIII. Unio retusus Lamarck.
IX. Unio rotundatus Lamarck.
X. Unio metanevrus Rafinesque.
XI. Unio cylindricus Say.
XII. Unio schoolcraftii Lea.
XIII. Unio schoolcraftii Lea. Varieties.
XIV. Unio schoolcraftii Lea. Figures 1–4.
Unio pustulosus Lea. Figures 5–6.
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XVI. Margaritana complanata Barnes.
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XIX. Unio sayii Ward. Figures 1–2.
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XXI. Unio ligamentinus Lamarck.

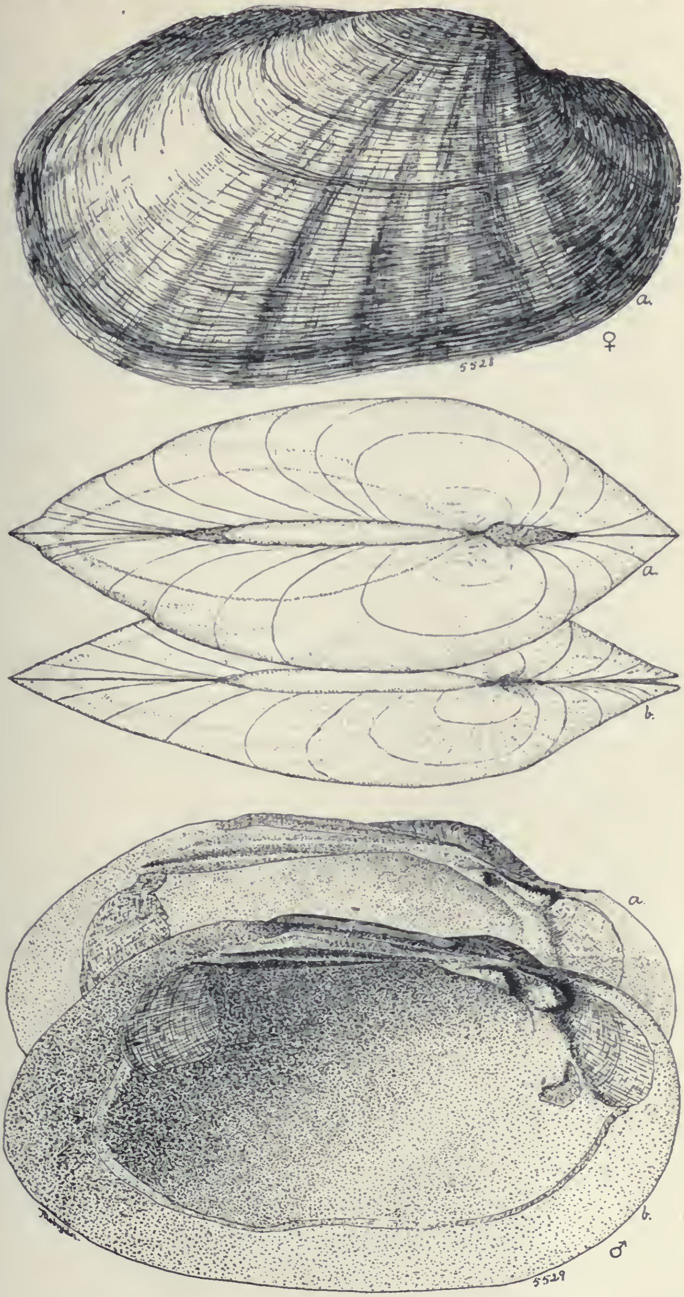
66

CALL ON UNIO. PLATE I.

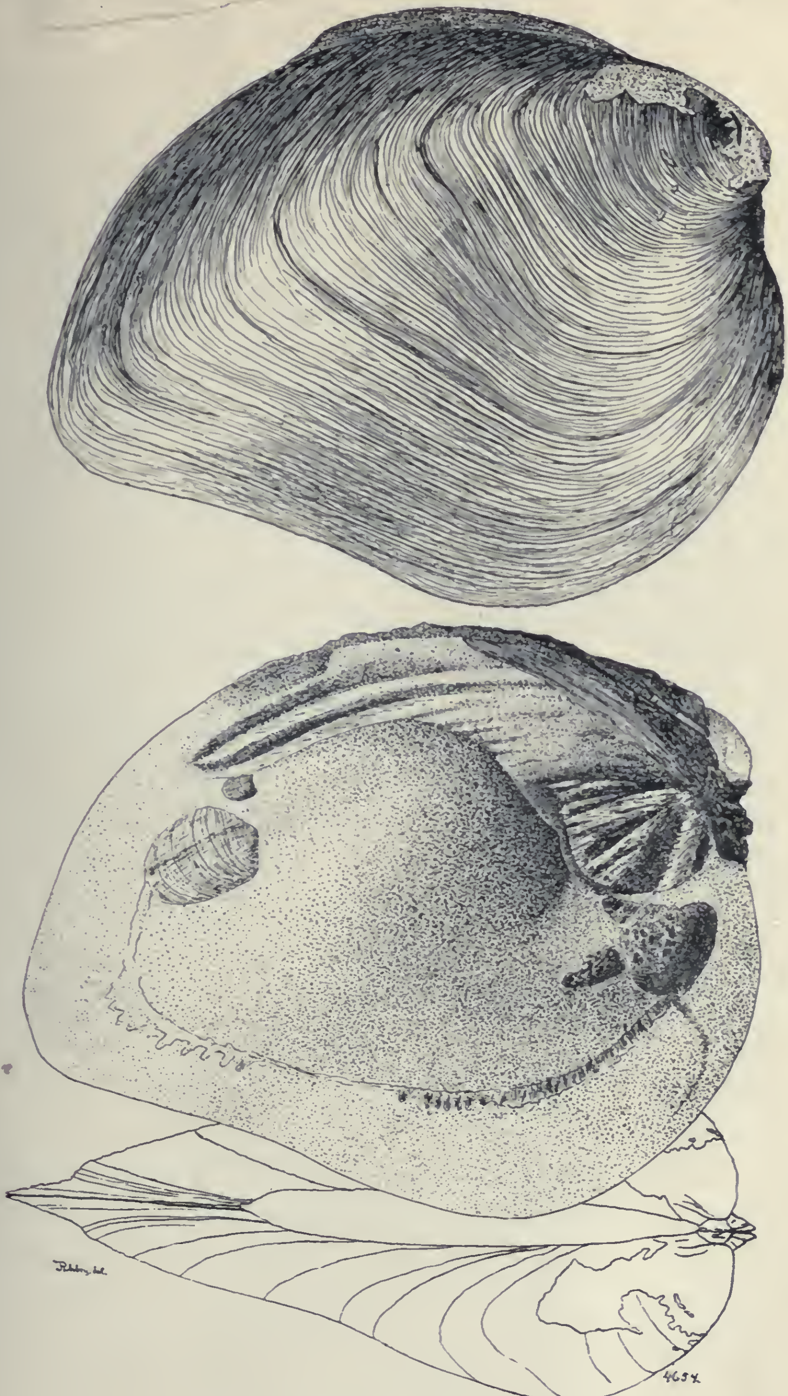
Unio clavus Lamarck.

69

Unio crassidens, Lamarck.

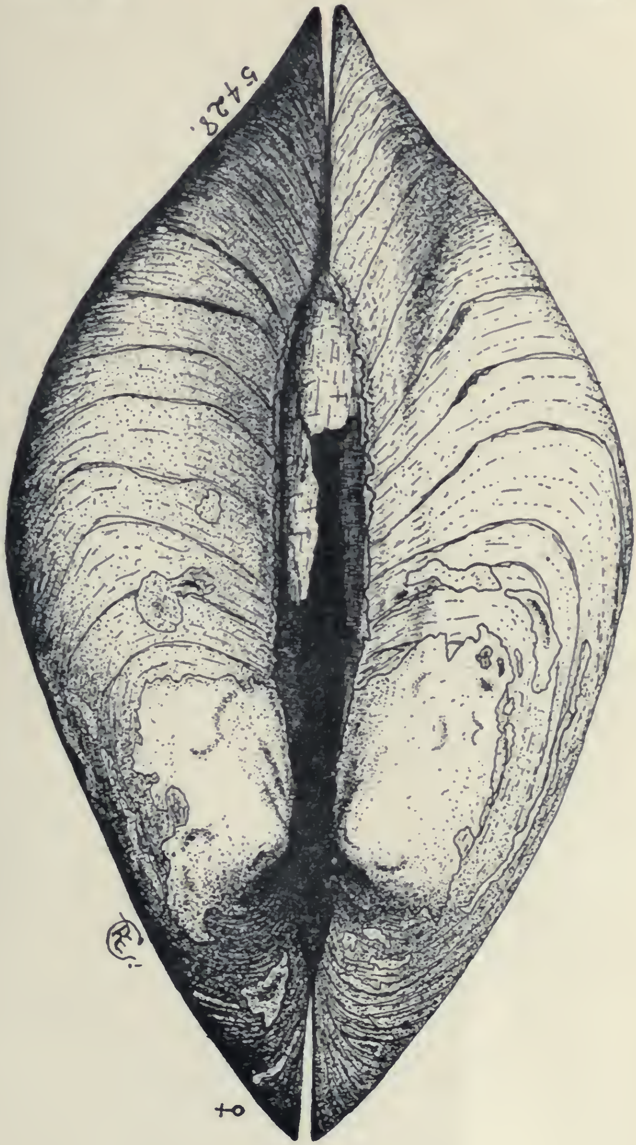


Unio luteolus Lamarck.

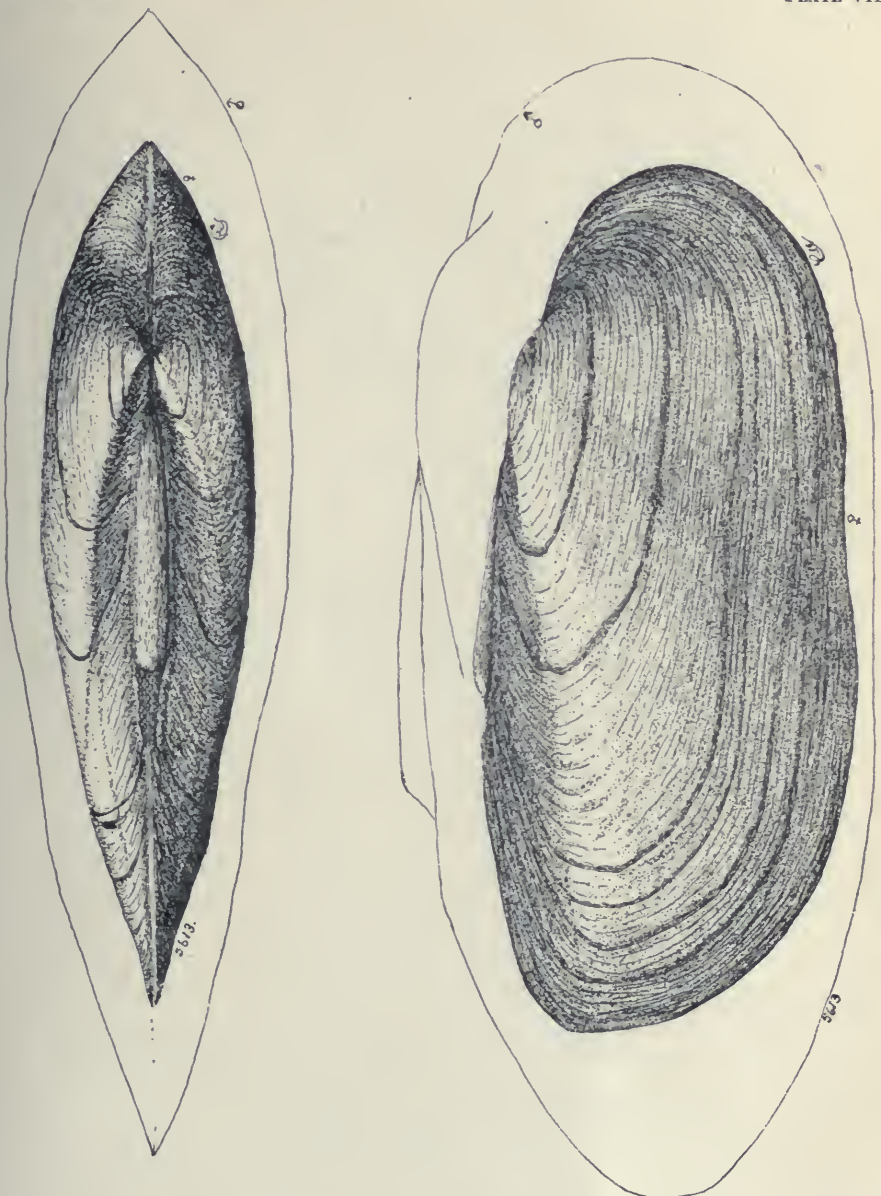


Unio obliquus Lamarck.

Unio purpuratus Lamarck.

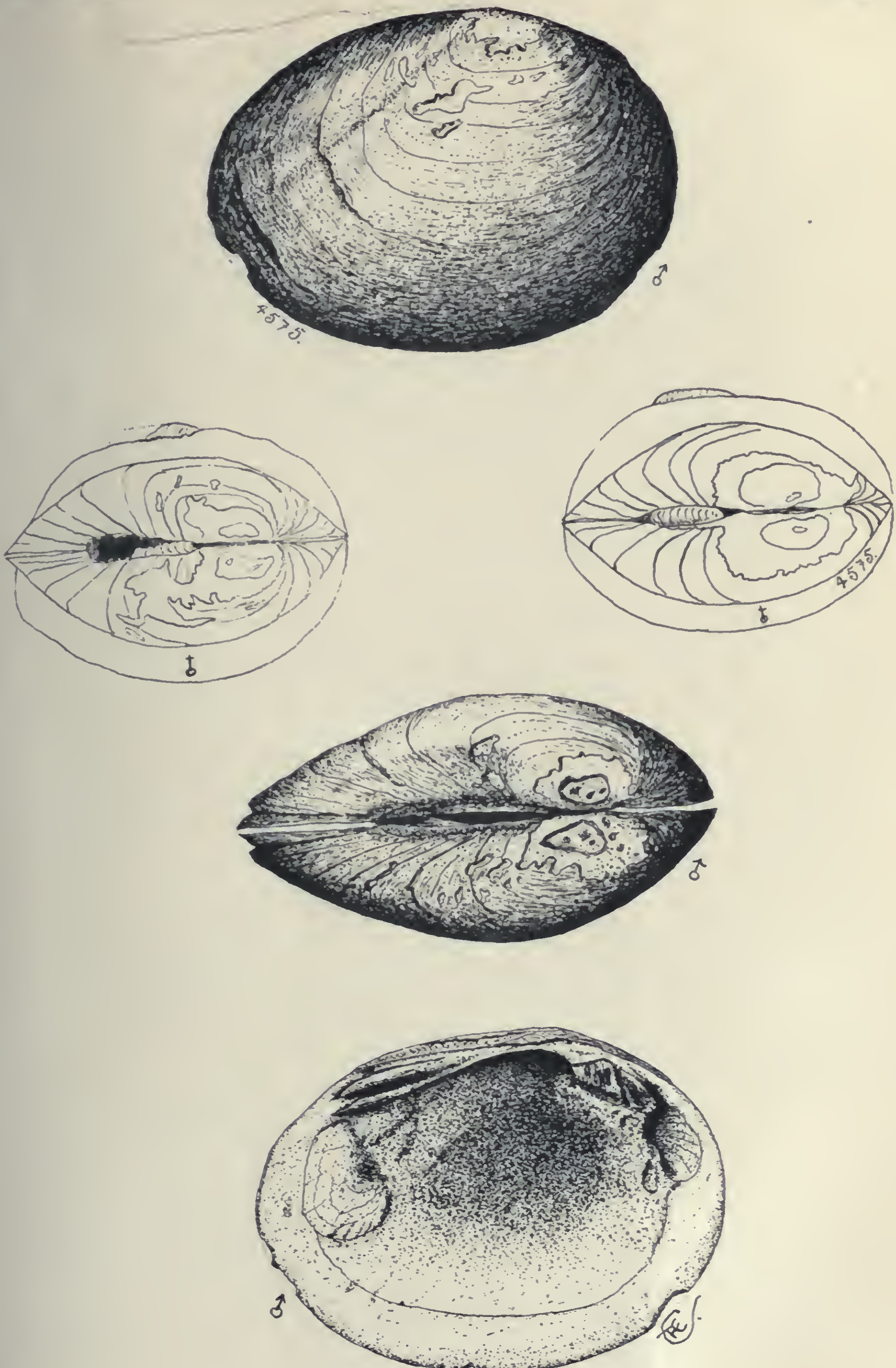


Unio purpuratus Lamarck.



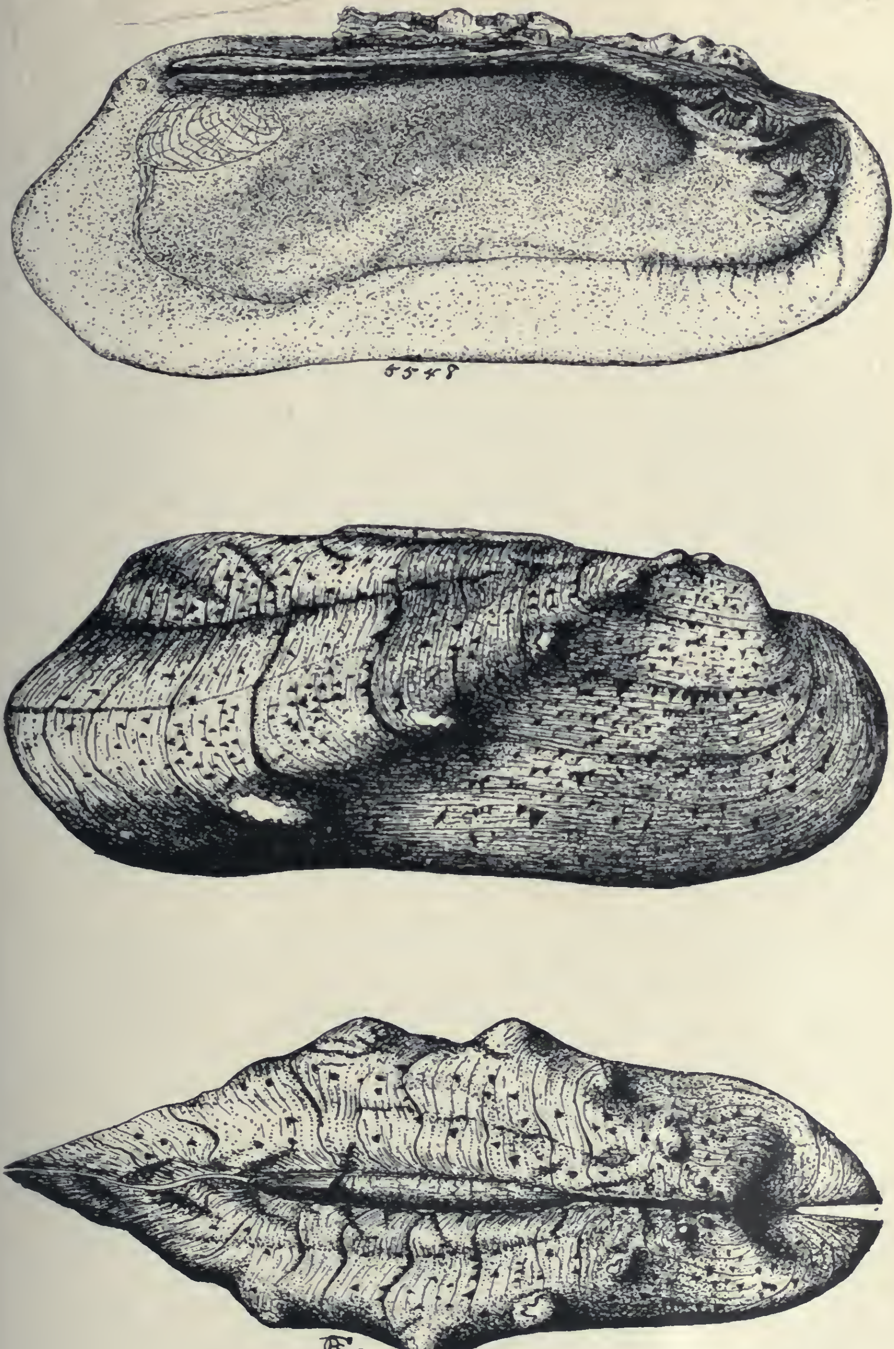
Unio rectus Lamarck.

Unio retusus Lamarck.



Unio rotundatus Lamarck.

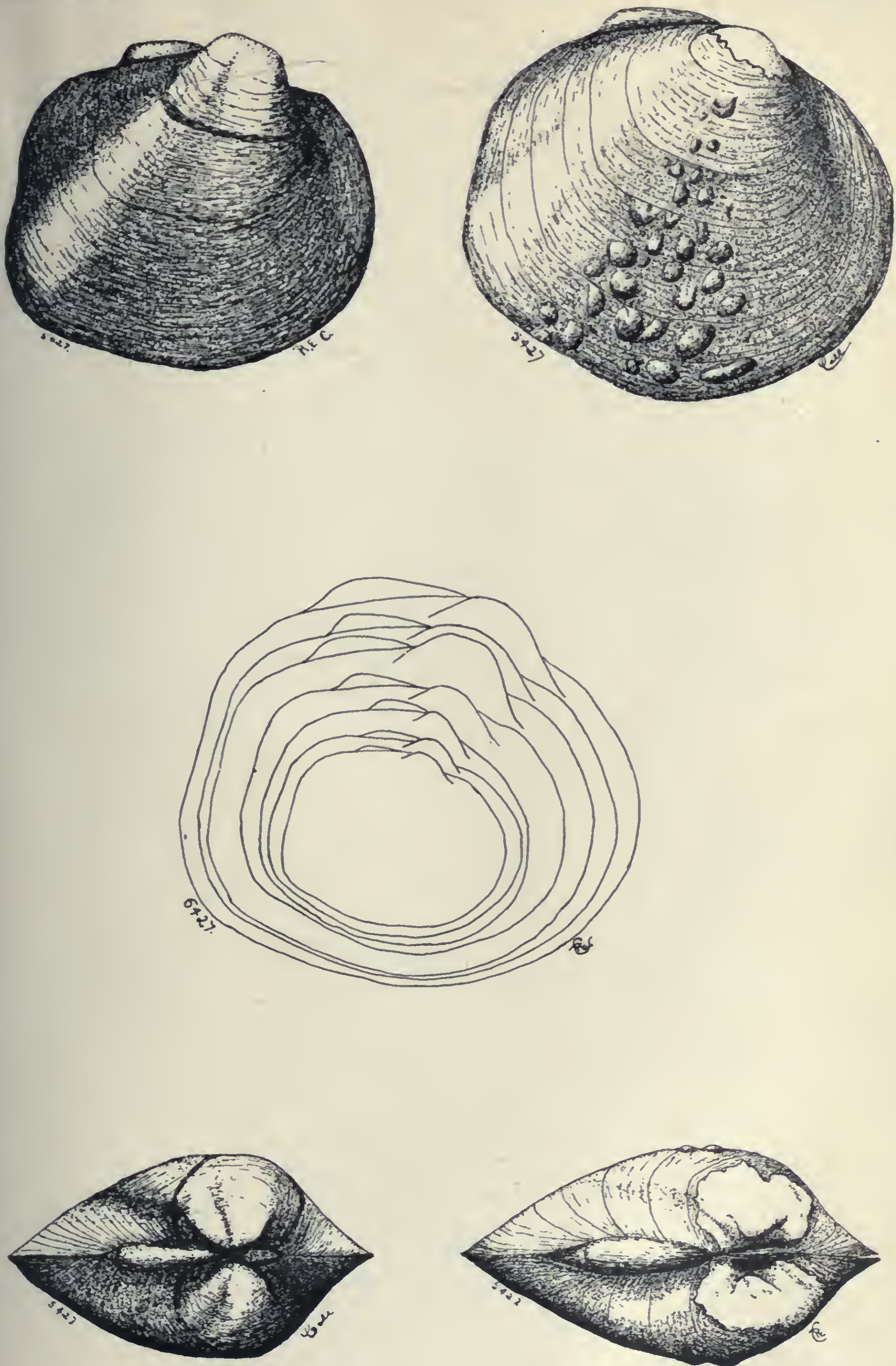
Unio metanevrus Rafinesque.



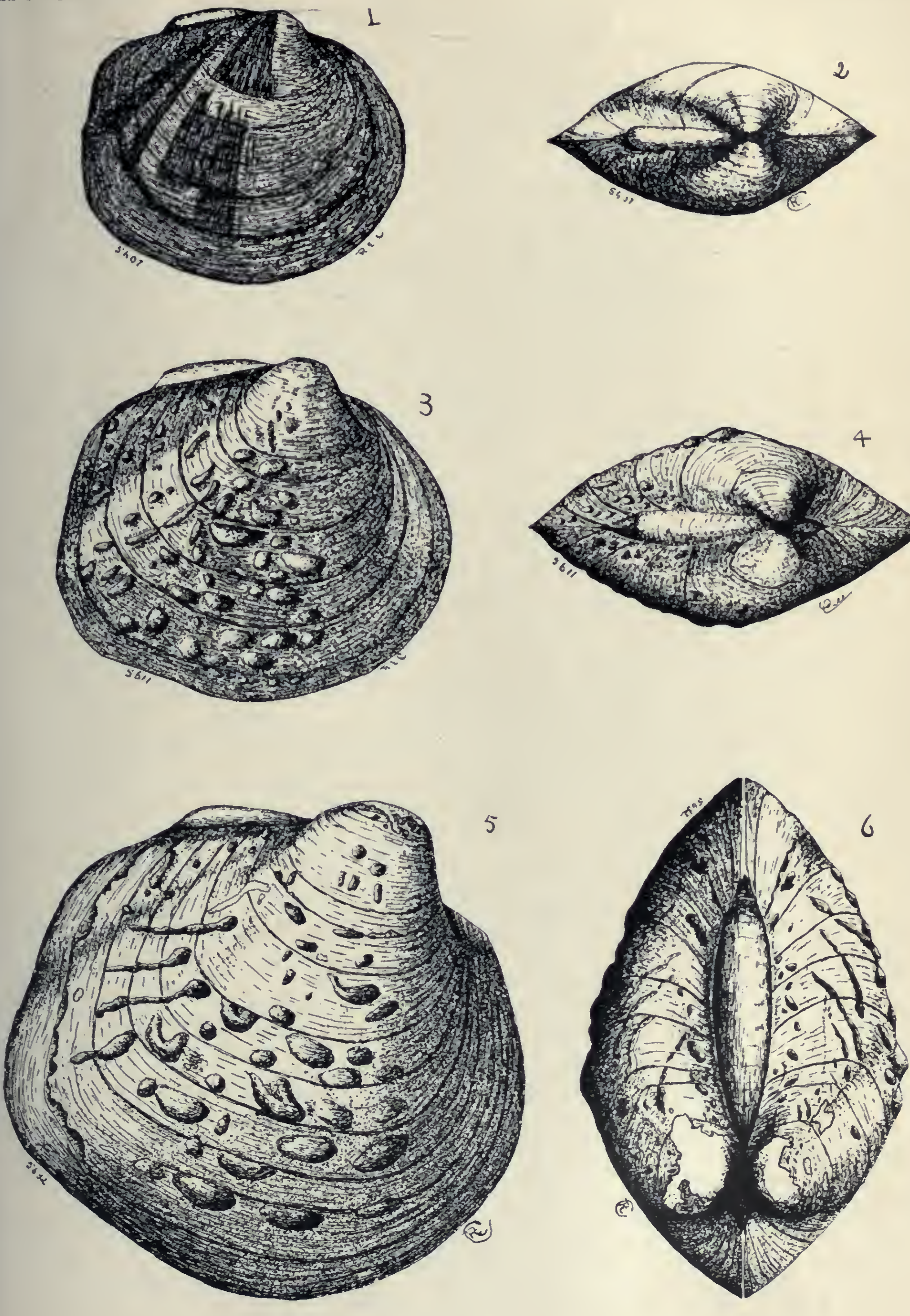
Unio cylindricus Say.

Unio schoolcraftii Lea.

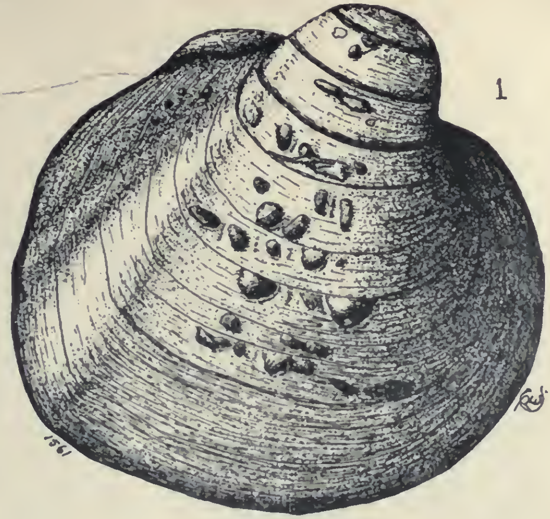
(REDUCED.)



Unio schoolcraftii Lea.
(VARIETIES.)



Figs. 1–4. Unio schoolcraftii Lea.
Figs. 5–6. Unio pustulosus, Lea.



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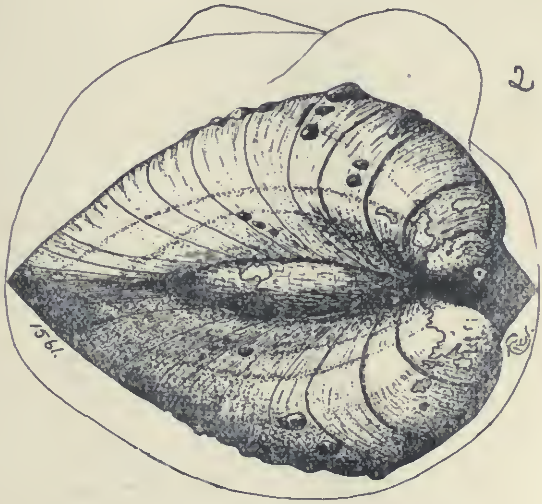

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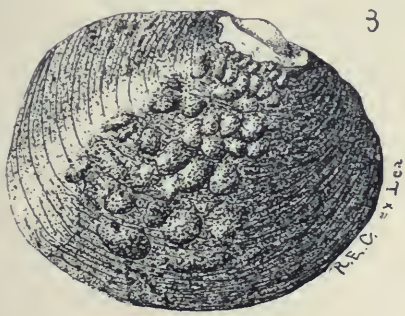

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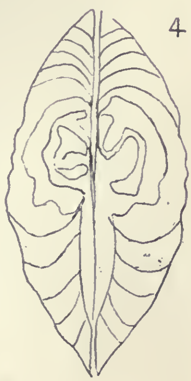

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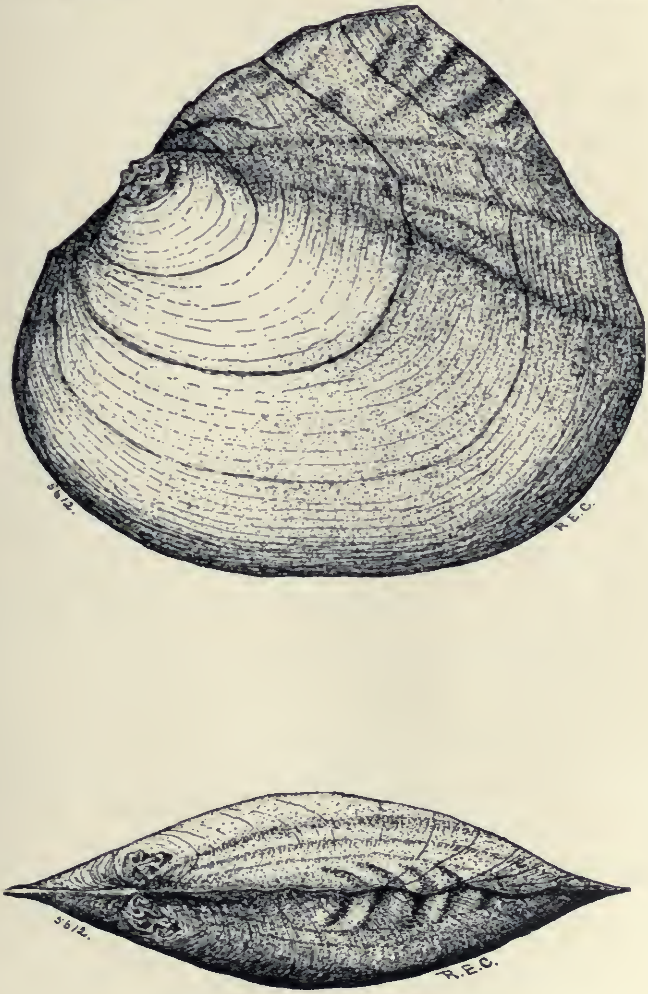
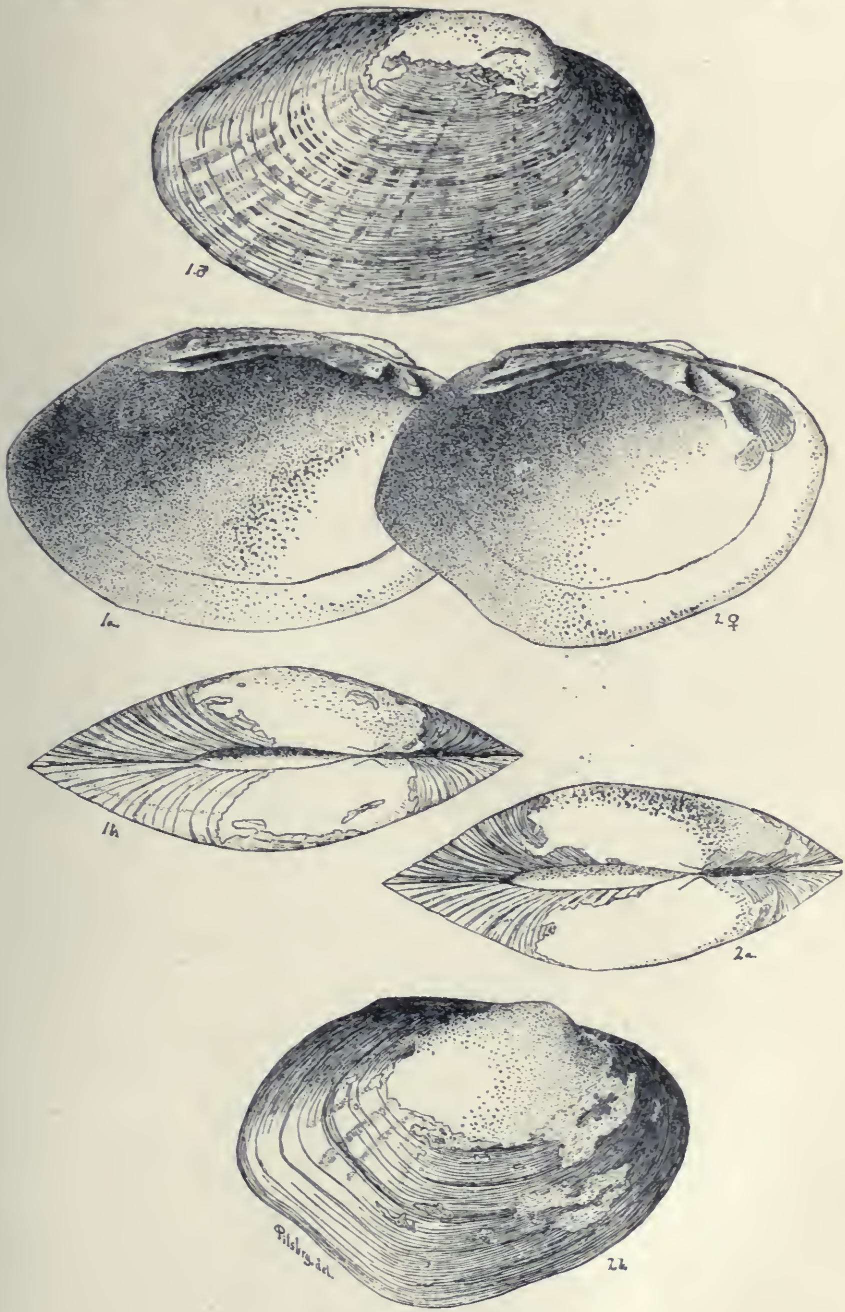
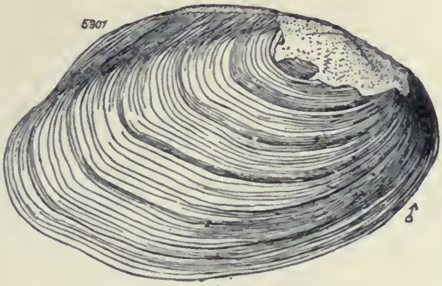
Figs. 1–2. Unio dorfeuillianus Lea.
Figs. 3–4. Unio refulgens Lea.



Margaritana complanata, Barnes.



Unio breviculus Call.



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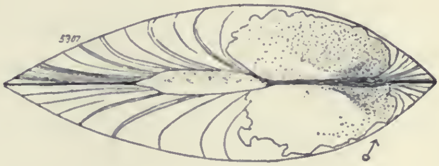

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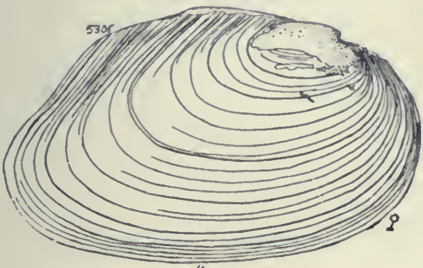

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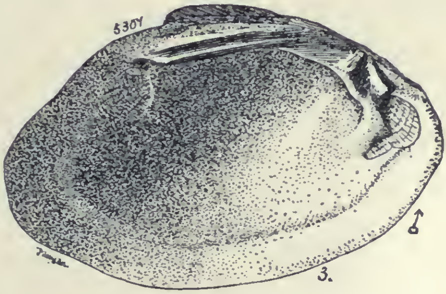

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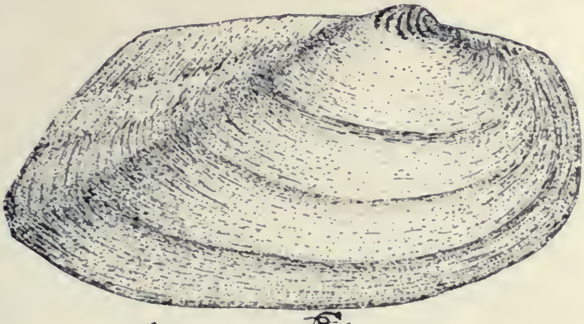
Unio ozarkensis Call.



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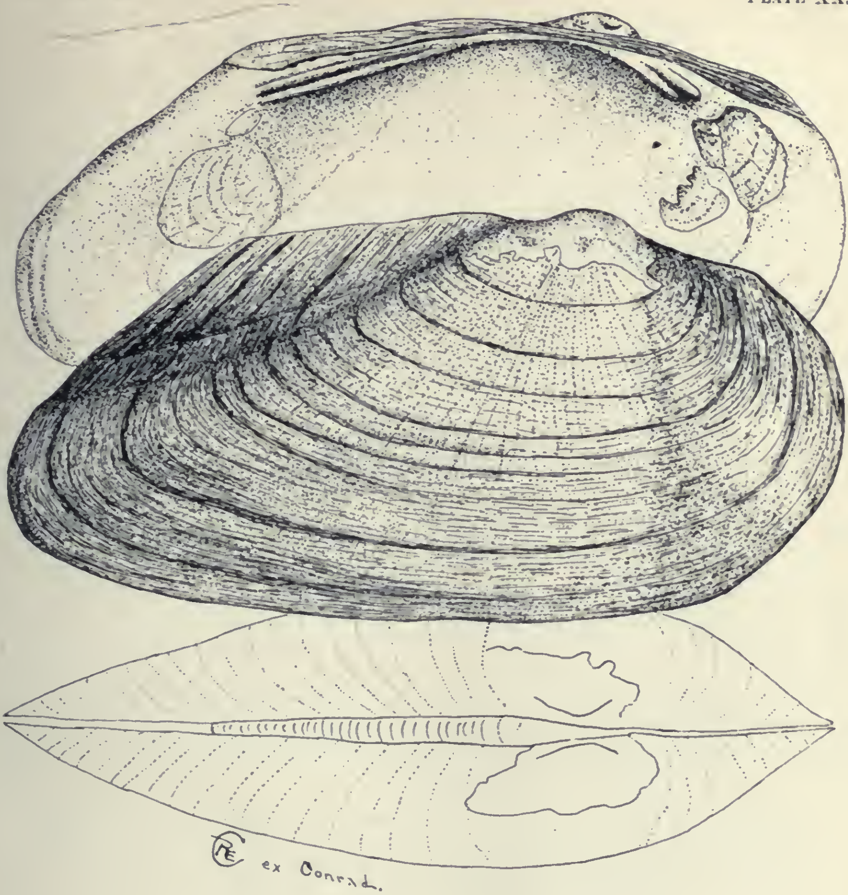
3–5.

Figs. 1–2. Unio sayii Ward.
Figs. 3–5. Unio sayanus Conrad.



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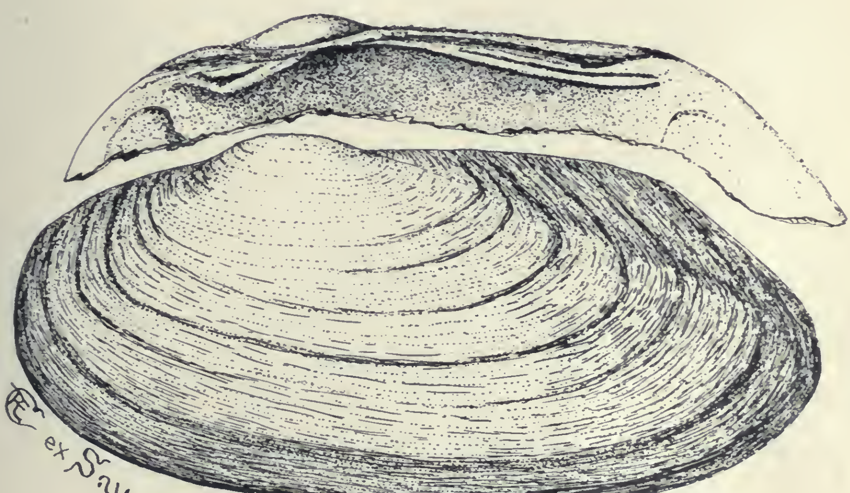

4 – 5

Figs. 1–3. Unio excultus Conrad.
Figs. 4–5. Unio tetralasmus Say.

Unio ligamentinus Lamarck.

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ON THE ELECTRICAL CAPACITY OF BODIES AND THE ENERGY OF AN ELECTRICAL CHARGE.

FRANCIS E. NIPHER.

The lines of force or induction around an electrified body distribute in space as if space offered resistance to their passage. They follow Ohm's law, the number of lines per unit area being always inversely as the resistance. In case of a small sphere of radius r_0, and having a charge Q, the number of lines of force proceeding from the sphere is $4\pi Q$. The potential of the sphere is $\frac{Q}{r_0}$. If R represent the resistance of space to these lines of force then by the application of Ohm's law

$$4\pi Q = \frac{\frac{Q}{r_0}}{R}$$

$$\text{or } R = \frac{1}{4\pi r_0} \qquad (1)$$

Here the total flow of force from the sphere is treated as a current, flowing from the sphere under a potential $\frac{Q}{r_0}$ and to an infinite distance where the potential is zero. If the radius of the sphere be changed, the flow of force is unchanged, since the potential and resistance are changed in the same ratio.

If the sphere were surrounded by a shell of shellac or other de-electric of specific inductive capacity μ, the capacity of the sphere would be increased, and its potential thereby diminished. The flow of induction $\mu\int F dS$ would remain unchanged and would be $4\pi Q$. The resistance R would then be diminished in the same ratio.

In the treatment proposed in this paper it becomes necessary to treat the quantity which Faraday called specific inductive capacity as a specific conducting power for lines of induction. It is a quantity analogous to what is called permeability of a medium for magnetic lines. My former assistant, Mr. Timmerman, has suggested a name for this quantity which seems to me very satisfactory. It is *perviability*. For electrostatic conduction of any tube of induction as expressed by equation (3) which follows, he suggests the name *perviance* as meaning electrostatic conductance in the field of an electrical system. If the medium of perviability μ were of infinite extent, the capacity of the sphere would be $\mu\, r_0$ and the resistance of space to the lines of induction would be $\frac{1}{4\pi\mu r_0}$.

This result is readily reached by direct integration. The resistance of a shell bounded by surfaces concentric with the sphere is

$$d\,R = \frac{dr}{4\pi\mu r^2} \qquad (2)$$

which integrated between r_0 and ∞ gives for the resistance

$$R = \frac{1}{4\pi\mu r_0} \qquad (3)$$

If the sphere be surrounded by a concentric spherical and conducting shell, forming a condenser, the difference of potential between the acting surfaces will be

$$V = \frac{Q}{\mu}\left(\frac{1}{r_0} - \frac{1}{r_1}\right)$$

The number of lines of induction is $\mu \int F\, d\, S = 4\pi Q$.

Hence applying Ohm's law

$$4\pi Q = \frac{Q}{\mu}\left(\frac{1}{r_0} - \frac{1}{r_1}\right)\frac{1}{R}$$

$$\therefore R = \frac{1}{4\pi\mu}\left(\frac{1}{r_0} - \frac{1}{r_1}\right) \qquad (4)$$

This formula is also the same as would be obtained by integrating (2) between r_0 and r_1. If C represent electrical capacity, and we indicate by $P = \frac{1}{R}$, the perviance of the medium, both (3) and (4) may be written,

$$\frac{1}{R} = P = 4\pi C \tag{5}$$

$$\text{or } C = \frac{P}{4\pi}. \tag{6}$$

This means that the electrical capacity of these bodies depends solely on the nature of the medium which surrounds them, and upon the characterizing dimensions of that portion of the medium which carries the field of force. Or in other words, the capacity depends solely on the perviance for the flow of induction from the body, of that part of the surrounding medium which carries the field of force.

The energy of the electrification is

$$W = \frac{Q^2}{2C} = \frac{(4\pi Q)^2 R}{8\pi} \tag{7}$$

If the flow of force or induction which we have treated as a current in applying Ohm's law, be denoted by I, the last equation becomes

$$W = \frac{Q^2}{2C} = \frac{I^2 R}{8\pi} \tag{8}$$

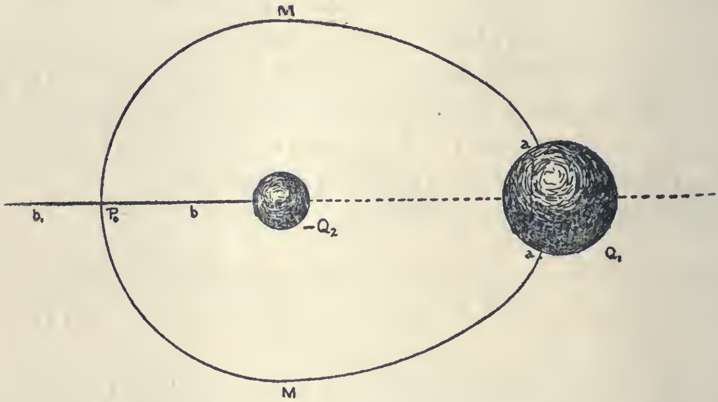
The first member of this equation is the potential energy of an electrification, which is in equilibrium. The second member represents the same quantity, in terms, which, in form, are precisely like the expression for power, or work per second, done on a conductor having a resistance R, by a current of electricity I. In the electrical conductor, this expression represents the heat generated per second in the conductor. In the dielectric through which the flow of force takes place no heat is developed, but a condition of stress is maintained.

We will apply equation (8) to determine the energy of a system consisting of two charged spheres having radii r_1 and r_2, and having charges Q_1 and $-Q_2$. We will assume that the spheres are in air, so that $\mu=1$, and that $Q_1 > Q_2$ numerically.

The potentials of the spheres will be

$$V_1 = \frac{Q_1}{r_1}$$

$$V_2 = -\frac{Q_2}{r_2}$$



In the figure, the smaller sphere is assumed to have the charge $-Q_2$. All of the lines proceeding to it come from the larger sphere. They are all within a surface of revolution generated by revolving any critical line P_0 M a around the principal axis of figure of the system.

The point P_0 is the position of unstable equilibrium, where the attraction of $-Q_2$ balances the repulsion due to Q_1. This critical surface intersects the charge Q_1 in a circle, and proceeding to P_0 it continues either in the line P_0 b or $P_0 b_1$. The lines of force external to this surface, proceed from the larger sphere to an infinite distance. We have here two tubes of force separated from each other by the critical surface, a M P_0.

In the external tube of force there are $4\pi\ (Q_1 - Q_2)$ lines.

Calling R_1 the resistance to flow within this tube and applying Ohm's law we have

$$4\pi(Q_1 - Q_2) = \frac{Q_1}{r_1}\frac{1}{R_1}$$

$$\therefore R_1 = \frac{1}{4\pi r_1}\frac{Q_1}{Q_1 - Q_2}. \qquad (9)$$

$\frac{Q_1 - Q_2}{Q_1}$ is evidently the fraction of the spherical surface which the free charge $Q_1 - Q_2$ occupies. If the charge Q_1 were alone in space, since the entire resistance around the sphere would be $\frac{1}{4\pi r_1}$, it follows from (9) that the lines proceeding from the free charge $Q_1 - Q_2$ suffer the same resistance when charge $- Q_2$ is present as when it is absent and the lines are all radial.

This is due to the fact that we have assumed that the bodies are so far apart that they do not appreciably disturb each other.

The charge on the larger sphere within the critical surface is $+ Q_2$. From this charge $4\pi Q_2$ lines proceed to the other sphere. The difference of potential between the two spheres is

$$V_1 - V_2 = \frac{Q_1}{r_1} + \frac{Q_2}{r_2}$$

Hence as before

$$4\pi Q_2 = \left(\frac{Q_1}{r_1} + \frac{Q_2}{r_2}\right)\frac{1}{R_2}$$

$$\therefore R_2 = \frac{1}{4\pi r_1}\frac{Q_1}{Q_2} + \frac{1}{4\pi r_2} \qquad (10)$$

This is the resistance of the internal tube terminating on the two bodies. The charges on the ends of this tube may be called bound charges.

The first term of eq. (10) contains a factor $\frac{Q_1}{Q_2}$, the reciprocal of which is the fraction of the surface of the larger sphere which its bound charge occupies.

The first term therefore represents the resistance which the lines of the bound charge on the larger sphere would suffer, if they proceeded radially to an infinite distance in the absence of the other sphere.

The second term on the other hand is the resistance which these lines would suffer if they proceeded radially from the smaller sphere. The sum of these two resistances, then, is the resistance of the internal tube.

If the first term of eq. (10) and the resistance R_1 as determined in (9) be treated as resistances in multiple, their product divided by their sum, will be found to be $\frac{1}{4\pi r_1}$ which is the resistance around the larger sphere when it is alone in space and its lines are radial. The remaining term of (10) gives the resistance around the other sphere under the same conditions.

If $Q_1 = Q_2$ then

$$R_1 = \infty$$

$$R_2 = \frac{1}{4\pi r_1} + \frac{1}{4\pi r_2}$$

If now $r_1 = r_2 = r$

$$R_2 = \frac{1}{2\pi r}$$

which is a very well-known result. The resistance offered to the lines of either body is the same as it would be if the other were absent and the lines were radial.

It is evident that the two terms of (10) represent resistances from the respective charges $+ Q_2$ and $- Q_2$ within the internal tube, to the surface of zero potential surrounding the smaller charge $- Q_2$, and which all the lines of this tube cross. If $\frac{Q_1}{r_1} = \frac{Q_2}{r_2}$ these terms become equal.

If we now apply equation (8) to these two tubes of force we have

$$W = \frac{1}{8\pi}\left(I_1^2 R_1 + I_2^2 R_2\right) \qquad (11)$$

$$= \frac{1}{8\,\pi}\Big[16\;\pi^2\,(Q_1 - Q_2)^2\,\frac{1}{4\;\pi\;r_1}\,\frac{Q_1}{Q_1 - Q_2}$$

$$+\;16\;\pi^2\,Q_2^2\left(\frac{1}{4\;\pi\;r_1}\,\frac{Q_1}{Q_2} + \frac{1}{4\;\pi\;r_2}\right)\Big]$$

$$= \frac{Q_1^2}{2\;r_1} + \frac{Q_2^2}{2\;r_2} \qquad (12)$$

This is the well-known expression for the energy of these two spheres, in terms of their respective charges and capacities.

If the spheres are brought near enough so that they react on each other, the density will no longer be uniform on the spheres.

The total flow of force from the positive charge Q_1 and to the negative charge Q_2 will, however, remain unchanged. The potential of each body will, however, be changed. The potential of each body can then be determined to any desired precision by determining the successive images of the two charges. Knowing the resulting potentials, the perviance between the two bodies can be computed.

The conclusion that the energy of an electrical system resides in the medium has been formerly inferred from the following considerations. The energy of any system is usually represented in general by the equation

$$W = \frac{1}{8\,\pi}\int V \bigtriangleup V\,dv \qquad (13)$$

This equation is the exact equivalent of (8) for $\bigtriangleup V$ is defined by Poisson's equation to be

$$\bigtriangleup V = \frac{d^2 V}{dx^2} + \frac{d^2 V}{dy^2} + \frac{d^2 V}{dz^2} = -\,4\;\pi\;\rho$$

where ρ is the volume density of the medium. $\bigtriangleup V$ therefore represents the flow of force from unit volume of the medium and $\bigtriangleup V\,dv$ is the flow from an element of volume. If the integration in (13) be extended through the volume of a tube of force the result would be $\frac{VI}{8\pi}$ which is the same as (8).

By Green's equation

$$\int V \triangle V \, dv = \int V \frac{dV}{dn} ds - \int F^2 dv. \tag{14}$$

This formula is to be applied to the volume bounded by a sphere of very large radius and which includes the electrical system. The first term of the second member is to be applied to the surface of the sphere, the center of which is at the center of gravity of the system. The potential V varies inversely as r, and the normal force $\frac{dV}{dn}$ varies inversely as r^2. Since the surface is directly as r^2 the total surface integral is inversely as r and becomes nearer zero as r becomes greater. The second member of (14) therefore reduces to its second term and we have for the energy

$$W = \frac{1}{8\pi} \int F^2 dv. \tag{15}$$

The energy per unit volume is therefore

$$\frac{dW}{dv} = \frac{1}{8\pi} F^2. \tag{16}$$

To apply this method more specifically let us suppose the electrical charges of the system to be transferred to the spherical surface of large radius which is an equipotential conducting surface of the system. The force outside of the surface will remain unchanged, when the charge comes to equilibrium.

The force with which an element of surface dS having a charge σdS is repelled outward by the rest of the electrified surface is

$$dp = 2\pi \sigma^2 dS \tag{17}$$

$$\text{where } \frac{dp}{dS} = \frac{1}{8\pi} F^2.$$

$$\text{But } dS = r^2 d\omega$$

$$\sigma = \frac{Q}{4\pi r^2}$$

$$\therefore dp = \frac{Q^2}{8\pi r^2} d\omega$$

If the sphere be collapsed by external pressure the radius being shortened by dr, the work applied to the element dS against the opposing electrical repulsion is

$$d^2W = d\ p\ dr = \frac{Q^2}{8\pi}\frac{dr}{r^2}d\omega$$

The work required to shorten the radius from r″ to r′ will be found by integrating in ω over the surface of the sphere and by integrating in r between r″ and r′. Hence we have

$$W = \frac{Q^2}{8\pi}\int_{r'}^{r''}\frac{dr}{r^2}\int_{0}^{4\pi}d\omega = \frac{Q^2}{2}\left(\frac{1}{r'} - \frac{1}{r''}\right)$$

This shows that the work done on the sphere is equal to the difference between its initial and final energy.

If the initial radius were infinite, the work done is $\frac{Q^2}{2}\frac{1}{r}$

The force within the electrified surface is zero, but as the radius of the sphere shortens, the electrical density and therefore the strength of field at the surface increases. According to older views the charge on the surface exerts mutual repulsions, and the work done consists in overcoming this repulsion. This view still gives color to modern statements just as astronomers sometimes speak of the daily motion of the sun. But we may also say that as parts of the medium pass through the electrified surface, they are thrown into a condition of stress. When a point in the medium is at the contracting surface the force is $4\pi\sigma$ where σ is the density at the point. As the surface leaves this point, the force at the point remains unchanged. The condition of stress into which the medium is thrown is maintained constant at a value directly dependent on the value of σ when the surface was at the point. As the surface is pressed in toward the system, it must deform and coincide with the equipotential surfaces of the original system. Here, however, we meet with complications. The electrified surface must break up into separate closed sheets, surrounding the various bodies of the system. Some of these surfaces may surround bodies which were originally positively charged, and others bodies which were negatively charged. The charge on the collapsing surface is, however, all of one sign. It is like a case where equal terms of unlike sign in an equation have destroyed each other during an operation. They will not replace themselves when the operation is sought to be reversed. If, however, we intelligently restore the charges to the separating sheets of the collapsing surface until we have reproduced the original electrification, then the energy which we have applied to the surface is the energy of the system. But all of this leaves untouched the question concerning the nature of the force against which we have been working. There is reason to believe that it is not mutual repulsions between the elements of the electrification. There is reason to believe that it is a reaction between the electrification and a stressed condition which is impressed upon each element of the medium, as soon as it becomes external to the surface.

The electrical system is in fact produced by forcing the charges upon the surfaces of the cavities in the medium which the bodies occupy, and the condition of stress is propagated outwards and is maintained in some manner at present unknown.

It is evident that the evaluation of the volume integrals involved in determining perviance, resolves itself into a determination of electrostatic capacity. This is capable of direct determination by discharges through a ballistic galvanometer. As the same integrals are involved in determining magnetic permeance, it seems feasible to apply this method to a study of many cases of leakage from magnetic circuits. It would only be necessary to construct wooden or other models having conducting surfaces, and having the forms to be investigated.

For resistance to electric induction or the reciprocal of perviance, several names have been suggested to me, the best of which is *diviance*, from *dis*, *via*. Here the prefix *dis* must have the effect which it has in such words as discomfort or discourtesy. It denotes a lack of the quality without implying a total absence of it. The word *diviability* would then represent the reciprocal of perviability.

Issued Jan. 21, 1895.

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NOTE ON THE GLACIAL DRIFT IN ST. LOUIS.

H. A. Wheeler, E. M.

(Read in somewhat less extended form at the meeting of the Academy of Science, April 1st, 1892.)

In driving a tunnel under West Pine street, in the western-central part of St. Louis, for a sewer, the blue glacial clay or "till" was found for a distance of about 2,000 feet. A shaft at the junction of Taylor avenue and Pine street, which was about the middle of the till formation, disclosed a thickness of 12 feet. The blue-clay carried gravel and boulders as usual, and though none of the latter exceeded a foot in diameter, they were largely made up of distant-carried material, or crystalline rocks from the North like granite, mica-schist, white-quartzite, besides white saccharoidal sandstone, chert and limestone. It rested on the St. Louis Limestone (subcarboniferous), and was overlaid by 10 to 15 feet of the non-pebble bearing loess, or the unstratified, columnar jointed, brown, homogeneous sandy-clay formation (the "brick-clay"). The till feathered out on the west side of Euclid avenue, and was not again encountered in the westerly extension of the sewer.

From the limited width of the till, as the sewer-section was on about an east and west line, and the comparative thinness, not exceeding 12 feet, it seems to be a local tongue or extension of an ice-stream beyond the main body of the southern limit of the great ice-sheet. The nearest recognized development of the till is at the Chain of Rocks region, or ten to fifteen miles north, where heavy sheets of mixed gray and brown clays and sands, carrying pebbles and boulders of foreign rocks, occur in the tongue of land between the Mississippi and Missouri rivers. In this region the till attains a thickness of over thirty feet, and contains, as erratics, red pegmatite, granitite, red and gray granite, diorite, dolerite, quartz porphyry (like the Keweenaw Point series), porphyrite, red quartzite, quartz geodes (Keokuk), white "sugary" sandstone (Saccharoidal), besides abundant cherts from the immediate neighborhood. But no blue-clay has been observed there, and the Pine street sheet is the only occurrence of blue till known to the writer in Missouri that is south of the Missouri river, which lies 12 miles north.

A thin layer of gravel bearing loess (?) is usually found at the base of the true loess throughout St. Louis County, as far as 10 to 15 miles south of Pine street, and while most of the pebbles are local cherts, they occasionally include distant material like granites, etc. This gravel bearing bed is always thin, ranging from $\frac{1}{2}$ to 2 feet in thickness and is similar in character to the transition bed that is found about the Chain of Rocks region between the typical loess and the typical drift, or has the general character of the loess plus more or less gravel, though usually only a little gravel is present. It totally lacks the character of the true till, and cannot be regarded as an ice-sheet deposit. This Pine street occurrence of till is therefore the most southern known extension of the ice-sheet in St. Louis County, though the Illinois lobe advanced considerably further south, according to the studies of Leverett, Salisbury, Chamberlain, and others.

I am indebted to Mr. Robt. E. McMath, the former sewer-commissioner, for calling my attention to the Pine street blue-clay.

Issued February 21st, 1895.

NOTE ON AN OCCURRENCE OF BLENDE IN LIGNITE.

H. A. WHEELER, E. M.

(Read at the meeting of Academy of Science, of November 19, 1894.)

In excavating for the foundations of the new high-service pumping-station at Baden, in North St. Louis, fragments of blende-bearing lignite were found in the "Ferruginous Sandstone" at a depth of about 25 feet. The pit is in the river-bottom at the base of the bluffs that mark the western edge of the valley of the Mississippi river, being about half a mile west of the present river-bank, and furnishes the following section:—

Black "Gumbo" Soil	2′ to 3′	*Recent.* (Mississippi River) Deposits.
Fine Sand	12′ to 18′	
Coarse Sand and Pebbles	2′ to 8′	
Gray to Drab Sandstone	2′ to 10′	*Base of Coal Measures.*
Yellow Shale	1′ to 2′	
Green Shale	2′ to 3′	
St. Louis Limestone—average depth,	32′	*Sub-Carboniferous.*

The excavation stopped at the limestone, on which the coal-measures rested unconformably.

The sandstone in which the fragments of lignite occurred was coarse-grained, porous, cross-bedded, light-gray to dark-drab in color, and rich in lignitic streaks with occasional fragments several inches in thickness. Some of these fragments of lignite or brown-coal are full of longitudinal and transverse desiccation cracks, which are completely filled with a crystalline mixture of sphalerite or zinc-blende, calcite and pyrite. The blende decidedly predominates, forming thin seams $\frac{1}{10}$ to $\frac{1}{2}$ inch in thickness through the lignite, and is light to dark brown in color, has a perfect cleavage, and the usual resinous fracture. Calcite, of the white, crystalline variety, is occasionally intermixed, and less frequently pyrite. The lignite is brown in color, shows an eminent wood structure, and dries out on prolonged exposure, becoming heavily checked and very tender.

The coarse sand and gravel of recent age that overlays the sandstone is cross-bedded (showing that it is a channel deposit of the river), and contains abundant fragments of drift-wood that is more or less lignitic. None of these lignitic fragments in the sand contain any blende, which shows that the zinc was introduced before they were deposited.

This occurrence of blende in this basal coal-measure sandstone is very interesting from its bearing on the problem of the origin of our Missouri zinc deposits. For though only found in specimen quantities, it shows that during or since the coal-measure epoch, this coarse-grained, porous sandstone has been permeated with solutions carrying zinc-sulphate, from which by the reducing action of the lignite, the soluble zinc-sulphate has been reduced to the insoluble zinc-sulphide or blende, and precipitated in the interstices and cracks of the shrinking lignite. The blende is only found in the lignite, so that large amounts of zinc may have been present in the sandstone, but was only retained where locally converted by the lignite into the insoluble blende.

The nearest known occurrence of zinc is in the quarries in the underlying St. Louis limestone that are worked five to ten miles south, where small disseminated grains of crystalline blende occur occasionally in the geode-bearing magnesian limestone beds; the latter are sufficiently porous for the feeble infiltration of solutions, and organic matter in the limestone seems to have precipitated slight amounts of zinc. Numerous other instances of occasional disseminated grains or nodules of zinc have been observed in the neighboring limestones, and unsuccessful attempts at zinc-mining have been made near Troy, in Lincoln County, 45 miles northwest, and at Hannibal, 90 miles, at the base of the Sub-Carboniferous. The nearest producing zinc mines are 50 miles south, at the Vallé Diggings, in St. Francois County, where the zinc occurs in gash-veins, associated with galena in magnesian-limestone of Lower Silurian or Cambrian age; while the great zinc region of Southwest Missouri, where the zinc occurs so extensively in irregular bodies in broken chert and limestone of Sub-Carboniferous age, is 250 miles southwest.

Dr. W. P. Jenney* thinks that the zinc occurrences of the Mississippi Valley are all of the same age, and that the source of the zinc was from below. While the former idea of contemporaneous age may be possible, the occurrence of the disseminated grains in the St. Louis limestone and in the seams of the lignite in the Baden sandstone, decidedly show that in at least these two cases the zinc was derived from *lateral secretion.* The Baden sandstone, which is the equivalent of the "Ferruginous" or at the base of the Coal Measures, also shows that the zinc was introduced at least as late as the Coal Measure period, but not so recent as the Quaternary; the lack of any formations between these horizons prevents any closer determination of this question.

The writer is indebted to Mr. J. Gordon Reel, C. E., the engineer in charge of the work, for an excellent suite of the blende specimens.

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* "Lead and Zinc Deposits of the Mississippi Valley." W. P. Jenney, E. M. Transactions American Inst. Mining Engineers. Vol. 22.

Issued February 21st, 1895.

RECENT ADDITIONS TO THE MINERALOGY OF MISSOURI.

H. A. Wheeler, E. M.

(Read by title at Academy meeting, March 17th, 1890.)

A contribution to our Missouri mineralogy was made in Vol. 4, p. 440, of the "Transactions of the St. Louis Academy of Sciences" by Mr. A. V. Leonhard who, in a paper entitled "Notes on the Mineralogy of Missouri," describes 70 species and 5 varieties of minerals that are found in the State of Missouri. Later collectors have since added 48 more species and 11 additional varieties to our local mineralogy, which are herewith given (1894) as a supplement to Mr. Leonhard's list (1884).

GOLD.

Placer Gold. Occasional occurrences, in small amounts, in the Glacial Drift in the Northern and Western parts of the State; by Norwood and Broadhead.

SILVER.

Argentiferous Galena, at the Einstein mine, in Madison County, in a fissure-vein in archean granite; it assays 100 to 300 ounces per ton, but is not abundant.

MERCURY.

Native Mercury. In the Loess or surface clay at Cheltenham station, St. Louis, in very small amounts, by J. P. Gazzam, E. M.; is probably of artificial origin.

TIN.

Cassiterite was reported as occurring as disseminated grains in greenstone near Frederickstown, in Madison County; a large company was formed in 1871 to work it, but it proved to be a case of "salting."

COPPER.

Chrysocolla, at the Cornwall Copper Mines, in St. Genevieve County, as a thin incrustation with other oxidized products in the chalcopyrite-bearing limestone, by H. A. Wheeler; uncommon.

LEAD.

Leadhillite. In small green crystals and clusters, of exceptional beauty, from a lead mine near Granby, Newton County. See American Journal of Science, Sept., 1894.

Mimetite, at Seneca, in Newton County, as a thin crystalline coating on galenite, by Dr. W. P. Jenney; rare.

Artificial Silicate of Lead. Beautiful hexagonal prisms of lead-silicate, resembling Pyromorphite, of an opaque brown to transparent ruby-red color, and with a resinous fracture, from the hearth of a lead roasting-furnace at Bonne Terre, by J. T. Monell, E. M. See American Journ. Science, Aug., 1885, and Sept., 1886.

ZINC.

Goslarite, at Joplin, Jasper County, as a white, stalactitic incrustation in the blende mines; first found very sparingly by Broadhead, and later quite frequently in the drainage of the mines, by Dr. W. P. Jenney.

Ferro-Goslarite, at Webb City, Jasper County, as a brown stalactitic incrustation in the old-workings of the zinc-mines, by H. A. Wheeler; rare. See American Journ. Science, Mch. 1891 (Vol. 41).

Amorphous Sphalerite, as an amorphous, white, pulveralent mass or "natural-paint" in a zinc mine at Joplin, Jasper County, by J. D. Robertson. Only a single pocket of a few tons was found, and was evidently the result of recent oxidation of the blende and subsequent chemical precipitation.

TITANIUM.

Rutile, in Southeastern Mo., in the granites, as an accessory mineral of microscopic size, by Dr. E. Haworth; rare?

NICKEL.

Siegenite. A new occurrence of this nickeliferous Linneaite has just been found (Nov., 1894) at the Donnelly Lead

Mine, in the Flat River district, St. Francois county, where the Siegenite occurs mainly massive though occasionally in fine crystals, in seams 2 to 4 inches thick in magnesian limestone, by J. N. Judson.

IRON.

Arsenopyrite, at the Einstein Silver Mine, in Madison County, as one of several minerals filling a fissure vein in granite; occurs as imperfect crystals 4 to 15 m.m. long and is not abundant, by H. A. Wheeler.

Also sparingly in association with pyrite in the limonite deposits of the Mine-la-Motte estate, by J. W. Neill.

Turgite, at Des Arc, Iron County, in stalactitic aggregations of reddish-brown color and sub-metallic luster, and containing 5.8% combined water, by H. A. Wheeler; uncommon.

Copiapite, at Granite Bend, Wayne County, as a yellow, crystalline incrustation on pyrite in granite, by H. A. Wheeler; rare.

Petkoite, at Granite Bend, Wayne County, as a black, amorphous incrustation on pyrite in granite, by H. A. Wheeler; rare.

Dufrenite, at the Cherry Valley Iron Mines, Crawford County, as minute green crystals less than 1 mm. in size, incrusting specular hematite, by A. V. Leonhard; uncommon.

Cacoxenite, at Cherry Valley Mines, Crawford County, as a thin, yellow, earthy incrustation on quartz and specular hematite, by A. V. Leonhard; uncommon.

Vivianite, from Joplin, Jasper County, as a blue, earthy powder, by Dr. G. Hambach; rare.

MANGANESE.

Rhodochrosite, at Iron Mountain, St. Francois County, in massive form, filling thin seams in specular hematite, by W. B. Potter; uncommon.

Manganocalcite, at Iron Mountain, St. Francois County, as crystalline masses, of a reddish-brown color, associated with calcite in specular hematite, by W. B. Potter; uncommon.

ALUMINUM.

Aluminite, at Joplin, Jasper County, as a white incrustation on limestone; rare.

Alunogen (alum) as a white incrustation, as silky tufts, and as fine disseminations in pyritic shales in the coal measures in the western part of the State, by H. A. Wheeler; common.

Wavellite, in Jasper County, as small white radiating crystals on chert, by Broadhead; rare.

Earthy Lazulite? in Dallas County, as a white, pulveralent earth or plastic clay in caves, by W. B. Potter.

BARIUM.

Ammoniacal Barite. Finely crystallized banded barite, from Pettis County, that contains small amounts of sulphate of ammonia (mascagnite). See American Journal of Science, Vol. 42, p. 495.

STRONTIUM.

Strontianite, in St. Louis, as small crystals in geodes in the St. Louis limestone; very rare.

SILICATES.

Chalcedony, as pink, gray and white pebbles in the drift in North St. Louis, by H. A. Wheeler; uncommon.

Tripoli, at Seneca, Newton County, as extensive beds of soft, massive, pulveralent, white to buff colored masses, where it is mined and shipped.

Frequently as fragments of altered chert in the "flint hills" of the southern half of the State, by H. A. Wheeler.

Hyalite, at Granite Bend, Wayne County, as transparent, colorless, irregular botryoidal incrustations on granite, by H. A. Wheeler; rare.

Augite
Uralite } in Southeastern Mo., in diabase, by E. Haworth.

Almandite, at the Einstein Mine, Madison County, as bright red, transparent crystals 0.1 to 0.5 mm. in size, by H. A. Wheeler; rare.

Essonite, at Iron Mt., St. Francois County, as yellow, subtransparent, rhombic-dodecahedral crystals 1 mm. in size on specular hematite, by W. B. Potter; rare.

Zircon *Chrysolite* *Biotite* *Microcline* *Piedmontite*	in microscopic sections of the granites in Southwestern Mo., by E. Haworth.
Anorthite *Andesite* *Bytownite*	in microscopic sections of the porphyries in Southwestern Mo., by E. Haworth.
Topaz *Lepidolite*	at the Einstein Mine, Madison County, in the granite, by E. Haworth.

Talc, at Pilot Knob, Iron County, as thin, white scales on specular hematite; not common.

Margarodite, at the Einstein Mine, Madison County, as imperfectly radiating scales of a light gray color and pearly lustre, from 4 to 8 mm. long, by H. A. Wheeler; not common.

KAOLINITE. *Kaolin variety.* Very abundant in pockets as soft, white to pink, slightly plastic clay in Bollinger, Cape Girardeau and Howell counties. Is extensively mined.

China or Ball Clay Variety. Occurs as pockets, of light gray color, and very plastic, in Jefferson and Franklin counties; is extensively mined.

Lithomarge Variety. Very abundant in pockets as a hard, non-plastic, light gray to buff color, with conchoida fracture, in Warren, Callaway, Osage, Phelps, Crawford and Franklin counties. Is extensively mined and shipped as "flint fireclay."

Pholerite, occurs with the Lithomarge, as above, by H. A. Wheeler.

Pyrophyllite, at Potosi, Washington County, as very thin, white, greasy feeling scales, intermixed with clay, from the lead mines, by Dr. G. Hambach; rare.

CARBON MINERALS.

Peat, at Glenwood, Schuyler County, in local swamps, in the drift, by H. A. Wheeler; not abundant.

Lignite, as fragments of wood changed into lignite, in clay pockets in Jefferson (Regina) and Cape Girardeau counties, by H. A. Wheeler.

Also as fragments of drift-wood in the Ferruginous Sandstone (coal measures) at Baden, North St. Louis, by H. A. Wheeler.

Petroleum / *Natural Gas* } In slight amounts in an artesian well at the Excelsior Brewery, St. Louis, by C. A. Luedeking.

SULPHUR.

Sulphuretted Hydrogen, dissolved in mineral or "sulphur" water in some springs and artesian wells about St. Louis, Jefferson, Henry, Vernon and other counties. See "Report on Mineral Waters," Mo. Geol. Survey, 1892.

Issued February 21st, 1895.

*THE LAW OF MINIMUM DEVIATION OF LIGHT BY A PRISM.**

FRANCIS E. NIPHER.

An elementary proof of the law of minimum deviation of light by a prism may be obtained as follows : —

Let i and r represent the angles of incidence and refraction at the point where the light enters the prism, and let i' and r' represent these angles where the same ray leaves the prism. The angles i and r' are in air and r and i' are in the glass. Then by geometry, calling d the angle of deviation of the ray,

$$d = i - r + r' - i' = i + r' - A \quad (1)$$

where $A = r + i'$, is the angle of the prism. If we lay off the angles d, i and r' on three rectangular axes, (1) is the equation of a plane. The trace of this plane on the plane d, i is obtained from (1) by making $r' = 0$. If i be made zero we shall have the trace on the plane d, r'.

These traces make an angle of 45° with the axes which they intersect, and the distance of each point of intersection, from the origin, is A. The position of this plane is wholly independent of the refractive properties of the prism. Any two prisms having equal

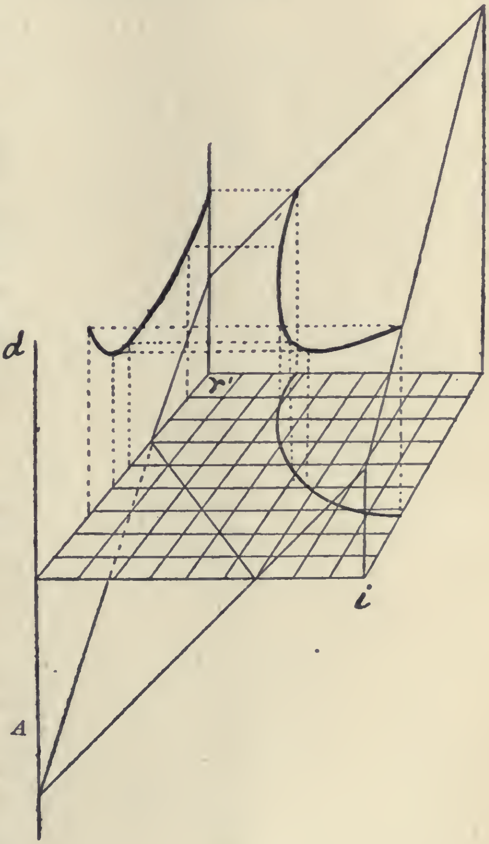

FIG. 1.

* Read before Regular Academy Meeting, November 4, 1895. Approved by Council, November 18, 1895.

angles A, the ordinates d would terminate in points upon a common plane whose equation is (1). If any two prisms have unequal angles A, the ordinates d would terminate in different, but parallel planes. This plane is in all cases symmetrically placed with respect to the axes i and r'. Its position is shown in Fig. 1.

There is, however, another condition depending on the index of refraction. We have

$$\begin{aligned}\sin i &= n \sin r \\ \sin r' &= n \sin i' \\ &= n \sin (A - r) \\ &= n \sin A \cos r - n \cos A \sin r \\ &= n \sin A \sqrt{1 - \sin^2 r} - \cos A \sin i\end{aligned}$$

or finally

$$\sin r' = \sin A \sqrt{n^2 - \sin^2 i} - \cos A \sin i \text{.........} (2)$$

By considering the physical conditions, it is easily seen that the quantities r' and i must be symmetrical in equation (2). If the light be made to reverse its direction, it will retrace its path through the prism. The angles r' and i will then replace each other. The same result will be obtained by solving (2) for sin i, which gives

$$\sin i = \sin A \sqrt{n^2 - \sin^2 r'} - \cos A \sin r' \text{........} (3)$$

Equation (2) or (3) may be used in the computation of simultaneous values of i and r'. When $r' = 90$, we have

$$\sin i = \sin A \sqrt{n^2 - 1} - \cos A.$$

The values of i that will be physically possible must lie between the value determined in the last equation, and 90°. These values of r' and i determine a curve on the plane of r', i of Fig. 1. This curve is convex toward the axes r' and i, and it is symmetrical with respect to them. This curve is a projection in a direction parallel to the axis d, of points on the plane represented by (1), which must represent the relation between d, r' and i. The conditions of symmetry involved in equations (1) and (2), both of which must be satisfied, show that the minimum ordinate d must lie in a plane symmetrically located with respect to the axes r' and i. This plane is determined by the condition $r'=i$, which makes the entering and emergent rays symmetrical with respect to the bounding surfaces of the refracting angle A.

Putting this condition in (2) it reduces to

$$\sin^2 i = \frac{\sin^2 A}{2+2\cos A} n^2.$$

Since $\sin i = n \sin r$ we have

$$\sin^2 r = \frac{\sin^2 A}{2+2\cos A}.$$

The angles $r=i'$ within the prism then become independent of n, their value being dependent on A only.

If the sines are regarded as the variables, equations (2) and (3) represent an ellipse. Calling $\sin r' = y$ and $\sin i = x$, those equations become,

$$y^2 + x^2 + 2\, y\, x \cos A = n^2 \sin^2 A.$$

When the angle of the prism becomes zero the ellipse becomes the diagonal of a square whose sides are $2\, n$, the last equation being $y=-x$. When $A = 90°$ the ellipse becomes a circle whose equation is $y^2+x^2=n^2$. For intermediate values of A the ellipse has the square whose side is $2\, n$ as an envelope, the major axis lying in the line whose equation is $y=-x$. The minor axis always lies in the line whose equation is $y=x$, which involves the condition $i=r'$. In its general form (2) becomes

$$y = -x \cos A \pm \sin A \sqrt{n^2 - x^2}$$

The line $y = \pm n \sin A$ laid off on the axis y and the line whose equation is

$$y = -x \cos A$$

are conjugate diameters of the ellipse. Those portions of the ellipse corresponding to values of x or y greater than unity have no corresponding values of i and r', but within the limits where physical interpretation is possible, the symmetry of the curves

$$i = f(r')$$

with respect to the axes i and r' of Fig. 1 is evident.

RELATIONS OF SALIX MISSOURIENSIS, BEBB, TO S. CORDATA, MUHL.

BY N. M. GLATFELTER, M. D.

The great variability of that species of Salix formerly included under the name of cordata has long been known. Indeed, so impressed am I with the extent of this variation, I have come to feel that no simple, straight statement regarding any one of its characters, can represent a truth: it is for this reason that the usual descriptions render but a part of a truth, and, by too much inclusion, become virtually errors. Looking at the different forms of leaves and stipules as represented on the plates accompanying this paper, one will be struck with the apparent indifference of the plant as to what kind of leaf or stipule it produced. Certain of its forms have, long ago, been named as varieties. The matter of erecting one of these forms into a species under the name of Missouriensis, judging from the language of its projector, Mr. M. S. Bebb (see *Garden and Forest*, p. 373), seems, as yet, a somewhat open one. Considering it important to know whether we really have here a new species, and what its specific limits might be, I have collected during the season just past, nearly two hundred specimens. The range of the territory of my collections is limited westward to Forest Park, Ferguson and Creve Cœur lake, northward to the Missouri river, eastward to the Illinois bluffs and Cahokia.

For convenience of handling my subject-matter, I shall assume, from the first, but *one* species under the name S. Cordata, the reasons for which assumption will be apparent later on.

North of the city along most of the ravines it grows abundantly, extending almost to the very heads of the ravines or gullies, most of which, in dry seasons, become perfectly dry, as is the case at the present writing. These ravines and small creek valleys were all covered over with that earliest alluvium that followed immediately upon the closing scene of the Glacial period, viz., the deposition of the *loess*. The willow under consideration avoids *low* bottom lands, growing sparingly, however, on the higher elevations of such lands.

As observed in the limits already pointed out, it occurs as a shrub or small tree, chiefly the latter. The undoubted shrubby form is really very scarce in this region. Often, when, at first, I thought here I have one, upon closer inspection, it proved to be only sprouts of several years growth sprung from a stem or stems previously cut, or from a prostrate trunk covered with soil on occasion of flooding of the gully or ravine. The banks being alluvium, trunks are uprooted and laid prone along the edges. In such case there will be plenty of shrubs apparently. One can the better appreciate such complication when the fact is recalled that this willow, especially, by nature, hugs closely the water-courses. Moreover, inasmuch as trees are small before they are big, and as the habit of this willow is, frequently, to grow in a clump, like Nigra, from a common center, it becomes a no easy task, nay, often, an impossible one, to say whether the example before you is a tree or shrub.

As a tree, full grown, I think I may safely state the range, in height, from 15 to 35 ft., in diameter from 3 to 7 in. Its usual habit is to fork low, often near the ground, or from 3 to 8 ft. higher, or throw off branches within this distance; but if crowded, as in a grove, many may be noticed not giving off any considerable branches for at least 20 ft. above the ground. When growing in clump of 3 to 5 or more, one or two of the stems may be 5 to 7 in. thick, and as high as the single stemmed tree.

The bark on all is light or dark grey, smooth, except towards the base of old trunks, where it is roughish: Year-old twigs if downy or tomentose, which is usually the case, are grey or blackish; if not downy or tomentose, greenish, greenish-yellow and blotched, or even yellow, or red on the side toward the sun. The same shoot which, early in the season, puts out with a hairy, tomentose vestment, will, in a second, prolonged growth, later in the season, be perfectly smooth. The same holds true of the buds.

It has been stated S. Missouriensis flowers in February, S. Cordata in April (B. F. Bush as quoted by Bebb in the article above referred to). I have to report the collection of all my aments both sterile and fertile from April 14th to 28th, finding no material difference, in time, as to high or low. The opening of the earliest staminate flowers is, of course, much earlier. In this, as in every other particular, we must allow for great variation, especially as modified by season.

Of the whole number of specimens collected, 13 were rejected as hybrid sericea and cordata, either fully identified or probable. There remained 171, of which 93 attained a height of over 10 ft.; 78 10 ft. and under. Every one of the 171 was examined separately, its characters noted and tabulated. In order to secure a more telling parallel or contrast, all those of the former class reaching a height of 20 ft. and over, 38 in number, were selected. The remainder of this class numbering 55 reaching 10 to 20 ft. in height, were placed in a separate column in the summary. The 78 classed as shrubs, it should be remembered, are subject to the restrictions and uncertainties already referred to above. I feel quite confident many of them ought to be included with the tree form, but being anxious to preserve the purity of the latter, I unhesitatingly consigned all under 10 ft. into the shrub class.

The results of my investigations are, in part, summarized in tabulated form placed at the end of this paper. From it the reader can readily draw conclusions. One of these will certainly be the astonishing variation running all through the three classes, with equal pace, as to leaves, stipules, petioles, etc. Not having collected a sufficiently large number of flowers and fruit to draw reliable inferences, I do not, in this summary, present this side of the subject. I can say, however, I found in this, also, equally great variation. Pedicels, capsules, and styles are either long or short; capsules are beaked, or simply ovate-conical; scales and rachis are intensely hairy, or nearly bare. All this irrespective of the size of the plant.

Petioles vary from a line to more than one inch in length; stipules from ovate to reniform, to semicordate acutely to long acuminately pointed, in some examples distinctly stalked.

The bases of the leaves range from acute to cordate. It is an exceptional plant on which the truncate or cordate may not be found. In regard to their outline the variation on the same plant is often very surprising. The shapes of the leaves may all be reduced to about five types: First, the broad ovate or ovate-oblong, Figs. 1 and 7 of the plates; second, the obovate or rhombic, Figs. 2 and 12 (this the Missouriensis); third, the elliptical, Figs. 3* and 6 (a common tree form); fourth, the oblong-lanceolate with obtuse, truncate, or cordate base, Figs. 4 and 9 (the old recognized type form); fifth, the long narrow lanceolate, Figs. 5, 10, 11.

There is one idea which runs, more or less, through all the forms, viz., the *ob* idea,— the leaf broadening above the middle. Even in the long narrow leaves it may usually be noticed. There is, besides, another, a universal character of the highest importance, it, in conjunction with the *ob* idea, being probably the chief mark by which we so readily recognize the species. This is the lack of symmetry of the two sides, or in other words, the leaf is not equilateral. It has a peculiar concave curve on one side towards the apex, which I believe is distinctive.

It is, indeed, a wonder that, in spite of all the variation, there yet is not the least difficulty in the recognition of the species.

How do we come to know it? Surely, not by a remembrance of its technical characters as given in descriptions. I conceive it must be from a very complex impression produced by the plant as a whole, too spiritual, perhaps, to fully interpret upon paper. No doubt, the shade color of the foliage, the way the leaves are massed on the twigs and branches, as well as the manner in which these spread, all have to do with it.

A second inference to be drawn from the table is, that there is not sufficient ground to draw the specific line between tree and shrub. Comparing the column of 38 trees with the 78 shrubs, it may, in a general way, be affirmed that the latter bear leaves having greater tendency to the

* After plate was drawn, when too late to rectify, I discovered that Fig. 3 represents a hybrid. — N. M. G.

lance form, shorter petioles and less glaucousness. But to me, it appears quite evident, judging both from a review of the table, and comparison of the first two plates, there exists not a demonstrable line of separation justifying a division into two species. This is not saying there is not a form rather peculiar in Missouri and Nebraska. Such form may present itself in Mr. Bush's district in a purer or less mixed state than here about St. Louis. If such be the fact, it could be ascertained only by making an extensive collection in his vicinity as I have done in mine.

If we assume two species then the intermediates would have to be regarded as hybrids, but such line of separation could not be drawn between tree and shrub as already shown; for the parallelism in most of the characters is almost complete; and besides, assuming any two forms as types, there would still remain the others as side types not fitting in between.

Have we the typical form of cordata as originally given at St. Louis? I think we have. Having examined a copy of the original drawing by Muhlenberg besides many herbarium specimens from many parts, at the Missouri Botanical Gardens, and a specimen personally collected on the "Potomac Flats," D. C., I come to the above conclusion. Moreover, I think we have here all the forms growing in the Mississippi valley and eastward at least to the Falls of Niagara, but not those of California and Mexico.

Is it not possible that in some former age these various forms may have arisen in separate regions as very distinct varieties, but now, having in some unknown way been brought together, present an almost protæan and unresolvable complexity? Or what influence may some other species of salix have exerted in modifying the original or its varieties? Sericea, for example. This latter willow grows sparingly here, but leaves abundant evidence of its contaminating influence on cordata wherever found. At first I felt myself able to distinguish the hybrids thus produced, but finally had to succumb to the indistinctness of the line of separation. This hybridism is found in tree as well as shrub. The silkiness of the Sericea, in the hybrid is often completely lost; the differing capsule merges into that of cordata. These two important characters gone there remains little to distinguish the spurious specimen in hand from the narrow-leaved forms of cordata. Even the veining, perhaps the most constant single character of cordata, fails us here. Inasmuch as S. sericea is widely spread over the country, is not its influence the same wherever coming in contact with cordata? And may not many of our narrow, long-leaved forms be due to this influence?

A detailed technical description is not one of the objects of this paper. I will call attention, however, to several variations which seem, hitherto, to have been overlooked, or which may be peculiar to our region. One is a tendency, in some specimens, to the notching of the stigma, a good example being represented in Figs. 19, 20, 21. Another is the occasional tendency to union partways, of the filaments, represented in Fig. 18; both are from trees. Summing up the three classes into which the collection is divided, it will be seen that the oblong and long lance shapes, the obtuse to truncate base, the medium petiole, the obtuse stipule, and glaucous surface, predominate.

In conclusion, allow me to say, it gives me no pleasure to run counter to the results arrived at by Mr. Bebb. Had he the same material to work with, I feel confident there would be no essential difference. He wrote me he had barely a dozen specimens amongst which were no truncate or cordate leaves, which, of course, was very exceptional to all his experience of the cordatæ. This deficiency must be attributed to the fault of the collectors; for in the so-called Missouriensis, the collector must *look* for the most vigorous shoots to obtain the truncate and cordate leaves, inasmuch as the tendency in this direction is not strong. It is not to be expected this paper will settle the question at issue. It should provoke further inquiry.

St. Louis, Nov. 4, 1895.

	No.	OUTLINES OF LEAVES.							Base.											Petiole.					Stipules.						Surface.				Shoots.	
		Oblong-lance.	Elliptic-lance.	Long lance.	Ovate-lance.	Lance.	Ovate-oblong.	Broad oblong-lance.	Obtuse to truncate.	Obtuse to cordate.	Obtuse to acute.	Obtuse.	Obtuse to round.	Acute to cordate.	Truncate to cordate.	Truncate.	Truncate to round.	Round.	Acute to truncate.	Long (relatively).	Short.	Medium.	Medium to long.	Medium to short.	Obtuse.	Acute.	Pointed.	Acute to pointed.	Acute to obtuse.	Pointed to obtuse.	Glaucous.	Sub-glaucous.	Pale.	Green.	Downy or tomentose.	Smooth.
Trees, over 20 feet............	38	12	11	6	2	4	3	..	7	7	5	6	3	2	3	2	3	..	..	7	8	17	5	1	16	4	4	..	13	1	27	..	10	1	37	1
	%	32	29	16	5	10	8	..	18	18	13	15	8	5	8	5	8	..	..	18	21	45	13	3	42	11	11	..	34	3	71	..	26	3	96	3
Shrubs..................... ..	78	32	3	22	4	8	4	5	14	3	6	17	6	..	15	9	3	5	..	13	33	32	..	..	17	12	17	7	22	3	32	16	24	6	55	23
	%	41	4	28	5	10	5	6	18	4	8	22	8	..	19	12	4	6	...	17	42	41	..	..	22	15	22	9	28	4	41	21	31	8	71	30
Trees, 10 to 20 feet...........	55	19	10	10	2	7	7	..	10	5	6	12	4	4	5	2	4	1	2	17	12	21	5	..	14	5	8	9	17	2	32	5	14	4	52	3
	%	35	18	18	4	13	13	..	18	9	11	22	7	7	9	4	7	2	4	31	22	38	9	..	25	9	15	16	31	4	58	10	25	7	95	5
Total	171	63	24	38	8	19	14	5	31	15	17	35	13	6	23	13	10	6	2	37	53	60	10	1	47	21	29	16	52	6	91	21	48	11	144	27

A summary of the Record of 171 specimens of S. cordata, 93 of trees, 78 of shrubs, personally, collected and examined 1895.

PLATE 1.

EXPLANATION.— Figs. 1, 2, 3, 4, 5, 6, leaf forms from trees over 20 ft. high.

PLATE 2.

EXPLANATION.— Figs. 7, 8, 9, 10, 11, 12, leaf forms from shrubs under 10 ft. high.

PLATE 3.

EXPLANATION.— Fig. 13, stipules various forms, natural size, the first three, upper line from the same tree, the one at right of second line from a shrub collected at Washington, D. C.; Figs. 14 and 15, twigs with winter buds, natural size, the former most usual in the arborescent form; Figs. 16 and 17, pistillate catkins, natural size; Fig. 18, stamens partly aduate $\times$ 3; Figs. 19, 20, 21, three forms of pistil $\times$ 3, with stigmas $\times$ 6.

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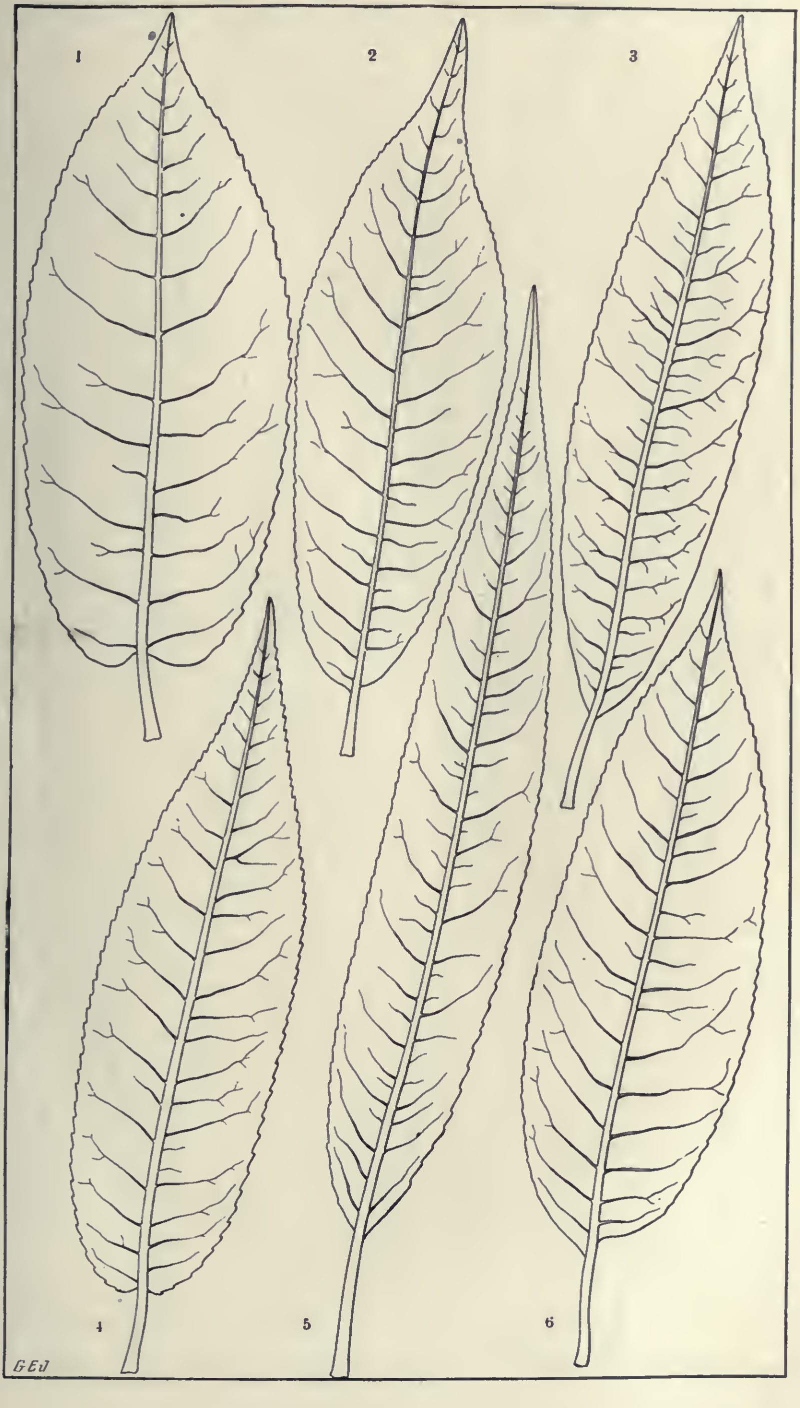

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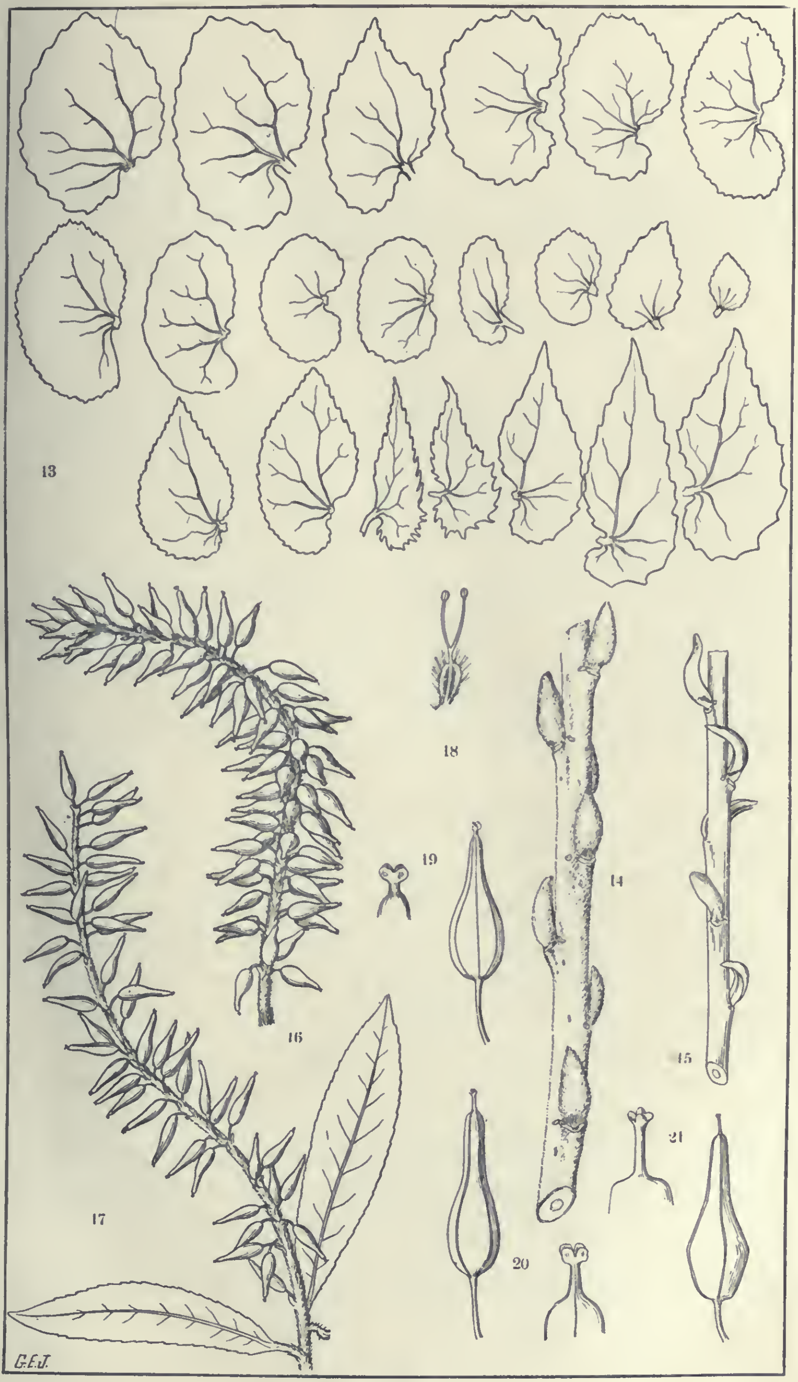
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G.E.J.

FLOWERS AND INSECTS.*

CONTRIBUTIONS TO AN ACCOUNT OF THE ECOLOGICAL RELATIONS OF THE ENTOMOPHILOUS FLORA AND THE ANTHOPHILOUS INSECT FAUNA OF THE NEIGHBORHOOD OF CARLINVILLE, ILLINOIS.

CHARLES ROBERTSON.

The following paper belongs with a series begun in the Botanical Gazette, Vol. XIV, May, 1889, which has reached the fifteenth number in the Gazette for February, 1896. The papers on Umbelliferae and Asclepiadaceae to Scrophulariaceae, in Vol. V, 449–460, 569–598, and on Labiatae and Rosaceae and Compositae, in Vol. VI, 101–131, 435–480, of these Transactions, as well as a paper on the Philosophy of Flower Seasons, in the American Naturalist, XXIX, 97–117, Feb., 1895, are parts of the same series. Unless otherwise stated, the observations were made in the neighborhood of Carlinville, Illinois, and within the limits of Macoupin County.

In making up the indexes to the literature of the several genera, use has been made of the bibliography compiled by D'Arcy W. Thompson, published in the translation of Müller's Befruchtung der Blumen, and giving titles of books and papers published up to 1883; of MacLeod's continuation of Thompson's list for the period 1883–1889, Bot. Jaarboek, 1890; of the abstracts by Müller and Dalla Torre in Just's Bot. Jahresbericht, those of Ludwig and others in the Bot. Centralblatt and those of Loew in the recent work now to be mentioned. Next in importance to the translation of Müller's Befruchtung der Blumen is Loew's Blütenbiologische Floristik des mittleren und nördlichen Europa sowie Grönlands — Systematische Zusammenstellung des in den letzen zehn

* Presented by title to the Academy of Science of St. Louis, April 6, 1896.

Jahren veröffentlichten Beobachtungsmaterials. Besides a slight German bias it must be used with caution on account of its time limit. I have had trouble with it because it mentions an author's name without citing the paper in which the observations are recorded.

For access to much of the literature I am indebted to the authorities of the Missouri Botanical Garden. Owing to the interest Professor Trelease has taken in the subject, the library probably contains the best collection of the literature of pollination in this country, and that, too, in the most convenient form for consultation. It is highly desirable to make this collection as complete as possible.

In the determination of Hymenoptera I have been aided by Mr. E. T. Cresson, W. H. Ashmead, L. O. Howard and W. J. Fox; in Diptera by Dr. S. W. Williston, C. H. T. Townsend and D. W. Coquillett; in Lepidoptera by Prof. G. H. French and C. A. Hart; in Coleoptera by Mr. Hart, Chas. Liebeck, through Entomological News, and S. Henshaw; in Hemiptera by Mr. P. R. Uhler and Mr. Hart.

HEPATICA Dill.— Sprengel (1) regarded *H. triloba* as a pollen-flower adapted to bees, and his view that the flower contained no nectar is confirmed by Axell (3) Müller (4) and Loew (8). Müller saw *Eristalis tenax* frequently feeding upon the pollen and hive-bees collecting it. He also notes that the male of *Osmia rufa* vainly sought for nectar, and that a butterfly, *Colias rhamni*, rested upon the flowers and probed for nectar upon different parts of the receptacle. Loew accounts for the visits of *Osmia rufa* as a result of a scarcity of food or as being in the search of the female. I have observed that when male bees fly about flowers looking for the female, they only do so about flowers upon which the female occurs, and they seldom alight. I make it a rule to capture these male bees and to watch the flowers for the visits of the females to which they belong.

Müller (6) goes to an extreme in mentioning *Hepatica* as an example of the blue flowers specially attractive to the highest specialized bees. The color is commonly quite pale, and the indications seem to point to an adaptation to the least specialized bees. The flowers are perfect and homogamous, but rare cases of gynomonoecism and gynodioecism have been recorded by Irmisch (2), Schröter (9), Calloni (10) and Schulz (11). The perfect flowers are spontaneously self-pollinated after the innermost anthers have begun to dehisce (Kerner 12).

HEPATICA ACUTILOBA DC.—*H. acuta* (Ph.) Britton.—The plants are common on hill-sides and bloom quite early — March 18th to April 19. The scapes rise 1-2 dm. high and bear erect flowers with about six sepals, which are blue, pinkish or white, expanding horizontally so that the flowers measure about 25 mm. across. Commonly several scapes are near together, and the plants, having no competitors to overshadow them, are quite conspicuous. The flowers close at night and open in the morning, the old ones persisting long enough to increase the attractiveness of the patches.

As stated above, *H. triloba* is considered to be without nectar, and I could not satisfy myself of its presence in this species either by sight, taste or test for sugar in water in which the flowers had been immersed. In spite of the failure to discover its presence I am inclined to suspect that it occurs in a thin layer, for all of the insects mentioned in the list thrust their proboscides about the bases of the filaments, except *Syrphus americanus*. On the other hand none of them were feeding upon the pollen, or collecting it, except the three Syrphidae and the hive-bee, which is not indigenous. The receptacle is covered with papillae which may secrete nectar. Unless they do, I can understand neither why they are present and so strongly developed, why the filaments are separated in such a way as to make room for them, nor the behavior of the insects. In *Anemone nemorosa*, which is also said to be devoid of nectar, Bonnier* states that similar papillae secrete nectar in minute drops.

The early flowers with their abundant exposed pollen, and possibly convenient nectar, are adapted to the less specialized bees, *Andrenidae*, though often also visited by Syrphidae and other insects. With rare exceptions, the visitors consist of a few individuals of the commonest insects flying at the

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* Les Nectaires, 141.

time. The following list was observed on March 21 and 29, and April, 4: —

Bees — *Apidae:* (1) Apis mellifica L. ☿, s. & c. p., freq.; (2) Ceratina tejonensis Cr. ♂, s.; *Andrenidae:* (3) Halictus sp. ♀, s.; (4) H. confusus Sm. ♀, s.; (5) H. stultus Cr. ♀, s.; (6) Andrena vicina Sm. ♂♀, s.; (7) A. erythronii Rob. ♂, s.; (8) A. mandibularis Rob. ♂, s.; (9) A. flavoclypeata Sm. ♀, s.; (10) A. rugosa Rob. ♂♀, s., freq.; (11) Colletes inaequalis Say ♂, s.

Flies — *Bombylidae:* (12) Bombylius major L., s., freq.; *Syrphidae:* (13) Syrphus americanus Wd., f. p.; (14) Eristalis dimidiatus Wd., s. & f. p.; (15) Brachypalpus frontosus Lw., s. & f. p., freq.; *Tachinidae:* (16) Gonia frontosa Say, s.; *Muscidae:* (17) Lucilia cornicina F., s., freq.; *Anthomyidae:* (18) Phorbia fusciceps Zett., s.

On the literature of *Hepatica* see: —

(1) Sprengel, Das entdeckte Geheimniss, 31, 291–2. 1793. *Anemone hepatica.* — (2) Irmisch, Montröse Anemonenblüthen. Bot. Zeit. 1848: 217–18. *A. hepatica.* — (3) Axell, Om anordningarna för de fanerogama växternas befruktning, 104. 1869. *Anemone hepatica.* — (4) Müller, Weitere Beobachtungen. I: 43. Verh. naturhist. Vereins preuss. Rheinl. u. Westfalens 1878. — (5) Hildebrand, Die Farben der Blüthen in ihrer jetzigen Variation und früheren Entwickelung, 25, 28. 1879. *H. triloba*, cyanic. (Just 7[1]: 110). — (6) Müller, Die Stellung der Honigbiene in der Blumenwelt. Bienenzeit. 38: No. 10. 1882. (Just 9[1]: 499). — (7) Müller, Fertilization of Flowers, 71. 1883. *H. triloba.* — (8) Loew, Blumenbesuch von Insekten an Freilandpflanzen. Jahrb. Bot. Gartens Berlin 3: 114 (46). 1884. — (9) Schröter, Gynodioecisme chez Anemone hepatica. Arch. sci. phys. et nat. Geneva 14: 283. 1885. — (10) Calloni, Fleurs unisexuées et mouvement spontané des etamines dans l'Anemone hepatica. Arch. sci. phys. et. nat. III. 13: 409. 1885. (Just 13[1]: 751) — (11) Schulz, Beiträge zur Kenntniss der Bestäubungseinrichtungen und Geschlechtsvertheilung bei den Pflanzen. 2: 178. 1890. — (12) Kerner, Pflanzenleben 2: 126, etc. 1891. — (13) Hansgirg, Neue biologische Mittheilungen. Bot. Centralblatt 52: 386. 1892. *H. angulosa.* — (14) Loew, Blütenbiologische Floristik, 177, 377. 1894. *H. triloba.*

Asimina triloba Dunal. — Common Papaw — Delpino (1–4) has given so complete an account of this flower that there is hardly anything new that can be said about it. It is our best example of a flower adapted to flesh-flies (sapromyiophilous). It is pendulous, broad bell-shaped, with dark purple color and an odor which Delpino compares to that of leaven. The short-lived stigmas protrude from the hemispherical mass of stamens and are receptive before the latter discharge, so that we have a very well marked case of proterogyny. The three outer petals are larger and form the most conspicuous parts. The three inner ones secrete nectar on their roughened inner faces, and are shaped and disposed so as to require the insects to come in contact with the anthers and stigmas. At first they are not so widely expanded, and this is important, since, when the flies crawl in, they are more apt to touch the stigmas, which are much fewer than the anthers and occupy a more limited and central position. Flies land upon the backs of the petals and crawl around to the underside, so that they strike the anthers and stigmas with their backs.

Asimina is an American genus, but there seems to be no reason why plants transferred to Europe should not be expected to show a quite natural assemblage of visitors, at least in the case of the species in question, since they would become exposed to a similar insect fauna. At Firenze, Delpino captured on the flowers a number of flies, which were determined by Rondani as follows:—

Muscidae: (1) Calliphora erythrocephala Mgn.; (2) Lucilia sericata Mgn.; (3) Cyrtoneura pasquorum Mgn.; (4) C. stabulans Fll.; (5) C. assimilis Fll.; *Anthomyidae:* (6) Homalomyia prostrata Rossi; *Ortalidae:* (7) Platystoma umbrarum Mgn.

Delpino did not seem to hold that the flower was adapted to flesh-flies until later (4). The following list observed on May 5th confirms this view. The trees are common on creek banks and bloom from April 22 to May 15.

Syrphidae: (1) Syrphus americanus Wd., one; *Tachinidae:* (2) Masicera sp., one; *Sarcophagidae:* (3) Cynomyia mortuorum L., freq.; (4) Sarcophaga aegra Wlk.; (5) Helicobia sp.; (6) H. helicis Twns.; *Muscidae:* (7) Lucilia caesar L.; *Anthomyidae:* (8) Phorbia fusciceps Zett. ; *Cordyluridae:* (9) Scatophaga squalida Mgn.

On the pollination of *Asimina triloba* see:—

(1) Delpino, Ulteriori osservazioni. Pt. I: 231, 242. Pt. II. fasc. 2: 24, 53, 94, 176, 178, 214, 301, 314. Atti d. soc. Ital. d. Sci. Milano 12: 221, 232. 1869. 16: 172–3, 201, 242, 324, 326. 1873. 17:—. 1874.—(2) Hildebrand, F. Delpino's Weitere Beobachtungen über die Dichogamie im Pflanzenreich. Bot. Zeit. 28: 672. 1870.—(3) Müller, Fertilization of Flowers, 90. 1883.—(4) Delpino, Sulla impollinazione dell' Arum Dracunculus. Malpighia 3: 389 (5). 1890. (Just 18[1]: 470).

PODOPHYLLUM L.—Loew (1) regards the two species of this genus as pollen-flowers. They are devoid of pathfinders.

The Himalayan *P. emodi* Wallr. resembles our species in a general way. It expands from 4 to 5 c. m. and has six petals and six stamens. The ovary is about 16 mm. long and bears a large stigma with six irregular lobes. The stamens are only 10 mm. long, so that self-pollination can hardly occur except as a result of irregular behavior on the part of the insect visitors.

PODOPHYLLUM PELTATUM L.— May Apple — The flower stem rises from a creeping rootstock to an height of about 3 d. m. and is terminated by two peltate leaves, between which is situated a single flower, which looks outwards and a little downwards. The flower is white and expands from 5 to 9 c. m. The petals are six to nine and the stamens 12 to 18. As a rule the anthers do not reach as far as the stigma, but sometimes their tips touch its edge so as to effect spontaneous self-pollination.

The flower seems to be devoid of nectar. I have watched it frequently, but have seldom seen it visited. A single hive-bee, *Apis mellifica* L. ☿, was observed collecting the pollen, but it is not a native insect. Two bumble-bees, *Bombus americanorum* F. ♀ and *B. separatus* Cr. ♀, probed about the bases of the filaments as if trying to find nectar, but did not try to collect the pollen. Another long-tongued bee, *Synhalonia frater* Cr. ♂, also sought for nectar.

The pollen protecting arrangements mentioned by Kerner (2) I think are quite imaginary.

The plant is common and blooms from April 26th to May 19th.

On the literature of *Podophyllum* see :—

(1) Loew, Blüthenbiologische Beiträge I. Pringsheim's Jahrbücher 22:452–3 (8–9). 1891. *P. emodi, peltatum.*— (2) Kerner, Pflanzenleben 2:126. 1891. (Just 17^1:529.)

SOLEA CONCOLOR GING.— Green Violet — The plant is rare in my neighborhood, there being, as far as I have observed, but one station for it. It grows in woods, in somewhat shady situations, and is the latest of the family to bloom, its season being from April 30 to May 30. The stems grow several decimetres high and bear small greenish flowers, which are pendulous, or nearly so. The flowers are rather inconspicuous and are partly concealed by the leaves, but there is an abundance of nectar. The lower petal is quite large. It is notched at the apex and bears a longitudinal groove which terminates in a blunt spur. The spur conceals the nectar, which is secreted by a large gland formed by a union of the two basal processes of the two lower stamens. The stamens are united into a tube enveloping the pistil, their cone-shaped tips receiving the loose pollen. Near the tip, the style is bent aside so that the stigma is placed in the groove of the lower petal. When a bee lands upon the lower petal, to which it clings, its proboscis is guided by the groove to the nectar at the base. The stigma is first touched and thrown upwards and backwards, a movement which disturbs the loose pollen and causes a downpour. Although there is evident adaptation for cross-pollination, and I have not seen any evident modification for securing spontaneous self-pollination, still the inconspicuous flowers, partly concealed by the leaves, the shady situations in which the plant grows, as well as the apparent infrequency of insect visits, lead me to suspect that spontaneous self-pollination may occur. On May 7th, I saw the flowers visited for nectar by a single female of *Augochlora pura* Say.

EUONYMUS L.— The flowers have freely exposed nectar. They are usually perfect, but in England, Darwin (5) found *E. europaeus* to be polygamous and trioicous, about one-half of the plants having all of the flowers pistillate. In the Tyrol Schulz (12) found this species to have perfect flowers in most cases, less frequently andro- or gynomonoecious. Of several thousand plants, he observed but two or three with only pistillate or staminate flowers.

Among the more or less fanciful types of floral mechanisms which Delpino (4) recognizes are the *Tipo ramnaceo* and *Tipo melantino*. He regards both as adapted to the larger flies. The former contains *E. europaeus*, *latifolius*, and *japonicus;* the latter contains *E. verrucosus*, with lurid color and offensive odor. In England, Darwin saw *E. europaeus* visited by many Diptera and some small Hymenoptera. In Germany, Müller (3) saw it visited by twelve flies, mostly *Syrphidae* and

Muscidae, while in the Tyrol Schulz observed many flies, bees and wasps, and beetles. In the Berlin Garden, Loew (8, 9) saw *E. latifolius* visited by a flesh-fly, *Calliphora erythrocephala*, and our *E. americanus* visited by the hive-bee.

According to Müller *E. europaeus* is proterandrous, with spontaneous self-pollination impossible. According to Schulz the proterandry is sometimes only slight. (See 2.)

EUONYMUS ATROPURPUREUS Jacq. — Waahoo. — This is a small tree bearing numerous small, dark purple, pendulous flowers in loose cymes. The flowers expand horizontally for about 8 mm. In the center is situated a nearly square flat disc which secretes nectar. Each angle of the disc bears a nearly sessile anther, while in the middle is situated a stigma which is also nearly sessile. The flowers are proterandrous. The stamens and style are so short that, I think, pollen is carried mainly upon the feet and proboscides of the insects. The flower has a disagreeable odor, which, with the dark purple color, would probably place it in Delpino's *Tipo melantino*, along with *E. verrucosus*. These characters suggest an adaptation to flesh-flies, but my observations as yet do not confirm this view.

I have found the flowers in bloom from the 28th of May, to the 23d of June. The following visitors were taken on June 8, 11 and 15:—

Bees — *Andrenidae:* (1) Halictus confusus Sm. ♀; (2) H. zephyrus Sm. ♀; (3) H. stultus Cr. ♀, freq.; (4) Augochlora labrosa Say ♀; (5) A. pura Say ♀.

Diptera — *Syrphidae:* (6) Syrphus ribesii L.; (7) Allograpta obliqua Say; (8) Mesograpta marginata Say; (9) Baccha tarchetius Wlk.; *Ortalidae:* (10) Seoptera colon Lw.

Coleoptera — *Chrysomelidae:* (11) Rhabdopterus picipes Oliv.; *Mordellidae:* (12) Mordellistena ornata Melsh.— All sucking.

On the pollination of *Euonymus* see :—

(1) Fournier, De la Fécondation dans les Phanerogames, 118. 1863. Proterandry.— (2) Delpino, Altri apparecchi dicogamici recentemente osservati. Nuovo. Giorn. Bot. Ital. 2: 52. Proterandry. 1870.— (3) Müller, Befruchtung der Blumen, 153. 1873. Fertilization of Flowers, 162. 1883.—(4) Delpino, Ulteriori osservazioni. II. 2: 25, 54, 160, 214, 300, 302. 1875. Atti d. soc. Ital. d. sci. nat. in Milano 16: 173, 202, 308. 1873. 17:—. 1874. (Just 2: 883, 895). — (5) Darwin, Forms of Flowers, 287–93. 1877. (Just 5: 738)— (6) Errera et Gevaert, Sur la structure et les modes de fécondation des

fleurs. Bull. Soc. royale bot. Belgique 17: 159. 1878. *E. europaeus.*— (7) Müller, Die Stellung der Honigbiene in der Blumenwelt. III. Bienenzeitung Jahrg. 39: 157–61. 1883. *E. europaeus,* Apis wanting. (Just 11[1]: 476).— (8) Loew, Blumenbesuch von Insekten an Freilandpflanzen. Jahrb. Bot. Gartens Berlin 3: 82 (14) 1884.— (9) Loew, Weit. Beob. über den Blumenbesuch von Insekten an Freilandpflanzen. Jahrb. Bot. Gartens Berlin 4: 152. 1886.— (10) Kirchner, Flora von Stuttgart und Umgebung, 356. 1888. *E. europaeus.*— (11) Trelease, Ilicineae and Celastraceae. Trans. St. Louis Acad. Sci. 5: 349–50. 1889.— (12) Schulz, Beiträge zur Kenntniss der Bestäubungseinrichtungen und Geschlechtsvertheilung bei den Pflanzen. 2: 61, 185. Bibliotheca Botanica 17. 1890.— (13) Kerner, Pflanzenleben 2: 169. 1891. *E. europaeus.* (Just 17[1]: 531) — (14) MacLeod, Bevruchting der bloemen van Vlaanderen. Bot. Jaarboek 6: 246, 437. 1894. *E. europaeus.* (15) Loew, Blütenbiologische Floristik, 214, 378. 1894. *E. europaeus.*

Aesculus L.— Most of the observations made upon this genus were upon plants growing in Europe, where none of them are indigenous. *AE. rubicunda* is andromonoecious, with the perfect flowers proterogynous (Hildebrand 2). *AE. macrostachya* is also andromonoecious, with the perfect flowers proterandrous, and is adapted to nocturnal Lepidoptera (Kirchner 21). *AE. flava* (lutea Wang. octandra Marsh.) has most of its flowers fertile, is perforated by *Bombus terrestris,* and in the Berlin Garden is visited by hive bees (see Loew 13, 26). According to Meehan (22) *AE. parviflora* is andromonoecious. Trelease (MS. notes) saw it visited by bumble bees and by *Trochilus colubris* (10). I suspect that the Red Buckeye, *AE. pavia*, is specially adapted to humming birds.

Aesculus hippocastanum L. ("Adv. from Asia via Eu.").— Sprengel's account of this species left little to be added. He was mistaken in regarding the perfect flowers as proterandrous instead of proterogynous (2). The plant is andromonoecious, but Ogle (4) found some flowers which were pistillate from losing their anthers before dehiscence. The flowers are supposed to be adapted to bumble-bees (1, 5, 11, 19). In my yard I have seen them visited by: —

Bees — (1) Bombus americanorum F. ♀, ab.; (2) B. pennsylvanicus De. G. ♀, ab.; (3) B. separatus Cr. ♀, ab.; (4) B. virginicus Oliv. ♀, ab.; (5) B. scutellaris Cr. ♀; (6) Synhalonia frater Cr. ♂♀, ab.

Birds — (7) Trochilus colubris L.

Aesculus glabra Willd.— Coulter (12) records the fact that the flowers are andromonoecious, the perfect ones proterogynous. The trees are common and bear numerous panicles of yellowish flowers. The two lower petals are directed horizontally, lying on each side of the stamens. The two upper ones are turned upwards and form a vexillum, being marked by yellow blotches which serve as pathfinders. These by turning reddish enable the bees to distinguish the older flowers, which only serve to increase the conspicuousness of the inflorescence. The stamens and style are declined to the lower side and are curved upwards. The stamens are of unequal length and the longest are exserted 10 mm. beyond the tips of the lower petals. The anthers dehisce in succession.

Nectar is secreted by a portion of the disc which is strongly developed above and may be reached by a bee inserting its proboscis above the filaments. On account of the depth of the calyx tube a proboscis 10 mm. long is needed to do this easily. The flowers are adapted to bumble bees, which on account of the early blooming time — April 20–May 11 — are represented only by the females, and by other long tongues, such as *Anthophora* and *Synhalonia*. May 4, 5 and 9, I saw the flowers visited by the following: —

Apidae — (1) Bombus separatus Cr. ♀; (2) B. pennsylvanicus De G. ♀, freq.; (3) B. americanorum F. ♀, freq.; (4) B. virginicus Oliv. ♀; (5) Anthophora ursina Cr. ♀; (6) Synhalonia frater Cr. ♀; (7) S. belfragei Cr. ♂♀, freq., in cop.— all sucking.

On the literature of *Aesculus* see: —

(1) Sprengel, Das entdeckte Geheimniss, 209–14. 1793.— (2) Hildebrand, Geschlechter-vertheilung bei den Pflanzen, 11, 26. 1867.— (3) Axell, Om anordningarna för de fanerogama växternas befruktning, 104. 1869. *AE. hippocastanum*, cit. (2)—(4) Ogle, The fertilization of some plants. Pop. Sci. Rev. 9:54 Ja 1870.— (5) Müller, Befruchtung der Blumen, 154–6. 1873. *AE. hippocastanum, rubicunda*. — (6) Delpino, Ulteriori osservazioni. II. 2:178, 266, 268. 1875. Atti. d. Soc. Ital. d. Sci. in Milano. 16:326. 1873. 17:—. 1874. *AE. hippocastanum, rubicunda*. — (7) Errera et Gevaert, Sur la structure et les modes de fécondation des fleurs. Bull. d. Soc. roy. d. Bot. Belgique 17:146. 1878. *AE. hippocastanum*, cit. (4).—(8) Hildebrand, Die Farben der Blüthen in ihrer jetzigen variation und früheren Entwickelung, 38. 1879. *AE. hippocastanum*, color changes. (Just 7^1:110)–(9) Bonnier, Les Nectaires. Ann. d. Sci. nat. Bot. VI. 8:107. f. 29

30. 1878. *AE. hippocastanum.* — (10) Trelease, Fertilization of flowers by humming birds. Am. Nat. 14:362. 1880.— (11) Müller, Fertilzation of Flowers, 164–6. 1883. *AE. hippocastanum, rubicunda.*— (12) Coulter, Notes on Aesculus glabra. Bot. Gaz. 8:245. 1883.— (13) Loew, Blumenbesuch von Insekten an Freilandpflanzen. Jahrb. Bot. Gartens Berlin 3: 84 (16). 1884.—(14) Urban, Zur Biologie der einseitswendigen Blütenstände. Ber. Deut. bot. Gesellschaft 3: 409. 1885. *AE. hippocastanum.*—(15) Kirchner, Neue Beobachtungen über die Bestäubungseinrichtungen einheimischer Pflanzen. Progr. d. 68 Jahresfeier d. K. Württemb. landwirtsch. Akademie Hohenheim, 31. 1886. (Just 14[1]: 790). *AE. rubicunda.*—(16) Ascherson, Der Farbenwechsel des Saft-mals in den Blüten der Rosskastanie. Naturwiss. Wachenschrift 2: 129–30. 1888. (Just 16[1]: 548)—(17) Martelli, Dimorfismo florale di alcune specie di Aesculus. Nuov. giorn. bot. Ital. 20: 401–4. 1888. *AE. hippocastanum, carnea, flava.* (Just 16[1]: 531. Bot. Centralblatt 36: 264.)—(18) Beyer, Die spontanen Bewegungen der Staubgefässe und Stempel. Wissenschaftliche Beilage zum Progr. d. Kgl. Gymnasiums zu Wehlau, 54. 1888. *AE. hippocastanum.* (Just 16[1]: 523)—(19) Focke, Der Farbenwechsel der Rosskastanien-Blumen. Verh. bot. Ver. Prov. Brandenburg 31: 108–12. 1889. (Just 18[1]: 473)—(20) Bail, Ueber die gelben Flecken der Rosskastanienblüte. Schr. Naturf. Gesellsch. Danzig 7: 6. 1890. *AE. hippocastanum, carnea,* color changes and sun light. (Just 18[1]: 463)—(21) Kirchner, Beiträge zur Biologie der Blüthen. Progr. z. 72 Jahresfeier d. K. Württemb. landwirtsch. Akademie Hohenheim, 30. 1890.— (22) Meehan, Contributions to the life histories of plants. V. Proc. Acad. Nat. Sci. Phila. 1890: 274–6. (Just 19[1]: 420)—(23) Kerner, Pflanzenleben 2: 179 etc. 1891. *AE. hippocastanum, macrostachya.* (Just 17[1]: 531, 533–4. 18[1]; 485)—(24) Newell, The flowers of the horse-chestnut. Bot. Gaz. 18: 107. 1893.—(25) Knuth, Blumen und Insekten auf den Nordfriesischen Inseln, 50. 1894. *AE. hippocastanum.* — (26) Loew, Blütenbiologische Floristik, 208–9. 1894. *AE. hippocastanum, rubicunda, flava, macrostachya.* See also (27) Jordan, Beiträge z. physiol. Oranographie d. Blumen. Ber. d. D. Bot. Ges. 5: 338–40. 1887. *AE. hippocastanum.*

Astragalus L.— The observations made upon this genus indicate an adaptation of the flowers to bumble-bees, though some species are also visited by other bees, such as *Megachile*. *A. alpinus* (6) shows a tendency to change to a butterfly-flower. In those cases in which the stigma surpasses the anthers, cross-pollination is indicated, while those in which these parts are near together have been supposed to be spontaneously self-pollinated. It seems, however, in these cases that it needs to be shown that the stigma is capable of being properly pollinated before it has been rubbed (Heinsius 19).

Of the two species which are the only ones found about Carlinville, *A. mexicanus* belongs to the spring group of

Leguminosae and blooms from April 15 to May 12, while *A. canadensis* blooms later and much longer, July 3 to August 26. These flowers illustrate what seems to be a general rule with the bumble-bee flowers of the neighborhood: the early ones visited by bumble-bee females, with accessory visits of *Anthophora* and *Synhalonia*, have the nectar more deep seated than the late flowers visited by bumble-bee workers, with accessory visits of *Melissodes* and *Megachile*.

ASTRAGALUS CANADENSIS L.— *A. carolinianus* L.—The flowers are entirely greenish-yellow, are crowded in racemes and are visited by bees crawling over them. The stigma touches the insect visitor in advance of the anthers. From the calyx tube being 4–5 mm. deep and the vexillum being strongly produced forwards the nectar is only readily exhausted by long-tongued bees. On July 7, 9, 16, 23, and Aug. 2, I saw the flowers visited by the following insects:—

Hymenoptera — *Apidae:* (1) Apis mellifica L. ☿, one, vainly trying to obtain nectar; (2) Bombus separatus Cr. ☿, s.; (3) B. pennsylvanicus De G. ♀☿, s. & c. p.; (4) B. americanorum F. ☿, s. & c. p., freq.; (5) Melissodes bimaculata Lep. ♂, s.; (6) Megachile relativa Cr. ♀, s.; (7) Anthidium emarginatum Say ♂, s.; *Andrenidae:* (8) Halictus parallelus Say ♀, s., one.; *Eumenidae:* (9) Odynerus fundatus Cr., s., one.

Lepidoptera — *Rhopalocera*: (10) Nisoniades martialis Scud., s., one.

At Mt. Carmel, Illinois, Schneck (17) saw the flowers perforated by *Xylocopa virginica* Dru.

ASTRAGALUS MEXICANUS A. DC.— This is the northernmost limit of the plant in Illinois, but it is quite common. To the list of visitors given before (14) add the following observed on April 19 and 29: —

Apidae: (3) Bombus pennsylvanicus De G. ♀, s. & c. p.; (6) Anthophora ursina Cr. ♂♀, s. & c. p., freq.; (7) Osmia brevis Cr. ♀, s. & c. p.

On the literature of *Astragalus* see:—

(1) Sprengel, Das entdeckte Geheimniss, 362. 1793. *A. onobrychis*.— (2) Axell, Om anordningarna för de fanerogama växternas befruktning, 17, 73, 111. 1869. *A. oroboides, alpinus*.— (3) Delpino, Ulteriori osservazioni. Pt. II, fasc. 2: 199. 1875. Atti d. soc. Ital. d. sci. nat. in Milano 16:347. 1873. *A. alpinus*.— (4) Errera et Gevaert, Sur la structure et les modes de fécondation des fleurs. Bull. Soc. royale bot. de Belgique 17:78. 1878. *A. alpinus*.—(5) Müller, Weitere Beobachtungen. II. Verh. naturhist. Ver. preuss. Rheinl. u. Westf. 1879. 252-3. *A. glycyphyllos*.— (6) Müller,

Alpenblumen, 230–2. 1881. *A. depressus, monspessulanus, alpinus.*— (7) Loew, Blumenbesuch von Insekten an Freilandpflanzen. Jahrb. Bot. Gartens Berlin 3:96–8, 112, 116, 275, (28–30, 44, 48, 73). 1884. 8 spp.— (8) Kirchner, Neue Beobachtungen über die Bestäubungseinrichtungen einheimischer Pflanzen. Progr. 68 Jahresfeier d. K. Württemb. landwirtschaftl. Akademie Hohenheim, 41. 1886. *A. cicer.* (Just 14¹:791).— (9) *Lindman*, Blühen und Bestäubungseinrichtungen im Skandinavischen Hochgebirge. Bot. Centralblatt 30:127, 157, 158, 1887. (Biol. Centralblatt 8:198–201.) *A. oroboides, frigidus, alpinus.*— (10) Lindman, Ueber die Bestäubungseinrichtungen einigen Skandinavischen Alpenpflanzen. Bot. Centralblatt 33:59. 1888. *A. oroboides.*— (11) Kerner, Ueber das Wechseln der Blütenfarbe an einer und derselben Art in verschiedenen Gegenden. Oest. Bot. Zeit. 39:77. 1889. *A. vesicarius.* (Just 17¹:536).— (12) Schulz, Beiträge zur Kenntniss der Bestäubungseinrichtungen und Geschlechtsvertheilung bei den Pflanzen. 1:32. 1888. 2:209–10. 1890. *A. excapus, danicus, cicer, glycyphyllos.*— (13) Kirchner, Beiträge zur Biologie der Blüten. Progr. 72 Jahresfeier K. Württemb. landwirtschl. Akademie Hohenheim, 44. 1890. *A. onobrychis.*— (14) Robertson, Flowers and insects. V. Bot. Gaz. 15:199. Ag. 1890.— (15) Kerner, Pflanzenleben 2:189, 266. 1891. *A. vesicarius*, (Just 17¹:532).— (16) MacLeod, De Pyreneeënbloemen. Bot. Jaarboek 3: 438. 1891. *A. monspessulanus.*— (17) Schneck, Further notes on the mutilation of flowers by insects. Bot. Gaz. 16:313. 1891.— (18) Taubert, Leguminosae. Engler u. Prantl, Die nat. Pflanzenfamilien. L. 63, 71, 77. 1891–2. *A. depressus.* (Just 19¹:436). — (19) Heinsius, Eenige waarnemingen en beschouwingen over de bestuiving van bloemen der Nederlandsche flora door insecten. Bot. Jaarboek 4:87–91. pl. 6. 1892. *A. glycyphyllos.*— (20) Loew, Blütenbiologische Floristik. 1894. 9 spp. See also (21) Kieffer, Observations sur la Cleistogamie. Bull. Soc. Bot. Lyon 8:17. 1890. *A. monspessulanus*, semi-cleistogamous. (Just 20¹: 488.)

Stylosanthes elatior Schwartz — *S. biflora* (L.) B. S. P.— This plant has a southerly range. In Patterson's Catalogue it is credited to Jackson and Union Counties. It is rare and blooms from June 8 to September 9. The small yellow flowers have the petals and stamens inserted at the summit of the calyx-tube. The vexillum is orbicular, bright yellow and marked with a few lines forming pathfinders. As in *Crotallaria*, the wings are bright yellow and cohere at the summit, serving to cover the pale keel. The keel is somewhat incurved and closed except at base and tip. The stamens are monadelphous, but there is an opening in the base of the tube to admit the bee's tongue to the nectar. As in *Crotallaria* and *Lupinus*, five stamens have long anthers attached near their bases and five have shorter anthers attached near their middle. As soon as the flower opens, the tip of the keel is filled with pollen from the long anthers. When the keel is depressed, the pollen is forced out in a band partly by the aid of the style and the shorter anthers, which have not yet discharged. It is quite probable that effectual pollination does not occur until the stigma has been rubbed.

The banner often extends horizontally and the keel in a vertical position. The flowers are adapted to the smallest bees and are abundantly visited for nectar by *Calliopsis andreniformis* Sm. ♀. Of nine species of *Calliopsis* occurring here, this species has the longest flight — June 3 to September 18 — extending throughout the blooming season of *Stylosanthes*.

According to Kuhn (1) *Stylosanthes* has cleistogamous flowers, but it is not stated in which of the about fifteen species close pollination occurs. Foerste (3), quoting Chapman (2), says of *S. elatior:* "It has 'flowers of two kinds: one perfect but sterile; the other destitute of calyx, corolla, and stamens, and fertile.' The fertile flowers consist therefore solely of the legume." It is needless to state that a legume is no part of a flower. It is not explained why the perfect flowers are supposed to be invariably sterile, or how the "legume" could receive pollen from the perfect flowers. Foerste says: "It is impossible to say whether the fertile flowers always were destitute of other floral envelops and organs or not." Then, speaking of the pollen of the perfect flowers, he says: "How from this place it reaches the recurved style of the fertile flower below, except by dropping off, is a mystery. Perhaps the long, bristle-like hairs on the subtending leaves and bracts serve as brushes. But even then it may be remarked that at least the earlier legumes seem already fertilized." From the above we may conclude that whether these legumes arose from perfect or cleistogamous flowers, or both, does not appear, though it is not improbable that the species has cleistogamous flowers.

Foerste infers from the horizontal position of the banner that: "Any insect visiting this flower will therefore receive the pollen on its upper side." This is not true of the *Calliopsis*, mentioned above. In fact there are a number of flowers, such as *Gerardia*, *Gratiola* and *Viola*, whose normal visitors usually turn upside down and receive the pollen on the under side.

On the literature of *Stylosanthes* see:—

(1) Kuhn, Einige Beobachtungen über *Vandellia* und den Blüthenpolymorphismus. Bot. Zeit. 25:67. 1867.—(2) Chapman, Flora of the Southern United States, 100. 1884. [2d ed.].—(3) Foerste, Botanical notes from Bainbridge, Georgia. I. Bot. Gaz. 18:462. 1893.

GYMNOCLADUS CANADENSIS Lam.— *G. dioicus* (L.) Koch.— The Coffee-tree is a large tree, growing in creek bottoms and blooming from May 7 to June 1. The flowers are regular, are arranged in panicles and are said to be dioecious or polygamous. The calyx-tube is about 10 mm. long, with five equal lobes, and with five petals and ten stamens inserted near the throat. The stamens are somewhat exserted, five of them being longer than the others. The anthers are introrse, form a circle about the mouth of the calyx-tube and serve to narrow the entrance. Nectar is secreted by the inner wall of the tube.

An adaptation to bumble-bees is indicated. The following visitors were noted on May 10:—

Apidae: (1) Bombus americanorum F. ♀, s., freq.; (2) B. virginicus Oliv. ♀, s. & c. p.; (3) Synhalonia frater Cr. ♂, s.
Papilionidae: (4) Papilio troilus L., s.
Trochilidae: (5) Trochilus colubris L., s.

SPIRAEA L.— According to Müller (4), *S. ulmaria* is devoid of nectar and is homogamous, though Axell (2) calls it proterandrous. Cross and self-pollination may be effected by insects, or, in their absence, spontaneous self-pollination or geitonogamy may occur. According to Schulz (18), this species and *S. filipendula* are andro-monoecious. Kerner (19) calls the scent of *S. ulmaria* benzoloid.

S. filipendula is also homogamous and devoid of nectar, according to Müller. Insects effect cross-pollination; in their absence, spontaneous self-pollination takes place.

On account of their abundant nectar and pollen and their proterogynous condition, *S. salicifolia*, *ulmifolia* and *sorbifolia* are abundantly cross-pollinated by insects. When these fail, there may be spontaneous self-pollination (Müller). In

S. ulmifolia and *chamaedrifolia* the scent is aminoid (Kerner).

In the case of *S. opulifolia*, Ludwig (13, 14) observes that the reddish color of the ovary in old flowers, which becomes more evident in the fruit, serves to increase the conspicuousness of the plants and to draw unbidden guests away from the younger flowers. He saw the flowers visited by bees and Syrphidae.

The principal visitors of *Spiraea* are flies, especially Syrphidae, beetles, and bees, especially Andrenidae. Other flies and the lower Hymenoptera are less abundant. The following table gives the results of observations in this line: —

			Diptera.	Coleoptera.	Bees.	Other Insects.	Total.
Spiraea { salicifolia, ulmifolia, sorbifolia } mixed list.	Low Germany.	Müller (4, 8) ..	46	25	20	19	110
ulmaria............	"	"	10	12	7	6	35
"	Flanders	MacLeod (24)	12	3	2	2	19
"	Scotland......	Willis (26)...	8	3	..	..	11
"	Pyrenees	MacLeod (20)	..	2	1	..	3
"	Netherlands ..	Heinsius (21).	2	..	..	..	2
"	North Frisian Islands	Knuth (25)...	1	..	..	..	1
"	Alps..........	Müller (10)...	..	1	..	..	1
filipendula.........	Low Germany.	" (4, 8).	4	4	2	..	10
"	Berlin Garden.	Loew (12)....	1	..	1	..	2
digitata............	"	"	2	2	1	..	5
aruncus	Alps..........	Müller (10)..	..	1	..	..	1
"	Low Germany.	" (4, 8).	2	6	4	3	15
"	Illinois.	....	4	30	13	4	51

Spiraea aruncus L.— *Aruncus aruncus* (L.) Karst.— I find nectar to be secreted by a perigynous disc, as observed by Delpino (5). On the other hand Müller (4, 10) states that the flowers are devoid of nectar, but he does not explain how the pistillate flowers, which of course bear no pollen, are to be visited.

According to Gray's Manual and Chapman's Flora, the flowers are dioecious, and this is the only condition in which I have found them. The staminate flowers have twenty stamens, the anthers of the outer ten discharging their pollen before the others. The pistillate flowers have the stamens aborted. Kerner (19) mentions *S. aruncus* as typical of a group, in which some plants bear only perfect flowers, others are andro-monoecius, a third set bear only staminate and a fourth only pistillate flowers. Kerner calls the pistillate and staminate flowers pseudo-hermaphrodite, but they are so very different that they give a different aspect to the plants that bear them, enabling one to distinguish the plants at a considerable distance.

The plants bearing staminate flowers are more conspicuous from the simple fact that the numerous stamens are more conspicuous than the pistils of the fertile flowers. On this account, as well as from the fact that they yield both nectar and pollen, these plants are more abundantly visited by insects. The pistillate flowers are consequently more likely to receive the visits of insects coming from the staminate flowers.

Delpino regards *S. aruncus* as adapted to the smaller bees (micromelittofile più segnalate), or at least principally visited by them. Müller found beetles more abundant, at any rate in number of species, while I have taken a larger proportion of beetles on it than on any other flower.

The blooming time previously recorded (22) is extended from May 24 to June 24. The following list of insects, taken on the flowers on June 4, 7–10 and 20, includes the one given before, with additions and corrections:—

Coleoptera — *Dermestidae:* (1) Anthrenus musaeorum L., ab.; (2) Cryptorhopalum haemorrhoidale Lec.; (3) C. triste Lec., ab.; (4) Orphilus glabratus, F., ab.; *Nitidulidae:* (5) Epuraea truncatella Mann; (6) E. labilis Er.; *Elateridae:* (7) Sericosomus silaceus Say; *Malachidae:* (8) Anthocomus erichsoni Lec.; (9) Attalus scincetus Say; *Ptinidae:* (10) sp., freq.; *Scarabaeidae:* (11) Trichius piger F.; (12) Valgus canaliculatus F.; *Cerambycidae:* (13) Euderces picipes F., ab.; (14) Acmaeops directa Newm.; (15) Typocerus badius Newm.; (16) T. lugubris Say; (17) Leptura exigua Newm.; (18) L. vittata Germ.; (19) L. pubera Say; *Chrysomelidae*: (20) Disonycha limbicollis Lec. var pallipes Cr.; *Bruchidae:* (21) Bruchus hibisci Oliv.; *Oedemeridae*: (22) Asclera puncticollis Say; *Mordellidae:* (23) Pentaria trifasciata Melsh., freq.; (24) Mordella marginata Melsh., ab.; (25) Mordellistena biplagiata Hel., freq.; (26) M. ornata Melsh.; (27) M. aspersa Melsh., freq.; (28) M. tosta Lec.; (29) M. pubescens F.; *Curculionidae:* (30) Centrinus picumnus Hbst., ab.— all s. or f. p.

Hymenoptera — *Apidae* (31) Heriades carinatum Cr. ♂, s.; (32) Nomada americana Kby. ♀, s.; *Andrenidae:* (33) Halictus sp. ♀, s.; (34) H. foxii Rob. ♀. s.; (35) H. stultus Cr. ♂♀, s. & c. p., freq.; (36) Andrena platyparia Rob. ♀, s.; (37) A. cressonii Rob. ♀, s.; (38) A. flavoclypeata Sm. ♂, s.; (39) A. ziziae Rob. ♀, s.; (40) A. crataegi Rob. ♀, s. & c. p., freq.; (41) A. spiraeana Rob. ♀ s.& c. p., ab.; (42) Prosopis modesta Say ♂♀, s. & f. p., freq.; (43) P. pygmaea Cr. ♀, s.: *Eumenidae;* (44) Eumenes fraternus Say, s.; *Crabronidae:* (45) Anacrabro ocellatus Pk, s.; (46) Oxybelus frontalis Rob., s.

Diptera — *Empidae:* (47) Empis distans Lw., freq.; *Conopidae:* (48) Zodion nanellum Lw.; *Oscinidae:* (49) Siphonella cinerea Lw.; *Phytomyzidae:* (50) Phytomyza palpalis Coq. (MS.) — all s.

Hemiptera — *Capsidae:* (51) Lopidea media, Say, s.

On the literature of *Spiraea* see :—

(1) Sprengel, Das entdeckte Geheimniss, 270. 1793. *S. opulifolia.*— (2) Axell, Om anordningarna för de fanerogama växternas befruktning, 111. 1869. *S. ulmaria.*— (3) Kerner, Schutzmittel des Pollens, 36. 1873. Ber. naturh.— med. Vereines Insbruck 2 and 3:—. 1872. *S. filipendula.*— (4) Müller, Befruchtung der Blumen, 211–14. 1873. Fertilization of Flowers, 222–6. 1883.— (5) Delpino, Ulterori osservazioni II. 2:46, 96, 160, 179, 215. 1875. Atti d. Soc. Ital d. Sci. in Milano 16: 194, 244, 308, 327. 1873. 17: —. (215). 1874. *S. aruncus, ulmaria, salicifolia, ulmifolia, sorbifolia.*— (6) Lubbock, British wild flowers in relation to insects, 90. 1875.— (7) Bonnier, Les Nectaires. Ann. Sci. nat. Bot. VI. 8: 114, 115, 147. 1878. *S. ulmifolia, salicifolia, aruncus.*— (8) Müller, Weitere Beobachtungen II. Verh. d. naturhist Ver. d. preuss. Rheinl. u. Westf. 1879: 243.— (9) Henslow, On the self-fertilization of plants. Trans. Linn. Soc. II. Bot. 1: 362. (1877) 1880.—(10) Müller, Alpenblumen, 228. 1881.— (11) Müller, Die Stellung der Honigbiene in der Blumenwelt. Bienenzeit Jahrgang 38:— (No. 10) 1882. *S. ulmaria, aruncus, filipendula.* (Just 9^1:498) — (12) Loew, Blumenbesuch von Insekten an Freilandpflanzen. Jahrbuch Bot. Gartens Berlin. 3:82 (14) 1884. 4:149, 157, 159, 160. 1886.— (13) Ludwig, Ueber einem eigenthümlichen Farbenwechsel in dem Blütenstande von Spiraea opulifolia. Kosmos 2:203–5. 1884. (Just 12^1:670) — (14) Ludwig, Einige neue Fälle von Farbenwechsel in verblühenden Blüthenständen. Biol. Centralb. 6:513–14. 1886. *S. opulifolia.* (Just 14^1:806) — (15) Meehan, Botanical Notes. Proc. Acad. Nat. Sci. Phila. 1886: 60. *S. reevesiana.*—(16) Jordan, Beiträge z. physiol. Organographie d. Blumen. Ber. D. Bot. Ges. 5:333. 1887. *S. sorbifolia.* (Ludwig, Biol. Centralb. 8:204) — (17) Beyer, Die spontanen Bewegungen der Staubgefässe und Stempel. Wissensch. Beilage zum Progr. Kgl. Gymnasiums zu Wehlau, 13, 14. 1888. *S. aruncus, hypericifolia, ulmaria.*— (18) Schulz, Beiträge zur Kenntniss der Bestäubungseinrichtungen und Geschlechtsvertheilung bei den Pflanzen. 1:33. 1888. 2:186. 1890.— (19) Kerner, Pflanzenleben 2:195–6, 299, 324. 1891. Oliver Translation 2:200, 300. 1895. (Just 17^1:533. 18^1:486).— (20) MacLeod, De Pyreneeën-bloemen. Bot. Jaarboek 3:426. 1891.— (21) Heinsius, Eenige waarnemingen en beschouwingen over de bestuiving van bloemen der Nederlandsche flora door insecten. Bot. Jaarboek 4:57. 1892.— (22) Robertson, Flowers

and Insects — Rosaceae and Compositae. Trans. Acad. Sci. St. Louis 6:437, 447–50, 477–9. 1894.— (23) Loew, Blütenbiologische Floristik, 85, 224. 1894. Seven species.— (24) MacLeod, Bevruchting der bloemen van Vlaanderen. Bot. Jaarboek 6:321–2, 380, 436–7. 1894.— (25) Knuth, Weitere Beobachtungen über Blumen und Insekten auf den Nordfriesischen Inseln, Schr. d. Nat. V. f. Schleswig-Holstein 10:233, 252. 1895.— (26 Willis and Burkill, Flowers and Insects in Great Britain. Ann. of Bot. 9:248. 1895.

GILLENIA STIPULACEA Nutt. — *Porteranthus stipulatus* (Muhl.) Britton — The stems grow from 5 to 10 dm. high and are terminated by a very loose cluster of white flowers which expand from 20 to 25 mm. The stems are slightly inclined so that the flowers are thrown into an almost horizontal position, and there is a tendency on the part of the petals to assume a position somewhat as in the violet, the three lower ones extending more horizontally, and the two upper being somewhat reflexed.

The calyx-tube is quite long — 5 to 6 mm. — and narrow, the stamens and pistils being included. When the flower opens, the mouth of the tube appears quite narrow and is filled with dehiscent anthers belonging to the outer stamens. Later the innermost anthers discharge their pollen. After the anthers have become empty, the calyx-tube opens wider at the mouth, and the stigmas, which are now receptive, become visible.

The depth and narrowness of the tube render the flowers most favorable for the smaller, long-tongued bees, though they may also force their heads in for some distance. Insects cannot reach the nectar without becoming thoroughly dusted with pollen or touching the stigmas. The plant is rather frequent in woods and blooms from June 3 to 29. On the 15th, 16th and 20th the following list was observed:—

Bees — *Apidae:* (1) Anthophora abrupta Say ♂, s.; (2) Ceratina dupla Say ♂, s. & c. p., ab.; (3) C. tejonensis Cr. ♂, s.; (4) Alcidamea producta Cr. ♀, s. & c. p., ab.; (5) Heriades carinatum Cr. ♂♀, s. & c. p., freq.; (6) Osmia distincta Cr. ♀, s. & c. p., ab.; (7) O. albiventris Cr. ♀, s. & c. p.; (8) O atriventris Cr. ♀, s.; (9) Nomada affabilis Cr. ♀, s.; (10) Calliopsis parvus Rob. ♂♀, s. & c. p., ab.; (11) C. andreniformis Sm. ♂. s.; *Andrenidae:* (12) Halictus pectoralis Sm. ♂♀, s. & c. p.; (13) H. macoupinensis Rob. ♀, s.; (14) H. confusus Sm. ♀, s. & c. p.; (15) H. stultus Cr. ♀, c. p., freq.

Diptera — *Conopidae:* (16) Stylogaster biannulata Say, s., freq.; *Syrphidae* (17) Pipiza pistica Will., f. p., one; (18) Baccha fuscipennis Say, f. p., one.

Lepidoptera — *Rhopalocera:* (19) Papilio troilus L., s., one; (20) Eudamus bathyllus S. & A., s.

Viburnum L.— In *V. opulus*, Sprengel (1) explained the significance of the more conspicuous, sterile marginal flowers. Delpino (3) includes *V. opulus* and *lantana* in his *Tipo idrangeino*, along with some species of *Hydrangea*, *Cornus* and *Sambucus*. He regards the inflorescences as favoring the visits of beetles. Sprengel observed that *V. opulus* was especially sought by beetles, and these form a majority of the insect visitors observed by Müller (2, 8), though he considered flies to be the most efficient pollinators. In Illinois I find a larger proportion of beetles on *V. pubescens* than on any other flower except *Spiraea aruncus*. After beetles, species of *Andrena* and *Empis* are next in abundance. The blooming time occurs when these insects are frequent. In the Tyrol Schulz (12) found *V. lantana* to be abundantly visited by Diptera, Hymenoptera and Coleoptera. In the Berlin Garden Loew (11) saw it visited by *Bibio laniger*. The following table gives the visitors which have been identified: —

			Coleoptera.	Empidae.	Syrphidae.	Andrenidae.	Other insects.	Total.
Viburnum opulus.........	Germany	Müller (2, 8)..	7	1	6	1	1	16
"	Flanders	MacLeod (15)	1	1	2	..	2	6
pubescens......	Illinois.........	....	10	4	..	8	1	23

In *V. opulus*, according to Müller (2), the flowers are crowded in a flat corymb. They are white, with short tubes, expanded borders, rather long stamens and short styles. Nectar is secreted by the upper surface of the ovary. Insects usually effect cross-pollination. Spontaneous self-pollination may occur by the pollen falling upon the stigma. According to Kerner (13), the flowers have an aminoid scent, and geitonogamy results from the stamens diverging so far that the pollen may fall upon the stigmas of surrounding flowers.

According to Kirchner (9), *V. lantana* resembles *V. opulus*, and spontaneous self-pollination may cocur in the same way. Schulz (12) finds it proterogynous with long-lived stigmas. Spontaneous self-pollination is not the rule and is superfluous on account of the visits of numerous insects which may effect self- or cross-pollination. Kerner (13) observes a similar scent to that of *V. opulus* and the occurrence of geitonogamy in this species.

Viburnum pubescens Pursh.— According to Patterson's Catalogue, this plant has been found by Bebb, in Winnebago County, and by Vasey, in McHenry. A few plants occur here, on a high creek bank where it was first found by Andrews.

The white flowers are arranged in nearly flat-topped corymbs, which measure about 3 cm. across. The corolla forms a shallow bell about 2 mm. deep, the lobes expanding about 7 mm. Nectar is secreted by the conical base of the style, and seems to be quite abundant.

The flowers are homogamous. The stamens rise from 4 to 5 mm. above the stigma and are often so divergent that geitonogamy may occur by the pollen falling upon the neighboring stigmas. Spontaneous self-pollination may be effected in a similar way by the pollen falling upon the stigma of the same flower. Cross-pollination must often result from the abundant insect visits.

The flowers bloom from May 6th to 25th. Most of the shallow flowers blooming at the same time show a preponderance of the less specialized bees — *Andrenidae* — and flies. The preponderance of beetles in this case seems to be no kind of an accident. The following insects were taken on the flowers on May 9th :—

Coleoptera — *Dermestidae:* (1) Anthremus musaeorum L., freq., (2) Cryptorhopalum triste Lec.; (3) Orphilus glabratus F., ab.; *Scarabaeidae:* (4)

Hoplia trifasciata Say, freq.; (5) Euphoria fulgida F.; (6) Valgus canaliculatus F.; *Cerambycidae:* (7) Molorchus bimaculatus Say, ab.; *Mordellidae:* (8) Mordellistena biplagiata Hel., freq.; (9) M. aspersa Mels., freq.; (10) M. grammica Lec.— all s. or f. p.

Bees — *Andrenidae:* (11) Halictus pectoralis Sm. ♀, s. & c. p.; (12) Andrena sayi Rob. ♀, s.; (13) A. serotina Rob. ♀, s. & c. p.; (14) A. cressonii Rob. ♀, s. & c. p.; (15) A. nuda Rob. ♀, s.; (16) A. rugosa Rob. ♀, s.; (17) A. claytoniae Rob. ♀, s.; (18) Prosopis modesta Say ♀, s.

Diptera — *Empidae:* (19) Empis humile Coq. (MS.); (20) E. otiosa Coq. (MS.); (21) E. distans Lw.; (22) Rhamphomyia priapulus Lw.; *Tachinidae:* (23) Siphona illinoensis Twns.— all s.

On the pollination of *Viburnum* see:—

(1) Sprengel, Das entdeckte Geheimniss, 21, 33, 43, 82, 159–60. 1793.—(2) Müller, Befruchtung der Blumen, 364. 1873. Fertilization of Flowers, 291. 1883.—(3) Delpino, Ulteriori osservazioni. II. 2: 238, 311. 1875. Atti d. Soc. Ital. d. Sci. Milano 17:—. 1874. (Just 2: 882)—(4) Lubbock, British wild flowers in relation to insects, 108. 1875. *V. opulus.*—(5) Darwin, Forms of Flowers, 6, 7. 1877.—(6) Errera et Gevaert, Sur la structure et les modes de fécondation des fleurs. Bull. Soc. Roy. Bot. Belgique 17: 146. 1878. Fls. agamo-monoïques. (Just 6[1]: 310)—(7) Henslow, On the self-fertilization of plants. Trans. Linn. Soc. II. Bot. 1: 327. (1877.) 1880. *V. opulus.*—(8) Müller, Weitere Beobachtungen. III, 75. 1882.—(9) Kirchner, Neue Beobachtungen über die Bestäubungseinrichtungen einheimischer Pflanzen. Progr. 68 Jahresfeier d. K. Württemb. landwirtschaftl. Akad. Hohenheim, 66. 1886. *V. lantana.* (Just 14[1]: 793)—(10) Hildebrand, Ueber die Zunahme des Schauapparates bei den Blüthen. Pringsheim's Jahrbücher 17: 622–41. 1886. (Just 14[1]: 804)—(11) Loew, Blumenbesuch von Insekten an Freilandpflanzen. Jahrbuch Bot. Gartens Berlin 4: 167. 1886.—(12) Schulz, Beiträge zur Kenntniss der Bestäubungseinrichtungen und Geschlechtsvertheilung bei den Pflanzen 2: 95. 1890. (Just 18[1]: 519)—(13) Kerner, Pflanzenleben 2: 183, 195, 324. 1891. Oliver Translation 2: 187, 200, 326. 1895. *V. opulus, lantana*, peripheral fls., aminoid scent, geitonogamy. (Just 17[1]: 532–3)—(14) Fritsch, Caprifoliaceae. Engler u. Prantl, Die nat. Pflanzenfamilien. IV. 4, 159. 1891. (Just 19[1]: 409)—(15) MacLeod, Bevruchting der bloemen van Vlaanderen. Bot. Jaarboek. 5: 254, 389. 1893. 6: 372–3, 438. 1894.—(16) Loew, Blütenbiologische Floristik, 249. 1894. *V. opulus, lantana.*

SYMPHORICARPOS Jus. — The observations made upon *S. racemosus* indicate an adaptation to wasps. Although the flowers are visited by other insects, the wasps usually occur in numbers which in proportion to other guests are only observed in cases of flowers which have been regarded as wasp flowers. There is certainly nothing to indicate an adaptation to the higher bees. The following table gives the results of observations which have been made in this line :—

			Apidae.	Andrenidae.	Vespidae and Eumenidae.	Other Hymenoptera.	Syrphidae.	Noctuidae.	Total.
S. racemosus	Oberpfalz & Westphalia	Müller (2,10,11)	6	2	7	1	1	..	17
	Paris.	Bonnier (5).....	2	1	3	....	..	..	6
	Oderberg.	Loew (12)......	1	2	4	....	5	..	12
	Belgium.	MacLeod (13)..	..	..	....	....	..	8	8
	Kiel.	Knuth (18).....	2	..	....	....	2	..	4
	Sylt.	" (19).....	2	..	....	....	..	..	2
	North Frisian Islands.	" (20).....	2	..	....	....	..	..	2
	Föhr.	" (22).....	2	..	....	....	1	..	3
vulgaris ..	Illinois.	....	..	5	7	2	..	..	14

Müller says that cross-pollination is insured in case of insect visits, but self-pollination can hardly occur in their absence. Henslow (7) regards spontaneous self-pollination as probable, but admits that it is less likely when the flowers are pendulous. This, however, according to Müller, is their normal position.

From observations of Delpino (14) it appears that nectar is secreted by the corolla and not by the swollen base of the style, as claimed by Müller. In this Loew (21) states that Delpino is anticipated by Kurr (1), but Kurr's observations were on *S. vulgaris*.

Symphoricarpos vulgaris Michx. — *S. symphoricarpos* (L.) Mac M. — In Patterson's Catalogue this species is not credited to Illinois. It agrees in a general way with Müller's account of *S. racemosus*. The flowers are collected in axillary clusters. They are commonly pendulous, but vary from that position to erect. The corolla tube is about 2 mm. long and expands at the throat about 3 or 4 mm. It is greenish-white with a trace of rose color. The nectar is concealed by hairs arising from the inner wall of the corolla near the insertion of the filaments. The stamens occupy a position near the corolla wall and have introrse anthers which surpass the stigma. The flowers are homogamous. Wasps coming with their noses covered with pollen are more likely to effect cross-pollination than otherwise, but they may also effect self-pollination by carrying pollen back to the stigma. In weather unfavorable for insect visits, spontaneous self-pollination is quite likely except in the pendulous flowers.

The flowers bloom from July 8 to Sept. 10. The following list, the result of observations made on July 8, 11, 12, 19, 25, and Aug. 30, seems to be a very natural one, for after the *Vespidae* and *Eumenidae* one would expect to find *Andrenidae* and lower Aculeata.

Hymenoptera — *Andrenidae:* (1) Halictus coriaceus Sm. ♂; (2) H. stultus Cr. ♀; (3) Agapostemon radiatus Say ♂; (4) Augochlora viridula Sm. ♀; (5) A. pura Say ♀; *Vespidae*: (6) Polistes pallipes Lep.; *Eumenidae:* (7) Eumenes fraternus Say, ab.; (8–10) Odynerus spp., ab.; (11) O. foraminatus Sauss., freq.; (12) O. conformis Sauss.; *Sphecidae:* (13) Ammophila vulgaris Cr.; *Pompilidae:* (14) Pompilus philadelphicus Lep. — all sucking.

On the pollination of *Symphoricarpos* see :—

(1) Kurr, Untersuchungen über die Bedeutung der Nektarien, 55. 1832. *S. vulgaris.* (2) Müller, Befruchtung der Blumen, 360–1. 1873.— (3) Delpino, Ulteriori osservazioni. Pt. II. fasc. 2:212, 321. 1875. Atti d. soc. Ital. d. sci. Milano 17:—. 1874. *S. racemosus.*— (4) Müller, Die Insekten als unbewusste Blumenzüchter, Kosmos 3: 485–6. 1878. *S. racemosus.* (Just 6¹: 313) — (5) Bonnier. Les Nectaires. Ann. d. Sci. nat. Bot. VI. 8:37, 138. f. 106. 1878.—(6) Müller, Die Wechselbeziehungen zwischen den Blumen und den ihre Kreuzung vermittelnden Insekten. Encycl. der Naturwiss. Breslau. 5:—.Schenk, Handbuch der Botanik (65). 1879. *S. racemosus.* (Just 7¹: 98) — (7) Henslow, On the self-fertilization of plants. Trans. Linn. Soc. Bot. II. 1: 366. (N 1877) 1880.— (8) Trelease, Note on the perforation of flowers. Bull. Torr. Bot. Club, 8: 69. 1881. *S. racemosus.*— (9) Müller, Die Entwickelung der Blumenthätigkeit der Insekten. Kosmos 9: 266, 272. 1881. *S. racemosus.* (Just 8¹: 148) — (10) Müller, Weitere Beobachtungen. III. 73. Verh. naturhist. Ver. preuss. Rheinl. u. Westf. 1882.—(11) Müller, Fertilization of Flowers, 292. 1883.—(12) Loew, Weitere Beobachtungen über Blumenbesuch von Insekten an Freilandpflanzen. Jahrb. Bot. Gartens Berlin 4: 99. 1886.—(13) MacLeod, Untersuchungen über die Befruchtung der Blumen. Bot. Centralblatt 29: 119. 1887. (Just 14¹: 793) — (14) Delpino, Il nettario florale del Symphoricarpus racemosus. Malpighia 1: 434. 1887. (Just 15¹: 431) — (15) Cocconi, Contributo allo studio dei nettari mesogamici delle Caprifogliaceae. Memor. accad. sci. istit. Bologna 9: 279–85. 1888. (Just 16¹: 552).—(16) Ludwig, Die Blütennectarien des Schneeglökchens und der Scheebeere. Biol. Centralblatt 8:225–6. 1888. (Just 16¹: 553) — (17) Fritsch, Caprifoliaceae. Engler und Prantl, Die nat. Pflanzenfamilien. IV. 4:159. 1891.— (18) Knuth, Blütenbiologische Herbstbeobachtungen. Bot. Centralblatt 49: 267. 1892.— (19) Knuth, Vergleichende Beobachtungen über den Insektenbesuch an Pflanzen der Sylter Haide und der Schleswigschen Festlandshaide. Bot. Jaarboek

4: 40, 41. 1892.— (20) Knuth, Blumen und Insekten auf den Nordfriesischen Inseln, 81. 1894.—(21) Loew, Blütenbiologische Floristik, 147, 250, 391. 1894. *S. racemosus.*— (22) Knuth, Weitere Beobachtungen über Blumen und Insekten auf den Nordfriesischen Inseln. Schr. d. Nat. V. f. Schleswig-Holstein, 10: 235. 1895.

ASTER ERICOIDES L. var. VILLOSUS Torr. & Gr.— *A. ericoides pilosus* (Willd.) Porter — This is a common plant, having rather small heads with yellow discs and white rays. It blooms from Aug. 21 to Oct. 17. The following visitors were taken on the flowers on Sept. 14, 18, 20–24, 26, 28 and Oct. 8 and 10 :—

Hymenoptera — *Apidae:* (1) Apis mellifica L. ☿, s.; (2) Bombus virginicus Oliv. ♂☿, s. & c. p.; (3) B. americanorum F. ♂☿, s.; (4) B. separatus Cr. ♂☿, s.; (5) Melissodes confusa Cr. ♂♀, s. & c. p., freq.; (6) M. nivea Rob. ♀, s. & c. p., freq.; (7) M. autumnalis Rob. ♀, s. & c. p., ab.; (8) Ceratina tejonensis Cr. ♂, s. freq.; (9) C. dupla Say ♀, s.; (10) Megachile latimanus Say ♀, s. & c. p.; (11) Heriades carinatum Cr. ♀, s. & c. p.; (12) Coelioxys altilis Cr. ♀, s.; (13) C. dubitata Sm. ♀, s.; (14) Epeolus cressonii Rob. ♀, s.; (15) E. illinoensis Rob. ♂♀, s.; (16) E. pectoralis Rob. ♀, s.; (17) E. donatus Sm. ♀, s.; (17) Nomada vicina Cr. ♂, s.; (18) Calliopsis asteris Rob. ♂♀, s. & c. p.; in cop., ab.; (19) C. compositarum Rob. ♂♀, s. & c. p., in cop., ab.; (20) C. andreniformis Sm. ♀, s. & c. p.; (21) Perdita 8-maculata Say ♀, s. & c. p.; *Andrenidae:* (22) Halictus foxii Rob. ♀, s.; (23) H. coriaceus Sm. ♂, s.; (24) H. ligatus Say ♂, s.; (25) H. pilosus Sm. ♂, s.; (26) H. confusus Sm. ♂, s.; (27) H. stultus Cr. ♂, s.; (28) Agapostemon viridula F. ♀, s. & c. p.; (29) A. radiatus Say ♀, s.; (30) Augochlora pura Say ♀, s.; (31) A. similis Rob. ♀, s.; (32) Andrena asteris Rob. ♂♀, s. & c. p.; (33) A. solidaginis Rob. ♂♀, s. & c. p., freq.; (34) A. nubecula Sm. ♀, s. & c. p.; (35) Colletes americana Cr. ♂♀, s. & c. p., freq.; (36) C. compacta Cr. ♂♀, s. & c. p., freq.; (37) Sphecodes stygius Rob. ♀, s.; (38) Prosopis pygmaea Cr. ♀, s.; (39) P. modesta Say ♀, s.; *Vespidae:* (40) Vespa maculata L.; (41) V. germanica F., freq.; (42) V. cuneata F.; (43) Polistes metricus Say; (44) P. annularis L.; (45) P. pallipes Lep.; *Eumenidae:* (46) Eumenes fraternus Say; (47) Odynerus sp.; (48) O. capra Sauss.; (49) O. campestris Sauss.; (50) O. tigris Sauss.; (51) O. forminatus Sauss.; (52) O. anormis Say; *Mimesidae:* (53) Mimesa cressonii Pack.; *Philanthidae:* (54) Cerceris clypeata Dlb.; (55) C. fulvipes Cr.; *Sphecidae:* (56) Ammophila gracilis Lep.; *Scoliidae:* (57) Scolia bicincta F.; *Ichneumonidae:* (58) Metopius polycinctorius Say var.— all s.

Diptera — *Empidae:* (59) Empis clausa Rob. (MS.); *Bombylidae:* (60) Argyramoeba albofasciata Mcq.; (61) Anthrax alternata Say, freq.; (62) Sparnopolius fulvus Wd.; (63) Systropus macer F., freq.; (64) Toxophora amphitea Wlk.; *Conopidae:* (65) Zodion fulvifrons Say; (66) Z. nanellum Lw.; *Syrphidae:* (67) Syrphus ribesii L., freq.; (68) S. americanus Wd.; (69) Xanthogramma emarginata Say; (70) Allograpta obliqua Say; (71) Mesograpta marginata Say; (72) M. geminata Say; (73) Sphaerophoria cylindrica Say; (74) Eristalis dimidiatus Wd.; (75) E. tenax L., freq.; (76) E. latifrons Lw.; (77) E. aeneus F.; (78) Helophilus similis Mcq.; (79) H. latifrons Lw.; (80) Tropidia mamillata Lw.; (81) Syritta pipiens L.; (82) Spilomyia longicornis Lw., freq.; (83) S. quadrifasciata Say; *Tachinidae:* (84) Gymnopareia americana Twns.; (85) Besseria atra Coq. (MS.); (86) Jurinia apicifera Wlk.; (87) Belvosia bifasciata F.; (88) Peleteria robusta Wd.; (89) Siphoplagia anomala Twns.; (90) Micropalpus fulgens Mg.; (91) Acroglossa hesperidarum Will., freq.; (92) Siphona illinoensis Twns.; *Dexidae:* (93) Ptilodexia abdominalis Desv.; *Sarcophagidae:* (94) Sarcophaga sp.; (95) Helicobia sp.; (96) H. helicis Twns.; *Muscidae:* (97) Lucilia sp.; (98) L. cornicina F.; (99) Compsomyia macellaria F.; (100) Musca domestica L.—all s. or f. p.

Lepidoptera — *Rhopalocera:* (101) Phyciodes tharos Dru.; (102) Pyrameis huntera F.; (103) Thecla melinus Hbn.; (104) Picris protodice Bd.-Lec.; (105) Meganostoma caesonia Stoll; (106) Colias philodice Gdt.; (107) Pyrgus tessellata Scud.; *Heterocera:* (108) Scepsis fulvicollis Hbn.; (109) Feltia subgothica Steph.; (110) Heliothis armiger Hbn.; (111) Drasteria erichto Gn.— all s.

Coleoptera — *Lampyridae:* (112) Chauliognathus pennsylvanicus De G.; *Cerambycidae:* (113) Cyllene robiniae Forst.; *Chrysomelidae:* (114) Diabrotica longicornis Say; *Meloidae:* (115) Epicauta pennsylvanica De G. — all f. p.

Hemiptera — *Capsidae:* (116) Lygus pratensis L., s.

Silphium perfoliatum L.—The cup-plant is common in low grounds along streams. The stems grow two or three metres high and bear yellow heads which expand six to seven, or more, centimetres. The disc florets yield nectar and pollen, the ray florets being pistillate. The tubes of the disc florets are rather large and measure about 5 mm. in length. This secures the visits of the longer-tongued insects. The blooming season is from July 9th to Sept. 12th. The following visitors were noted on July 23, 31, Aug. 3, 4, 9, 13, 15–17, and Sept. 12: —

Hymenoptera — *Apidae:* (1) Apis mellifica L. ☿, s. & c. p., freq.; (2) Bombus americanorum F. ♂☿, s. & c. p.; (3) Melissodes bimaculata Lep. ♂, s.; (4) M. obliqua Say ♂♀, s. & c. p.; (5) M. agilis Cr. ♂, s., freq.; (6) M. perplexa Cr. ♂♀, s., freq.; (7) M. dentiventris Sm. ♂, s., freq.; (8) M. confusa Cr. ♂, s.; (9) M. coloradensis Cr. ♂♀, s. & c. p.; (10) Ceratina dupla Say ♀, s.; (11) Megachile petulans Cr. ♂, s.; (12) M. mendica Cr. ♀, s.; (13) M. brevis Say ♀, s. & c. p.; (14) Epeolus concavus Cr. ♂♀, s.; (15) E. lunatus Say ♂♀, s.; (16) Calliopsis labrosus Rob. ♂, s., freq.; (17) C. rugosus Rob. ♂♀, s.; *Andrenidae:* (18) Halictus lerouxii Lep. ♀, s.; (19) H. ligatus Say ♀, c. p.; (20) H. pilosus Sm. ♀, c. p., freq.; (21) H. confusus Sm. ♀, c. p.; (22) H. stultus Cr. ♀, c. p., freq.; (23) Agapostemon viridula F. ♀, s. & c. p.; (24) A. radiatus Say ♀, s. & c. p.; (25) Augochlora pura Say ♀, s.; (26) Andrena pulchella Rob. ♂, s., freq.; (27) A. aliciae Rob. ♀, s.; *Scoliidae:* (28) Scolia bicincta F., s.

Diptera — *Bombylidae*: (29) Exoprosopa fasciata Mcq., s.; (30) Anthrax halcyon Say, s.; (31) A. alternata Say, f. p.; (32) Systoechus vulgaris Lw., s., freq.; (33) Sparnopolius fulvus Wd., s.; *Conopidae:* (34) Zodion leucostoma Will., s.; *Syrphidae:* (35) Allograpta obliqua Say, f. p.; (36) Eristalis transversus Wd., f. p.; *Tachinidae:* (37) Jurinia smaragdina Mcq., s.

Lepidoptera — *Rhopalocera:* (38) Danais archippus F.; (39) Papilio philenor L.; (40) Pamphila cernes Bd.-Lec.; (41) P. otho S. & A. var. egeremet Scud.— all s.

Heliopsis laevis Pers.— *H. helianthoides* (L.) B. S. P.— The plants are common, grow one metre, or more, high, and bear numerous orange-yellow heads, which expand about 5 cm. The ray florets are pistillate. The disc florets are perfect, yield nectar and pollen, and have tubes 3 to 4 mm. long. The blooming time is from July 1 to Sept. 28. The following visitors were taken July 16, 31, Aug. 1, 3, 6, 7, 12, 13, 15, 17, 21, 22; Sept. 10, 12: —

Hymenoptera — *Apidae:* (1) Melissodes perplexa Cr. ♂, s.; (2) M. coloradensis Cr. ♂, s.; (3) M. obliqua Say ♂, s.; (4) M. dentiventris Sm. ♂♀, s.; (5) Ceratina dupla Say ♀, s.; (6) Megachile brevis, Say ♂, s., freq.; (7) Coelioxys altilis Cr. ♂♀, s.; (8) Epeolus lunatus Say ♂♀, s., freq.; (9) E. fumipennis Say ♂, s.; (10) E. concavus Cr., s.; (11) E. cressonii Rob. ♂, s.; (12) Phileremus heliopsis Rob. ♂, s.; (13) Calliopsis labrosus Rob. ♂♀, s. & c. p.; (14) C. rugosus Rob. ♂, s., freq.; *Andrenidae:* (15) Halictus pectoralis Sm. ♀, c. p.; (16) H. ligatus Say, ♀, s.; (17) H. pruinosus, Rob. ♀, s. & c. p.; (18) H. obscurus Rob. ♂, s.; (19) H. pilosus Sm. ♀, s. & c. p.; (20) Augochlora labrosa Say ♀, s. & c. p.; (21) A. pura Say, ♀, s.; (22) Andrena aliciae Rob. ♀, s.; *Philanthidae:* (23) Cerceris sp.; *Sphecidae:* (24) Ammophila vulgaris Cr. s.; *Scoliidae:* (25) Scolia bicincta F., s.

Diptera — *Empidae:* (26) Empis clausa Rob. (MS.), freq.; *Bombylidae:* (27) Exoprosopa fasciata Mcq.; (28) E. fascipennis Say.; (29) Anthrax halcyon Say; (30) Systoechus vulgaris Lw.; (31) Sparnopolius fulvus Wd.; (32) Geron calvus Lw., freq.; (33) G. rufipes Mcq.; *Syrphidae:* (34) Eristalis transversus Wd.— all s.

Lepidoptera — *Rhopalocera:* (35) Phyciodes tharos Dru.; (36) Thecla melinus Hbn.; (37) Pieris protodice Bd.-Lec.; (38) Pholisora catullus F.— all s.

Coleoptera — *Lampyridae:* (39) Chauliognathus pennsylvanicus De G., s.

Hemiptera — *Lygaeidae:* (40) Lygaeus turcicus F., s.

Rudbeckia laciniata L. — The stems grow two or three metres high, are considerably branched and bear numerous heads with yellow discs and rays. The heads expand 8–9 cm., but the rays are inclined to droop. The discs soon become elevated into a conical globular form. The ray florets are neutral. Those of the disc are perfect, with erect lobes and admitting an insect's proboscis to the extent of 3 mm. The plant is common and blooms from July 17 to September 28. The following visitors were observed on August 13, 15, 17, 22, 26, 31, and September 10 and 12:—

Hymenoptera — *Apidae:* (1) Apis mellifica L. ☿, s. & c. p., ab.; (2) Bombus separatus Cr. ☿, s. & c. p.; (3) B. americanorum F. ☿, s.; (4) Melissodes obliqua Say ♀, c. p.; (5) M. dentiventris Sm. ♂♀, s. & c. p., freq.; (6) M. coloradensis Cr. ♂, s.; (7) M. autumnalis Rob. ♂, s.; (8) M. confusa Cr. ♂, s.; (9) Calliopsis labrosus Rob. ♂♀, s. & c. p., freq.; (10) C. rudbeckiae Rob. ♂♀, s. & c. p., freq.; *Andrenidae:* (11) Halictus ligatus Say ♀, s. & c. p.; (12) Andrena aliciae Rob. ♀, s. & c. p., freq.; (13) Colletes compacta Cr. ♂♀, s. &. c. p., freq.; *Bembecidae:* (14) Bembex fasciata F., s.; *Sphecidae:* (15) Ammophila gracilis Lep., s., freq.; (16) A. intercepta Lep., s.; *Scoliidae:* (17) Scolia bicincta F., s.

Diptera — *Empidae:* (18) Empis clausa Rob. (MS.), s., freq.; *Bombylidae:* (19) Exoprosopa fasciata Mcq., s.; (20) Anthrax halcyon Say, s.; (21) A. alternata Say, s.; (22) Systoechus vulgaris Lw., s., (23) Sparnopolius fulvus Wd., s.; *Syrphidae:* (24) Syrphus ribesii L., f. p.; (25) Eristalis transversus Wd., s.; (26) E. dimidiatus Wd., s.; *Tachinidae:* (27) Jurinia smaragdina Mcq., s.; (28) Peleteria robusta Wd., s., freq.; (29) Cyphocera fuesta V. d. W., s.; (30) Acroglossa hesperidarum Will., s.

Lepidoptera—*Rhopalocera:* (31) Phyciodes nycteis Db.-Hew.; (32) Lycaena pseudargiolus Bd.-Lec.; (33) Pamphila cernes Bd.-Lec.; *Heterocera:* (34) Scepsis fulvicollis Hbn. — all s.

Cacalia reniformis Muhl.— The stems grow from 5 to 15 dm. high and are terminated by rather large flat-topped corymbs of white heads. Each head contains five tubular perfect florets. These open in succession, the ones in the second stage being bent aside so that the stigma cannot touch the anthers of the younger flowers. The tubes are about 6 mm. long, very narrow below, but opening above into a wider portion about 2 mm. long. Insects only insert their proboscides into the wider part of the tube. The plant blooms from June 25 to Aug. 1. The following insects were taken on the flowers on June 25 and July 2, 8 and 16:—

Hymenoptera — *Apidae:* (1) Apis mellifica L. ☿, s.; (2) Melissodes bimaculata Lep. ♀, s.; (3) Ceratina tejonensis Cr. ♂, s.; (4) C. dupla Say ♀, s.; (5) Heriades carinatum Cr. ♀, s. & c. p.; *Andrenidae:* (6) Halictus foxii Rob. ♂, s.; (7) H. pectoralis Sm. ♂♀, s.; (8) H. cressonii Rob. ♂, s.;

(9) H. zephyrus Sm. ♀, s.; (10) H. confusus Sm. ♀, s. & c. p. freq.; (11) H. stultus Cr. ♀, s.; (12) Agapostemon radiatus Say ♂, s.; (13) Augochlora labrosa Say ♀, s. & c. p., freq.; (14) A. viridula Sm. ♂♀, s., freq.; (15) Prosopis modesta Say ♂, s.; (16) P. pygmaea Cr. ♂, s.; *Eumenidae:* (17) Eumenes fraternus Say; (18) Odynerus sp.; (19) O. tigris Sauss., freq.; (20) O. dorsalis F.; (21) O. fundatus Cr., freq.; (22) O. quadrisectus Say; (23) O. perennis Sauss.; *Crabronidae:* (24) Crabro interruptus Lep.; *Sphecidae:* (25) Ammophila gracilis Lep.; (26) A. intercepta Lep.; (27) A. vulgaris Cr.— all s.

Diptera — *Tipulidae:* (28) Geranomyia canadensis West.; *Empidae:* (29) Empis clausa Rob. (MS.) freq.; *Conopidae:* (30) Zodion nanellum Lw.; (31) Oncomyia loraria Lw.; *Syrphidae:* (32) Sphaerophoria cylindrica Say; (33) Syritta pipiens L.; *Tachinidae:* (34) Miltogramma argentifrons Twns.; (35) Siphona illinoensis Twns., freq.; (36) Siphophyto floridensis Twns.— all s.

Lepidoptera — *Heterocera:* (37) Sesia sexfasciata Edw., s.

Hemiptera — *Lygaeidae:* (38) Melanocoryphus bicrucis Say; *Capsidae.* (39) Lopidea media Say, freq. — both s.

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ON A ROTATIONAL MOTION OF THE CATHODE DISC IN THE CROOKES TUBE.*

Francis E. Nipher.

It is well known that the equations which represent the properties of the magnetic field external to a conductor, are inconsistent when applied to points within the body of the conductor. Assuming the total magnetic force within to be tangent to a circle whose center is at the wire center, and the surfaces of equal potential are radial planes. Assuming the force due to an element of the conductor of infinite length and of section ds to be $\frac{2\,di}{r}$, it follows that the force at any point without the conductor varies inversely, and at an internal point, directly as the distance from the center. If now within the wire, we assume any radial plane as a datum equipotential plane, and determine the locus of any other equipotential surface, such that the difference of potential, measured along the lines of force, is constant, this surface turns out to be one having as a cross-section, a spiral known as the lituus having the radius as an external asymptote, and reaching the center after an infinite number of turns. It is evident that these internal surfaces of equal potential cannot be both radial planes, and spiral cylinders.

Maxwell disposes of this absurdity to which the equations lead, in the single sentence which closes section 606 of his Electricity and Magnetism. He says: "Within the substance of the conductor, there is no such thing as magnetic potential."

It has long seemed to me that this failure of the equations must be the result of leaving some elements of the problem out of the discussion. I have spent a great amount of time in seeking for some rotational phenomenon hitherto unrepre-

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sented in the equations. Until recently the results were wholly negative. While recently experimenting with a Crookes tube I observed that the circular aluminum disc of the cathode became slightly loose on the aluminum wire, and that it was constantly rocking in rotary motion on the wire. After several days of use, during which it had been decided to construct a tube with discs capable of rotation, the cathode disc suddenly became loosened, and began to rotate slowly on the wire as an axis.

The bearings were somewhat rough, and the disc was not perfectly balanced. It often stopped, but then began to rock against the obstacle until it again freed itself. The direction of rotation was contrary to the hands of a clock, when the disc was viewed from the point where the cathode wire pierces the wall of the tube. All attempts to accelerate or retard the motion by means of strong bar magnets, as in Barlow's wheel, were without effect. Placing the tube at various distances from the induction coil and giving the disc all possible positions in the earth's field, produced no change in the rotation. A more decided rotation was produced by using the brush discharge of a 24-inch Holtz machine. No rotation has been produced as yet when the leading wires were in metallic contact with the conductors of the Holtz machine, but when the leads consisted of rods having spherical terminals, separated by short spark intervals, the rotation was always seen. When the loose disc was made the anode, no tendency to rotation has been observed. Thus far all attempts to produce the effect in air of ordinary pressure have failed, but the work in this direction is not yet concluded.

In the tube used, the tendency to rotation was not observed until by long use the vacuum had become very high, and it has now nearly reached the limit where the sparks pass around the tube, rather than through it.

The leading-in wires are at right angles to each other in the tube used. Tubes are now in preparation which will have rotary discs facing each other as well as at right angles to each other, and various other features, by which it is hoped that many questions which at once suggest themselves may be answered. There is much reason to suspect that the gas particles do not shoot off normally from the surface of the disc, but in a vortex, the axis of which is in the two dark spots opposite the cathode faces. The fact that the anode does not respond, and that similar experiments in open air have thus far failed seems to point to the cathode discharge as the direct active agent. This view is not easily reconciled with the result of the experiment made by Crookes with the hemi-cylindrical cathode (*Nature*, July 3, 1879, p. 229, Fig. 3), but the figure shown does not seem to quite agree with the description of it. Experiments are now in preparation which will decide this question. It is possible that the rotation observed is a direct action and reaction between the current in the disc, and the external field due to the current. In this case the rotation apparently ought to be producible in open air, and on the anode terminal of the Crookes tube.

Whatever may be the direct agency producing this rotation, it seems apparent that we now have an experimental basis for imposing a term representing a rotation into the equations representing the conditions within a conductor.

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AT WHAT AGE DO PUPILS WITHDRAW FROM THE PUBLIC SCHOOLS? *

C. M. Woodward.

1. Before attempting to answer this question, I desire to call attention to the obvious importance of a correct answer. The best planned course of study takes into consideration both the probable duration of a school course, and the age of the pupils. The direct bearing of this question is seen in the fact that an estimated average length of the period of pupilage is frequently made the basis of arguments for or against some proposed modification of the course of study, or some other detail of school management.

2. I use the word "withdraw" in a somewhat restricted sense, and as properly excluding the effect of mortality among school children; that is to say, I exclude from the number of those who can with propriety be said to "withdraw from school," those whose school course is cut short by death. Fortunately, this allowance is small, but it is not on that account to be ignored. The propriety of omitting from my calculations those who die cannot be seriously questioned. The practical inquiry is: At what age do pupils leave school to enter upon the active duties of life, or to enter private schools?

3. The data for my calculations are the reports of the superintendents of the public schools of St. Louis, Chicago and Boston. In these reports the ages of all the children enrolled are recorded either at the beginning, or in the middle of the school year; and the number for each year of age is given without any regard to the grading of those pupils. For example, we have the number that are between seven and eight years old, and the number between eight and nine, the number between nine

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and ten, and so on. These numbers are given in every annual report, and I have taken them from the annual reports of 12 or 13 consecutive years. I am bound to assume that these reports are accurate, although they exhibit certain anomalous results. By grouping these reports as exhibited in Tables I, II, and III, and then considering the figures in any vertical column, I am able to follow the same group of children through their course in the public schools. I have assumed that no pupils withdraw before the age of eight years. By following down any vertical column we can see how the numbers increase or diminish from the combined effect of immigration, emigration, death, and withdrawals from school, till the class disappears altogether at the age of 20.

4. To extend my investigations over as much ground as possible I have entered on Tables I, II, III, sufficient data to enable me to make three independent calculations from each table. I have named the columns "A," "B," "C," in each case so that in all I have applied my analysis to nine sets of pupils, three in each city. I will add that I limited my study to the cities St. Louis, Chicago, and Boston for the reason that all the other large cities failed to furnish me with the requisite data.

5. It is a source of regret that the data furnished by the three cities are not uniform in character. In the Boston schools the reports give the number "16 years old," "17 years old," "18 years old," "19 years old and over." In the Chicago reports all pupils "17 years old and over" are lumped together. In the St. Louis reports all pupils "16 years old and over" are lumped together. It has been necessary to distribute the pupils thus lumped together, according to their ages as accurately as possible.

It was useless to refer to the unpublished records in St. Louis and Chicago for the exact details of such distribution, as they could give no additional information. In this emergency I adopted the following method based upon an examination of the distribution in the Boston schools, and of the ratio which the 16 year old pupils bore to those "17 and over" in the city of Chicago. I will not give the details of my investigation, but will plainly state that I assumed in the case of

St. Louis that 52 per cent of those who were reported to me as "16 years old and over" were 16 years old; 30 per cent were 17 years old; 13 per cent were 18 years old; 5 per cent were "19 years old and over." This distribution is made for each of the numbers at the bottoms of several columns in Table I.

In the case of the Chicago schools I assumed that 63 per cent of those who were enrolled as "17 years old and over" were 17 years old; 27 per cent were 18 years old; 10 per cent were "19 years old and over." This, I may say in parenthesis, corresponds to the distribution in the St. Louis schools for those three years. This method of distribution is applied to the last numbers in several columns in Table II. The fact that nearly all of these tables show the withdrawal of the 20-year-old pupils in the years 1895–6, and even later, was an inevitable consequence, but the results are not on that account to be called in question. All my results are based upon averages, and are the consequence of laws which vary very slightly from year to year in any given city.

6. Other data essential to my calculation are: First, the rate at which the population is increasing on account of the excess of the number of births over the number of deaths. Secondly, the rate at which the population is increasing, or diminishing, from all causes, whether by accession of new territory, the moving in or the moving out of children, or from births or deaths. The internal growth (by which I mean that arising from the excess of births over deaths) I calculate from data furnished by the city officials. The growth from excess of immigration over emigration and death, added to the growth from the accession of new territory (as in the case of Chicago in the year 1889) I call the "external growth." The total growth is, of course, the sum of the "internal" and "external" growths. I may here remark that the growth in school population shown by the enrollment in the public schools may differ from that shown by a general census. There may be a general movement towards private schools, or from private schools. When a pupil leaves a public school and enters a private one, he practically "emigrates;" when he enters the public schools in one of the higher grades, he practically "immigrates."

7. The Rate of Internal Growth. As the number of children of school age in a city bears a very nearly fixed ratio to the total population, the increase in the number of school children from year to year is the same as the rate at which the total population increases. This is true of both the "external" and the "internal" growth. Now the internal growth of a city is exactly measured by the increase of births over deaths. Hence I calculate the rate from the official reports of births and deaths. All cities give accurate reports of deaths; the reports of births are incomplete. In Boston they are more nearly complete than in Chicago, and in Chicago they appear to be better than in St. Louis. In Boston, as would be expected, the internal growth is least, viz.: 7-1000 or 0.7 per cent. In St. Louis it is, as nearly as I can learn, 16-1000 or 1.6 per cent. In Chicago it is greatest, viz.: 20-1000 or 2 per cent. While these rates are not uniform they are approximately so. In fact these results are averages of several years. In a former discussion of this problem in May, 1879, I did not distinguish the two kinds of growth, but allowed for the death rate of school children directly.

8. The Total Rate of Growth in School Population. This rate is readily found by comparing the enrollment any one year by the enrollment for the same ages for the preceding year. For example: take the two years 1889–90 and 1890–91 in the table of the Chicago schools. The attendance of children above 7 years of age in 1889–90 was 115,366. The next year the enrollment was 124,144, a growth of 7.6 per cent. This approximately represents the growth of the city. In the last column but one on Tables I, II, and III, representing the attendance in St. Louis, Chicago and Boston, this total rate of growth of school population for each year is given. It will be seen that in some cases it is small, in others very large. Thus in Chicago schools the increase from 82 to 83 was 5.7 per cent; from 83 to 84, 4.5 per cent; from 84 to 85, 5.8 per cent; from 86 to 87, 2.5 per cent, and so on. In the year 88 to 89 I find the enormous increase of 41.5 per cent; this signalizes, of course, an immense accession of territory with a school population two-fifths as large as that of the former city itself. This explains the unexpected showing

made by the city of Chicago in the census of 1890. The growth since 1890 has been all the while rapid, reaching in the year 92 to 93, 9 per cent.

It is probable that the increase in the school population as shown by the public school report was relatively greater than the increase in the population of the city, for two reasons: (a) the ratio of children to population was greater in suburban than in urban districts; and (b) the proportion of children in the public schools was greater in the suburbs than within the old city limits.

It is evident that both the rate of internal growth and the total rate of growth are affected by the mortality rate of school children, so that element needs no further consideration.

9. Now it is evident that the increase with which we are concerned when we are considering any group of pupils is that which arises from "external" growth alone. No increase in the number of births over deaths can add to the number of those who were ten years old last year and who are eleven years old this year; though such increase does help to explain why the number who were ten years old this year is greater than the number who were ten years old last year. Consequently, in order to find the *possible* increase (which may be shown as we read down any vertical column) we must, from the total rate at which the school population increases, subtract the rate of internal growth, and then apply the remaining rate to the number enrolled the previous year. For example: I found that in 1890–91 the rate of increase of school attendance in Chicago was 7.6 per cent. I had already found that the internal rate of growth was 2.0 per cent; the difference is 5.6 per cent. This is the rate at which the number of pupils of certain ages in 1889–90 *would have been* increased during the next twelve months *had there been no withdrawals.* In the year 1889–90 there were 7,029 pupils in the Chicago schools who were between 14 and 15 years old. 5.6 per cent of that number is 394; hence the "possible number" of pupils between 15 and 16 years old at the registration in 1890–1 was 7,423, as given in Table VII. By means of the final rates, which I have in the same way

calculated for each and every year in the series, I have calculated the *possible* attendance for each year.

10. Now turn to Tables IV–XII. I have here in every case in the third column one of the columns from Tables I, II and III. In the fourth column I have the rates of external increase already obtained. The next column gives the theoretical "external" increase in numbers, and in the sixth column, the "possible" or ideal number for each age, obtained by adding the increase to the enrollment of the previous year. Now subtract the actual attendance from the "possible" attendance and we have of course the number who during the year withdrew.

11. It is evident that the average age of those withdrawing during any one year is one year greater than their age when they were last enrolled. For example: At enrollment the pupils in their fifteenth year are enrolled as 14, and it is evident that their average age is 14½. Then those who withdraw before the next enrollment are on the average half a year older, so that those 14-year-old pupils who do not reappear withdraw on the average when just 15 years old. Hence it makes no difference at what date during the year the ages are registered provided the date is always the same.

12. The average age of withdrawal is, of course, found by adding all the products found by multiplying the number of pupils withdrawing each year by their age, and dividing the sum by the total number of withdrawals.

13. It will be noticed in certain tables that not only is the rate of external gain *minus*, showing loss of school population, but in some cases they show a *negative withdrawal*, or an abnormal entrance of new pupils. This involves of course an unusual withdrawal during the same year from other groups or columns, as the rate of increase is calculated from all ages. I have carried out all such negative results, subtracting such amounts as have prefixed a minus sign.

14. Results. Table XIII gives the results of the nine calculations. I submit them without comment.

15. The Average Age of Withdrawal *versus* The Average Age of Children in School. I was originally led to this discussion by what I regard as erroneous statements

in regard to the average length of time that the children attend school; and I am convinced that a great deal of confusion exists on this point in the minds of both teachers and school superintendents.

For the purpose of clearing up this matter, I desire to state, first; the average age at which pupils withdraw from the public schools is a very different thing from the average age of pupils in the public schools. For example: I have shown by the results in Table XIII that the average age at which pupils withdraw from the St. Louis schools is approximately 13.3 years. Now the average age of the pupils in the St. Louis schools at the time of their enrollment in the year 1894–5 was 10.2 years, which is evidently a very different thing. In the same way the average age at which pupils withdraw from the Chicago schools I have found to be approximately 15.5 years. The average age of pupils in the Chicago schools at the time of their enrollment in the year 1894–5 was 10.1 years. So in the Boston schools the average age of withdrawal is approximately 15.9 years; while the average of those in the Boston schools at the time of their registration in 1894–5 was 10.52 years. However, this result must not be compared with the averages in St. Louis and Chicago for the reason that in the Boston schools pupils are admitted under 4 years of age, while in St. Louis no pupils are admitted until they are six years old. In Chicago all those under 7 years old are grouped together without specifying how old they are, whether 4, 5, or 6; consequently no comparison can be made except for those who are 7 years old and over.

Using the figures given on Tables I, II, and III for the year 1894–5 for the three cities, I find the average age of all those children who were above 7 years of age at the date of registration in the public schools in 1894–5, to be as follows: St. Louis, 10.83; Chicago, 10.87; Boston, 11.56.

I wish now to show how entirely reasonable it is that the average age of those in school should be very different from the average age at the time of withdrawal. Let us suppose that in an ideal city 1,000 pupils enter the schools every year at exactly the age of six years. Let us also suppose that this number of pupils remains without change, that is, there are no deaths, no removals, no additions, no withdrawals, but every pupil remains in school until the age of 20, and then withdraws. Under such an ideal condition of things, it is evident that the average age at the time of withdrawal would be exactly 20 years; and yet the average age at the time of registration at the beginning of any one year would be exactly $12\frac{1}{2}$ years, which is clearly seen to be a very different thing. This of course is an ideal and an extreme or limiting case toward which results may approximate more and more as the attendance is extended more and more generally throughout the course of the public schools.

TABLE I. ST. LOUIS PUBLIC SCHOOLS.

Year.												A	B	C										Actual Rate of Gain.	Rate of External Gain.
81-2														7 7273	8 6611	9 5669	10 5704	11 4997	12 4540	13 3311	14 2105	15 1016	16 and over 1034		
82-3													7 7835	8 7066	9 6295	10 5610	11 4953	12 4726	13 3510	14 2137	15 1098	16 and over 1045		4.8	3.2
83-4												7 8614	8 7171	9 6605	10 6192	11 5102	12 4839	13 3459	14 2212	15 1196	16 and over 1026			4.8	3.2
84-5											7 7896	8 7180	9 6590	10 6306	11 5430	12 4803	13 3552	14 2513	15 1462	16 and over 1262				1.3	—0.3
85-6										7 7670	8 7286	9 6675	10 6301	11 5568	12 4885	13 3716	14 2385	15 1467	16 and over 1333					.6	—1.0
86-7									7 7824	8 6978	9 6534	10 6477	11 5732	12 5262	13 3735	14 2576	15 1502	16 and over 1558						1.9	0.3
87-8								7 7794	8 7084	9 6705	10 6334	11 5720	12 5611	13 4142	14 2813	15 1442	16 and over 1607							2.2	0.6
88-9							7 7959	8 7075	9 6207	10 6167	11 5526	12 5464	13 4279	14 2881	15 1604	16 and over 1567								—0.5	—2.1
89-0						7 8427	8 7327	9 6811	10 6097	11 5698	12 5301	13 4214	14 2944	15 1587	16 and over 1853									2.5	0.9
90-1					7 8719	8 7743	9 6793	10 6353	11 5850	12 5475	13 4158	14 2046	15 1741	16 1069	17 616	18 267	19 103							3.1	1.5
91-2				7 9389	8 8101	9 7086	10 6910	11 5964	12 5245	13 4236	14 2978	15 1946	16 1091	17 630	18 273	19 105								4.1	2.5
93-3			7 9657	8 8472	9 7605	10 6966	11 6270	12 5574	13 4500	14 3163	15 2049	16 1085	17 626	18 271	19 105									4.4	2.8
93-4		7 10166	8 8649	9 8048	10 7452	11 6567	12 5985	13 4957	14 3335	15 2054	16 1257	17 726	18 314	19 121										5.9	4.3
94-5	7 9972	8 8632	9 8080	10 7672	11 6884	12 6145	13 5212	14 3481	15 2135	16 1218	17 703	18 305	19 117											1.5	—0.1
												19 119													

TABLE II.

CHICAGO PUBLIC SCHOOLS.

Year.												A	B	C										Actual Rate of Gain.	Rate of External Gain.
82-3	......	......	......	......	......	....	......	......	......	......	......	......	7 10161	8 9336	9 8926	10 8348	11 7317	12 6833	13 4971	14 3091	15 1606	16 798	17 and over 662		
83-4	......	......	......	......	......	......	......	......	......	......	......	7 10438	8 9932	9 9551	10 8943	11 7773	12 6985	13 5353	14 3342	15 1778	16 856	17 and over 633	......	5.7	3.7
84-5	......	......	......	......	......	......	......	......	......	......	7 10378	8 10058	9 10006	10 9363	11 8383	12 7458	13 5721	14 3581	15 1914	16 972	17 and over 711	......	......	4.5	2.5
85-6	......	......	......	......	......	......	......	......	......	7 10881	8 10409	9 10061	10 9953	11 8820	12 8156	13 6141	14 4035	15 2160	16 1095	17 and over 853	......	......	......	5.8	3.8
86-7	......	......	......	......	......	......	......	......	7 10656	8 10595	9 10201	10 10270	11 9356	12 8469	13 6344	14 4071	15 2313	16 1137	17 and over 988	......	......	......	......	2.5	0.5
87-8	......	......	......	......	......	......	......	7 11226	8 10901	9 10548	10 10705	11 9673	12 9103	13 6874	14 4430	15 2478	16 1255	17 and over 1105	......	......	......	......	......	5.8	3.8
88-9	......	......	......	......	......	......	7 11629	8 11060	9 10775	10 10980	11 10078	12 9471	13 7593	14 4748	15 2627	16 1378	17 and over 1172	......	......	......	......	......	......	4.1	2.1
89-0	......	......	......	......	......	7 16974	8 15507	9 15079	10 14929	11 13836	12 13310	13 10805	14 7029	15 3959	16 2078	17 and over 1860	......	......	......	......	......	......	......	41.5	39.5
90-1	......	......	......	......	7 19855	8 17207	9 16116	10 15782	11 14404	12 14025	13 11231	14 6431	15 4540	16 2391	17 and over 2162	......	......	......	......	......	......	......	......	7.6	5 6
91-2	......	......	......	7 21758	8 19639	9 17514	10 16571	11 15228	12 14473	13 11783	14 8042	15 4564	16 2563	17 1491	18 639	19 237	......	......	......	......	......	......	......	8.3	6.3
92-3	......	......	7 22584	8 21623	9 19743	10 18196	11 16159	12 14819	13 12076	14 8093	15 4575	16 2441	17 1637	18 702	19 260	......	......	......	......	......	......	......	......	6.2	4.2
93-4	......	7 24996	8 22629	9 21841	10 20363	11 17567	12 16261	13 13226	14 8628	15 5009	16 2661	17 1603	18 687	19 254	......	......	......	......	......	......	......	......	......	9.0	7.0
94-5	7 25748	8 23793	9 22263	10 21840	11 19581	12 17963	13 14408	14 9789	15 5809	16 3081	17 1903	18 815	19 302	....	......	......	......	......	......	......	......	......	......	7.4	5.4
												19 336													

Year.											A	B	C												Actual Rate of Gain.	Rate of External Gain
83-4........	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	7 5770	8 6215	9 6334	10 6017	11 5621	12 5163	13 4714	14 3462	15 2201	16 1171	17 592	18 250	19 107		
84-5........	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	7 5649	8 6097	9 6215	10 6294	11 5653	12 5441	13 4739	14 3704	15 2323	16 1255	17 605	18 275	19 104	.....	1.5	0 8
85-6........	.....	.....	.....	.....	.....	.....	.....	.....	.....	7 5628	8 5924	9 6197	10 6223	11 6025	12 5691	13 5073	14 3768	15 2520	16 1355	17 663	18 303	19 144	.....	.....	2.4	1.7
86-7........	.....	.....	.....	.....	.....	.....	.....	.....	7 5571	8 6103	9 6146	10 6234	11 6074	12 6087	13 5335	14 3984	15 2550	16 1431	17 721	18 306	19 154	.....	.....	.....	2.4	1.7
87-8........	.....	.....	.....	.....	.....	.....	.....	7 5612	8 5823	9 6128	10 6278	11 5941	12 6025	13 5608	14 4097	15 2710	16 1473	17 768	18 332	19 144	.....	.....	.....	.....	0.5	—0.2
88-9........	.....	.....	.....	.....	.....	.....	7 5732	8 6020	9 6018	10 6207	11 6053	12 6192	13 5813	14 4542	15 2836	16 1593	17 782	18 353	19 129	.....	.....	.....	.....	.....	2.0	1.9
89-0........	.....	.....	.....	.....	.....	7 5558	8 5885	9 5957	10 6020	11 5844	12 6028	13 5698	14 4546	15 3000	16 1647	17 816	18 326	19 163	.....	.....	.....	.....	.....	.....	—1.5	—2.2
90-1........	.....	.....	.....	...	7 5589	8 5853	9 5925	10 6072	11 5783	12 6014	13 5734	14 4539	15 3039	16 1714	17 893	18 378	19 144	.....	.....	.....	.....	.....	.....	.....	0.4	—0.3
91-2........	.....	.....	.....	7 5632	8 5929	9 6002	10 6028	11 5964	12 5932	13 5597	14 4544	15 2991	16 1777	17 913	18 397	19 158	.....	.....	.....	.....	.....	.....	.....	.....	0.4	—0.3
92-3........	.....	.....	7 5958	8 6081	9 6021	10 6237	11 5822	12 6157	13 5649	14 4505	15 3105	16 1672	17 921	18 369	19 146	.....	.....	.....	.....	.....	.....	.....	.....	.....	1.5	0.8
93-4........	.....	7 6117	8 6244	9 6073	10 6100	11 5965	12 6081	13 6014	14 4687	15 3113	16 1886	17 973	18 491	19 192	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	2.5	1.8
94-5........	7 6382	8 6487	9 6208	10 6223	11 5917	12 6349	13 5937	14 4827	15 3062	16 1877	17 1018	18 565	19 299	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	2 3	1.6
											18 509	19 281														
											19 254															

ST. LOUIS PUBLIC SCHOOLS.

TABLE IV. COLUMN "A."

Years.	Age.	Enrolled.	Per cent of External Gain in Population.	Amount of Increase.	Possible Number.	Withdrawn.	Year Pupils.
83–4	7	8,614	......	......	8,614	......	....
84–5	8	7,180	—0.3	— 26	8,588	1,408	11,264
85–6	9	6,675	—1.0	— 72	7,108	433	3,897
86–7	10	6,477	+0.3	+ 20	6,695	218	2,180
87–8	11	5,720	+0.6	+ 39	6,516	796	8,756
88–9	12	5,464	—2.1	—120	5,600	136	1,632
89–0	13	4,214	+0.9	+ 49	5,513	1,299	16,887
90–1	14	2,946	+1.5	+ 63	4,277	1,331	18,634
91–2	15	1,946	+2.5	+ 74	3,020	1,074	16,110
92–3	16	1,085	+2.8	+ 54	2,000	915	14,640
93–4	17	726	+4.3	+ 47	1,132	406	6,902
94–5	18	305	—0.1	— 1	725	420	7,560
....	19	119	0	0	305	186	3,534
....	20	......	......	......	119	119	2,380
						8,741	114,376

114,376 ÷ 8,741 = 13.1 years.

ST. LOUIS PUBLIC SCHOOLS.

TABLE V. COLUMN "B."

Years.	Age.	Enrolled.	Per cent of External Gain in Population.	Amount of Increase.	Possible Number.	Withdrawn.	Year Pupils.
82–3	7	7,835	......	......	7,835	......	....
83–4	8	7,171	+3.2	+250	8,085	914	7,312
84–5	9	6,590	—0.3	— 22	7,149	559	5,031
85–6	10	6,301	—1.0	— 66	6,524	223	2,230
86–7	11	5,732	+0.3	+ 19	6,320	588	6,468
87–8	12	5,611	+0.6	+ 34	5,766	155	1,860
88–9	13	4,279	—2.1	—118	5,493	1,214	15,782
89–0	14	2,944	+0.9	+ 39	4,318	1,374	19,236
90–1	15	1,741	+1.5	+ 44	2,988	1,247	18,705
91–2	16	1,091	+2.5	+ 44	1,785	694	11,104
92–3	17	626	+2.8	+ 31	1,122	496	8,432
93–4	18	314	+4.3	+ 27	653	339	6,102
94–5	19	117	—0.1	0	314	197	3,743
....	20	......	......	......	117	117	2,340
						8,117	108,345

108,345 ÷ 8,117 = 13.3 years.

ST. LOUIS PUBLIC SCHOOLS.

TABLE VI. COLUMN "C."

Years.	Age.	Enrolled.	Per cent of External Gain in Population.	Amount of Increase.	Possible Number.	Withdrawn.	Year Pupils.
81–2	7	7,273	......	......	7,273	......	....
82–3	8	7,066	+3.2	+233	7,506	440	3,520
83–4	9	6,605	+3.2	+226	7,292	687	6,183
84–5	10	6,306	—0.3	— 20	6,585	279	2,790
85–6	11	5,568	—1.0	— 63	6,243	675	7,425
86–7	12	5,262	+0.3	+ 17	5,585	323	3,876
87–8	13	4,142	+0.6	+ 32	5,294	1,152	14,976
88–9	14	2,881	—2.1	— 87	4,055	1,174	16,436
89–0	15	1,587	+0.9	+ 26	2,907	1,320	19,800
90–1	16	1,069	+1.5	+ 24	1,611	542	8,672
91–2	17	630	+2.5	+ 27	1,096	466	7,922
92–3	18	271	+2.8	+ 18	648	377	6,786
93–4	19	121	+4.3	+ 12	283	162	3,078
94–5	20	......	—0.1	— 0	121	121	2,420
						7,718	103,884

103,884 ÷ 7,718 = 13.5 years.

CHICAGO PUBLIC SCHOOLS.

TABLE VII. COLUMN "A."

Years.	Age.	Enrolled.	Per cent of External Gain in Population.	Amount of Increase.	Possible Number.	Withdrawn.	Year Pupils.
83–4	7	10,438	......	......	10,438	......	....
84–5	8	10,058	+ 2.5	261	10,699	641	5,128
85–6	9	10,061	+ 3.8	382	10,440	379	3,411
86–7	10	10,270	+ 0.5	50	10,111	—159	—1,590
87–8	11	9,673	+ 3.8	390	10,660	987	10,857
88–9	12	9,471	+ 2.1	203	9,876	405	4,860
89–0	13	10,805	+39.5	3,741	13,212	2,407	31,291
90–1	14	6,431	+ 5.6	605	11,410	4,979	69,706
91–2	15	4,564	+ 6.3	405	6,836	2,272	34,080
92–3	16	2,441	+ 4.2	192	4,756	2,315	37,040
93–4	17	1,603	+ 7.0	171	2,612	1,009	17,153
94–5	18	815	+ 5.4	86	1,689	874	15,732
....	19	336	+ 5.0	41	856	520	9,880
....	20	......	......	......	336	336	6,720
						16,965	244,268

244,268 ÷ 16,965 = 14.4 years.

CHICAGO PUBLIC SCHOOLS.

TABLE VIII. COLUMN "B."

Years.	Age.	Enrolled.	Per cent of External Gain in Population.	Amount of Increase.	Possible Number.	Withdrawn.	Year Pupils.
82–3	7	10,161	......	......	10,161	......	....
83–4	8	9,932	+ 3.7	376	10,537	605	4,840
84–5	9	10,006	+ 2.5	248	10,180	174	1,566
85–6	10	9,953	+ 3.8	380	10,386	433	4,330
86–7	11	9,356	+ 0.5	50	10,003	647	7,117
87–8	12	9,103	+ 3.8	355	9,711	608	7,296
88–9	13	7,593	+ 2.1	191	9,294	1,701	22,113
89–0	14	7,029	+39.5	2,999	10,592	3,563	49,882
90–1	15	4,540	+ 5.6	394	7,423	2,883	43,245
91–2	16	2,563	+ 6.3	286	4,826	2,263	36,208
92–3	17	1,637	+ 4.2	107	2,670	1,033	17,561
93–4	18	687	+ 7.0	115	1,752	1,065	19,170
94–5	19	302	+ 5.4	37	724	422	8,018
....	20	......	......	......	302	302	6,040
						15,699	227,386

227,386 ÷ 15,699 = 14.5 years.

CHICAGO PUBLIC SCHOOLS.

TABLE IX. COLUMN "C."

Years.	Age.	Enrolled.	Per cent of External Gain in Population.	Amount of Increase.	Possible Number.	Withdrawn.	Year Pupils.
82–3	8	9,336	......	......	9,336	......	....
83–4	9	9,551	+ 3.7	345	9,681	130	1,170
84–5	10	9,363	+ 2.5	239	9,790	427	4,270
85–6	11	8,820	+ 3.8	356	9,719	899	9,889
86–7	12	8,469	+ 0.5	44	8,864	395	4,740
87–8	13	6,874	+ 3.8	322	8,791	1,917	24,921
88–9	14	4,748	+ 2.1	144	7,018	2,270	31,780
89–0	15	3,959	+39.5	1,875	6,623	2,664	39,960
90–1	16	2,391	+ 5.6	222	4,181	1,790	28,640
91–2	17	1,491	+ 6.3	151	2,542	1,051	17,867
92–3	18	702	+ 4.2	63	1,554	852	15,336
93–4	19	254	+ 7.0	49	751	497	9,443
94–5	20	......	......	......	254	254	5,080
						13,146	193,096

193,096 ÷ 13,146 = 14.7 years.

BOSTON PUBLIC SCHOOLS.

TABLE X. COLUMN "A."

Years.	Age.	Enrolled.	Per cent of External Gain in Population.	Amount of Increase.	Possible Number.	Withdrawn.	Year Pupils.
84–5	7	5,649	......	......	5,649	......	....
85–6	8	5,924	+1.7	+ 96	5,745	—179	—1,432
86–7	9	6,146	+1.7	+101	6,025	—121	—1,089
87–8	10	6,278	— .2	— 12	6,134	—144	—1,440
88–9	11	6,053	+1.9	+119	6,397	344	3,784
89–0	12	6,028	—2.2	—133	5,920	—108	—1,296
90–1	13	5,734	— .3	— 18	6,010	276	3,588
91–2	14	4,544	— .3	— 17	5,717	1,173	16,422
92–3	15	3,105	+ .8	+ 37	4,581	1,476	22,140
93–4	16	1,886	+1.8	+ 56	3,161	1,275	20,400
94–5	17	1,018	+1.6	+ 30	1,916	898	15,266
....	18	509	......	......	1,018	509	9,162
....	19	254	......	......	509	255	4,845
....	20	......	......	......	254	254	5,080
						5,908	95,430

95,430 ÷ 5,908 = 16.2 years.

BOSTON PUBLIC SCHOOLS.

TABLE XI. COLUMN "B."

Years.	Age.	Enrolled.	Per cent of External Gain in Population.	Amount of Increase.	Possible Number.	Withdrawn.	Year Pupils.
83–4	7	5,770	......	......	5,770	......	....
84–5	8	6,097	+ .8	+ 46	5,816	—281	—2,248
85–6	9	6,197	+1.7	+104	6,201	4	36
86–7	10	6,234	+1.7	+105	6,302	68	680
87–8	11	5,941	— .2	— 13	6,221	280	3,080
88–9	12	6,192	+1.9	+113	6,054	—138	—1,656
89–0	13	5,698	—2.2	—136	6,056	358	4,654
90–1	14	4,539	— .3	— 17	5,681	1,142	15,988
91–2	15	2,991	— .3	— 14	4,525	1,534	23,010
92–3	16	1,672	+ .8	+ 24	3,015	1,343	21,488
93–4	17	973	+1.8	+ 30	1,702	729	12,393
94–5	18	565	+1.6	+ 16	989	424	7,632
....	19	282	......	......	565	283	5,377
....	20	......	......	......	282	282	5,640
						6,028	96,074

96,074 ÷ 6,028 = 15.9 years.

BOSTON PUBLIC SCHOOLS.

TABLE XII. COLUMN "C."

Years.	Age.	Enrolled.	Per cent of External Gain in Population.	Amount of Increase.	Possible Number.	Withdrawn.	Year Pupils.
83–4	8	6,215	......	......	6,215	......	....
84–5	9	6,215	+ .8	+ 50	6,265	50	450
85–6	10	6,223	+1.7	+106	6,321	98	980
86–7	11	6,074	+1.7	+106	6,329	255	2,805
87–8	12	6,025	— .2	— 12	6,062	37	444
88–9	13	5,843	+1.9	+114	6,139	296	3,848
89–0	14	4,546	—2.2	—128	5,715	1,163	16,366
90–1	15	3,039	— .3	— 14	4,532	1,493	22,395
91–2	16	1,777	— .3	— 9	3,030	1,253	20,048
92–3	17	921	+ .8	+ 14	1,791	870	14,790
93–4	18	491	+1.8	+ 16	937	446	8,028
94–5	19	299	+1.6	+ 8	499	200	3,800
....	20	......	......	......	299	299	5,980
						6,466	99,934

99,934 ÷ 6,466 = 15.5 years.

AVERAGE AGE OF WITHDRAWAL.

TABLE XIII.

ST. LOUIS.

Column "A" ....13.1 Years.
" "B" ....13.3 "
" "C" ....13.5 "

Average ....13.3 Years.

CHICAGO.

Column "A" ....14.4 Years.
" "B" ....14.5 "
" "C" ....14.7 "

Average ....14.5 Years.

BOSTON.

Column "A" ....16.2 Years.
" "B" ....15.9 "
" "C" ....15.5 "

Average ....15.9 Years.

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GEOMETRICAL CONSTRUCTIONS OF THE LINES OF FORCE PROCEEDING FROM (a) TWO PARALLEL ELECTRIFIED LINES, (b) TWO ELECTRIFIED POINTS.*

WM. H. ROEVER.

(*a*) *The curve representing a line of force proceeding from a system consisting of two parallel electrified lines, is the locus of the intersection of two straight lines, rotating in the same plane about these two parallel lines as axes, with uniform but different angular velocities.*

The number of lines of force proceeding from an electrified point having a charge dm is $4\pi dm$. The number proceeding from an electrified straight line, made up of an infinite number of points, is $4\pi m = 4\pi\lambda l$, in which l is the length of the line, and λ the charge per unit length. The mass or charge included between two planes perpendicular to the electrified line and separated by a distance l is $\lambda l = m$. The flow of force between these two planes is $4\pi m$; and if we pass through the electrified line $4\pi m$ planes equally spaced, each of the $4\pi m$ dihedral angles thus determined constitutes an orthogonal tube in which the flow of force is unity. The flow of force corresponding to an angle ω is then

$$n = 4\pi m \frac{\omega}{2\pi} = 2m\omega.$$

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* Read before The Academy of Science of St. Louis, April 6, 1896.

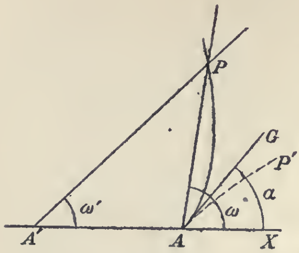


Fig. 1.

Now consider the case of two parallel straight lines electrified oppositely and situated at two points A and A'. (Fig. 1.) Let the charge on line A be $+m$ and that on A' be $-m'$ such that $m > m'$ numerically. The number of lines of force leaving the mass m through the wedge whose edge is the line A and whose semi-angle is ω is

$$N = 2m\omega.$$

The number of lines of force converging to $-m'$ through the wedge whose edge is the line A' and whose semi-angle is ω' is

$$N' = 2m'\omega'.$$

The number of lines of force proceeding to the right between the two parallel lines of intersection of the wedges is

$$N - N' = 2m\omega - 2m'\omega'.$$

The locus of all such lines of intersection constitutes a tube of force, the right section of which is a line of force. If in the above equation $\omega' = 0$,

$$N - N' = 2m\omega = 2ma,$$

in which a is the special value of ω for which $\omega' = 0$. Combining these equations gives

$$m\omega - m'\omega' = ma \ldots\ldots\ldots\ldots\ldots\ldots (1),$$

which is the equation of a line of force whose direction at A makes an angle a with AX. When the lines A and A' have charges of like sign the equation of a line of force is

$$m\omega + m'\omega' = ma \ldots\ldots\ldots\ldots\ldots\ldots (2).$$

Equations (1) and (2) were obtained from electrical considerations. In what follows it will be shown how they can be obtained from geometrical considerations.

In Fig. 1 suppose A and A' to be the traces of two axes of rotation, each perpendicular to the plane of the paper, and AP and $A'P$ two right lines in the plane of the paper. AP rotates around A with an angular velocity m_1, and $A'P$ around A' with an angular velocity m'_1, such that $\frac{m'_1}{m_1} = K$, a constant. If the lines rotate in the same direction (in the figure, counter clockwise) and $A'P$ starts from a position $A'X$ and AP from a position AG, making an angle a with AX, the locus of the point of intersection, P, is

$$\omega' = \frac{m'_1}{m_1}(\omega - a),$$

in which $\omega = \angle PAX$, $\omega' = \angle PA'X$ and $a = \angle GAX$.

The above equation written in another form is

$$m'_1\omega - m_1\omega' = m'_1 a \ldots\ldots\ldots\ldots\ldots (3).$$

When the rotations are in opposite directions the locus of the point of intersection, P', is

$$\omega' = \frac{m'_1}{m_1}\ (a - \omega)$$

or

$$m'_1\omega + m_1\omega' = m'_1 a \ldots\ldots\ldots\ldots\ldots (4).$$

Equations (1) and (3) have the same form, but the primed constants are interchanged. This shows that the curve representing a line of force proceeding from a system consisting of two parallel electrified lines having charges of *opposite algebraic sign* is the locus of the intersection of two straight lines rotating in the same plane about the two parallel lines as axes with angular velocities having *the same algebraic sign* (*i. e.*, the lines rotating in the same direction); also that the angular velocities of the rotating lines are, numerically, inversely proportional to the charges on their respective axes.

Equations (2) and (4) also have the same form, and in this case also the primed constants are interchanged. This shows that the curve representing a line of force proceeding from a system consisting of two parallel electrified lines having charges of *the same algebraic sign* is the locus of the intersection of two straight lines rotating in the same plane about the two parallel lines as axes with angular velocities having *opposite algebraic signs* (*i. e.*, the lines rotating in the opposite directions); also, as in the last case, that the angular velocities of the rotating lines are, numerically, inversely proportional to the charges on their respective axes.

Fig. 2.

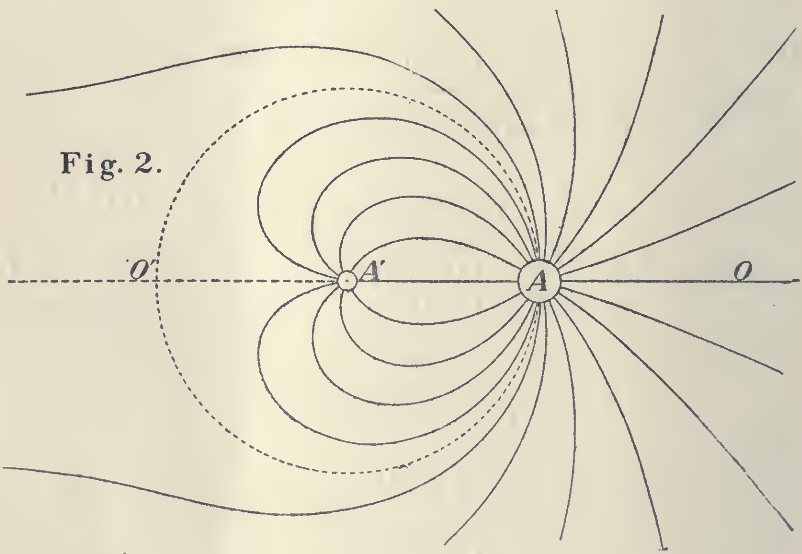


Fig. 2 shows the lines of force proceeding from a system consisting of two parallel and oppositely electrified lines A and A' having charges $m = 2$ and $-m' = -1$, respectively. If A and A' were the axes of two wheels having radial spokes, and if wheel A' rotated twice as fast as wheel A and in the same direction, the points of intersection of the spokes of A

with those of A' would trace the same curves. Fig. 3 shows a few of the lines of force proceeding from a system consist-

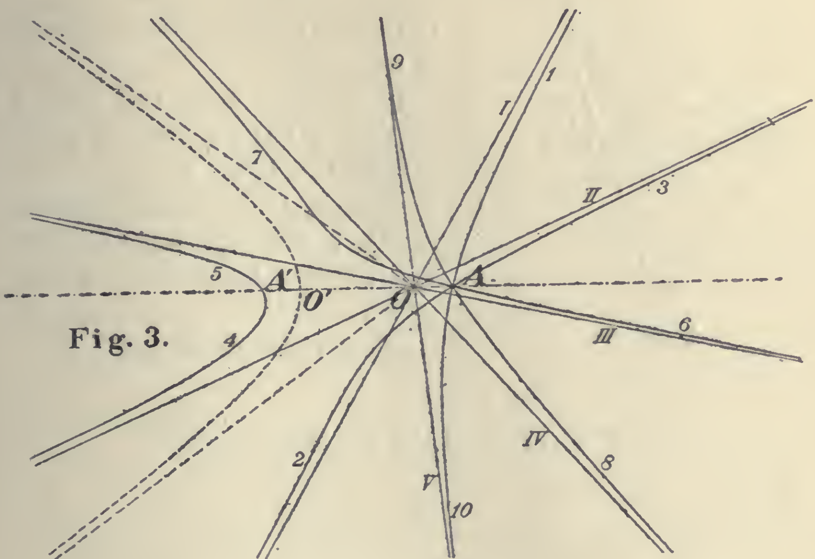


Fig. 3.

ing of two parallel electrified lines A and A' having charges $m = 4$ and $m' = 1$, respectively, of like sign.

If $m = m'$, numerically, equation (1) becomes

$$\omega - \omega' = a \quad \ldots\ldots\ldots\ldots\ldots\ldots (5),$$

which is the equation of a circle referred to the poles A and A'. A line of force is only an arc of this circle. It starts at A and stops at A'.

If $\omega = \omega' = \theta$, then from equation (1)

$$\theta = \frac{m}{m - m'} a \quad \ldots\ldots\ldots\ldots\ldots\ldots (6),$$

which determines the direction of the asymptote to a line of

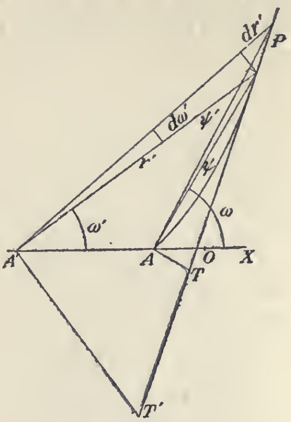


Fig. 4.

force. The angle θ is measured from the same line, $A'AX$, and in the same direction as α.

The asymptote passes through the centre of gravity of the masses m and $-m'$.

In order to show this draw a tangent PT to a line of force AP at P. (Fig. 4.)

Also draw the two *radii vectores* $AP = r$ and $A'P = r'$, and the two polar subtangents AT and $A'T'$.

Then, from the figure,

$$AT = AP \tan TPA = r \tan \psi = r \frac{r\,d\omega}{dr}$$

and

$$A'T' = A'P \tan T'PA' = r' \tan \psi' = r' \frac{r'\,d\omega'}{dr'}.$$

Whence

$$\frac{AT}{A'T'} = \frac{r^2\,dr'\,d\omega}{r'^2\,dr\,d\omega'}.$$

But from equation (1)

$$\frac{d\omega}{d\omega'} = \frac{m'}{m}$$

$$\therefore \frac{AT}{A'T'} = \frac{r^2\,dr'\,m'}{r'^2\,dr\,m}.$$

As r approaches r'

$$\frac{AT}{A'T'} \text{ approaches } \frac{m'}{m}.$$

Hence in the limit

$$\frac{AT}{A'T'} = \frac{AO}{A'O} = \frac{m'}{m},$$

or

$$AO \times m = A'O \times m' \ldots\ldots\ldots\ldots\ldots (7).$$

O is the point in which the asymptote cuts $A'A$ produced. Equation (7) shows that the moments taken about O are equal; hence O is the centre of gravity.

The angle θ, equation (6), cannot be greater than π, and when it has this value ($\theta = \pi$)

$$\pi = \frac{m}{m - m'} \, a,$$

from which

$$a_0 = \frac{m - m'}{m} \pi \ldots\ldots\ldots\ldots\ldots (8),$$

in which a_0 is the special value of a that makes $\theta = \pi$.

For this value of a equation (1) becomes

$$m\omega - m'\omega' = (m - m') \, \pi$$

or

$$\pi - \omega' = \frac{m}{m'} (\pi - \omega) \ldots\ldots\ldots\ldots (9).$$

This is the equation of the *limiting* or *critical line* which separates the lines of force that go to infinity from those that go to A'. The dashed line Fig. 2 is the critical line for that system.

A positive particle at O', the point in which AA' produced is cut by the critical line, is in unstable equilibrium, being attracted as much by A' as it is repelled by A. The point O' and the centre of gravity O are symmetrically situated with respect to the points A' and A.*

* "Electricity and Magnetism," Mascart and Joubert, Vol. I, 1883.

For any point of the critical line

$$\frac{r}{r'} = \frac{\sin\omega'}{\sin\omega} = \frac{\sin(\pi - \omega')}{\sin(\pi - \omega)};$$

from this and equation (9)

$$\frac{r}{r'} = \frac{\sin\left(\frac{m}{m'}(\pi - \omega)\right)}{\sin(\pi - \omega)}.$$

As ω approaches π

$$\frac{r}{r'} \text{ approaches } \frac{m}{m'}.$$

Hence in the limit

$$\frac{r}{r'} = \frac{AO'}{A'O'} = \frac{m}{m'}$$

or

$$AO' \times m' = A'O' \times m \ldots\ldots\ldots\ldots\ldots (10).$$

If $m = 2m'$, numerically, as in Fig. 2, equation (9) becomes

$$\pi - \omega' = 2(\pi - \omega) \ldots\ldots\ldots\ldots (11).$$

This is the equation of a circle having its centre at A' and a radius $A'A = 2a$.

If $m = m'$, numerically, equation (2) becomes

$$\omega + \omega' = a \ldots\ldots\ldots\ldots\ldots\ldots (12).$$

This is the equation of an equilateral hyperbola referred to the poles A and A'. A line of force is only an arc of this curve.

If $\omega = \omega' = \theta$, then from equation (2),

$$\theta = \frac{m}{m + m'}a \ldots\ldots\ldots\ldots\ldots (13),$$

which determines the direction of the asymptote.

The asymptote passes through the centre of gravity of the masses m and m'.

This is proved in a manner similar to that in the last case (Fig. 4). In this case

$$\frac{d\omega}{d\omega'} = -\frac{m'}{m}.$$

$$AT = r^2 \frac{-d\omega}{dr}, \; A'T' = r'^2 \frac{d\omega'}{dr'}$$

$$\frac{AT}{A'T'} = \frac{-r^2\, dr'\, d\omega}{r'^2\, dr\, d\omega'} = \frac{r^2\, dr'}{r'^2\, dr} \frac{m'}{m}.$$

In the limit, when $r = r'$,

$$\frac{AT}{A'T'} = \frac{AO}{A'O} = \frac{m'}{m}$$

or

$$AO \times m = A'O \times m' \ldots\ldots\ldots\ldots (14).$$

The point O in this case is between A and A'. (Fig. 3.)

The angle α, equation (2), cannot exceed π, and when it has this value ($\alpha = \pi$) equation (2) becomes

$$m\omega + m'\omega' = m\pi$$

or

$$\omega' = \frac{m}{m'}(\pi - \omega) \ldots\ldots\ldots\ldots (15).$$

This is the equation of the *limiting* or *critical line*, which separates the region occupied by the lines of force that start at A (Fig. 3) and go to infinity, from that occupied by the lines of force that start at A' and go to infinity.

The point O', in which $A'A$ is cut by the critical line (dashed in Fig. 3), and the centre of gravity O, are symmetrically situated with respect to the points A' and A.

For any point on the critical line

$$\frac{r}{r'} = \frac{\sin\omega'}{\sin\omega} = \frac{\sin\omega'}{\sin(\pi - \omega)}.$$

From this and equation (15)

$$\frac{r}{r'} = \frac{sin\left(\frac{m}{m'}(\pi - \omega)\right)}{sin(\pi - \omega)}.$$

In the limit, when $\omega = \pi$,

$$\frac{r}{r'} = \frac{AO'}{A'O'} = \frac{m}{m'}$$

or

$$AO' \times m' = A'O' \times m \ldots\ldots\ldots\ldots\ldots (16).$$

If $m = m'$, equation (15) becomes

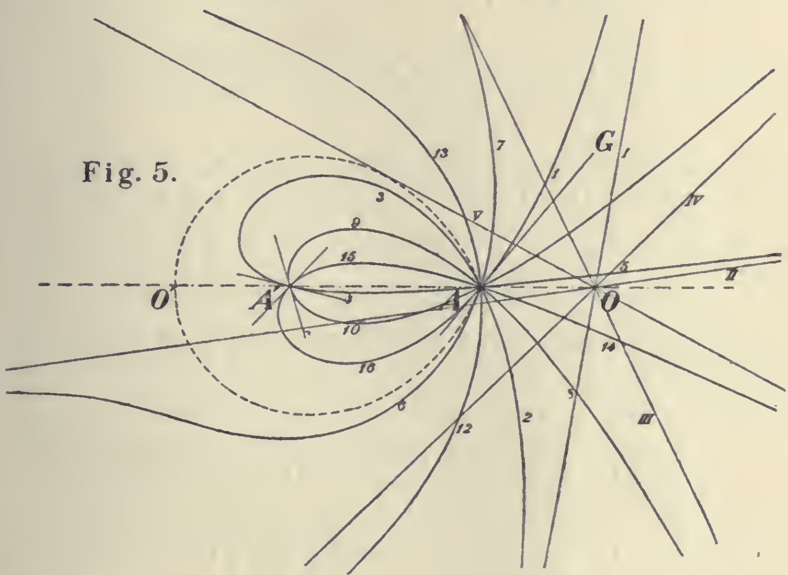
$$\omega' = (\pi - \omega) \ldots\ldots\ldots\ldots\ldots\ldots (17).$$

This is the equation of the perpendicular bisector to $A'A$. In this case (when $m = m'$) O and O' coincide and are at the middle point of $A'A$.

If we assume that the rotating lines extend in both directions from their axes, and that ω and ω' can have any values from plus infinity to minus infinity, equation (1) or (3) represents a curve which may have a number of loops and infinite branches, depending upon the relative values of m and m', and equation (2) or (4) represents a curve which may have, depending upon the relative values of m and m', a number of infinite branches, of which some pass through A and the rest through A', but none of which pass through both A and A'.

Consider first the case in which the lines rotate in the same direction, which is represented by equation (3) or (1). In Fig. 5, in which $\frac{m}{m'} = \frac{m'_1}{m_1} = \frac{8}{3}$ numerically, AG, at angle $a = 50^\circ$ with AO, and $A'A$, coinciding with $A'O$, are the initial positions of the rotating lines AP and $A'P$. As these lines rotate in a counter clockwise direction, the part marked 1, and having AG as a tangent at A, is traced. This part approaches the asymptote marked I. After a position of parallelism the point of intersection is below $A'A$, and the part marked 2 is traced. This part necessarily has the same asymptote as part 1. The point A on part 2 is reached when the line $A'P$ makes an angle π with $A'A$, and then the line AP is tangent to part 2 at A. On further rotation the part 3 of a loop is traced. The point A' on this loop is reached

Fig. 5.



when AP makes an angle π with AO, and then $A'P$ is tangent to part 3 at A'. Next the part 4 of the loop below $A'A$ is traced; the point A is reached when $A'P$ again coincides with $A'A$, and then AP is tangent to part 4 at A. Next part 5, which approaches asymptote II, is traced. After this second position of parallelism part 6 is traced, then part 7, and so on in the order indicated by the numbers. Any two consecutive asymptotes, as for instance III and IV, are not, in general, adjacent.

The equation of the curve in Fig. 5 is

$$8\omega - 3\omega' = 8\,\frac{5}{18}\,\pi = \frac{20}{9}\,\pi,$$

in which $\angle\ GAO = \frac{5}{18}\pi$. If in place of $\frac{5}{18}\pi$ we put the angle which a tangent at A to another part of the curve makes with AO, the new equation is still the equation of the curve shown in Fig. 5. Each of the $2m$ parts of the complete curve represented by equation (1) is a line of force. This is shown in Fig. 5, which may be considered as representing $2m = 16$ lines of force.

In order to investigate the curve for asymptotes, put for the

1st position of parallelism				$\omega' = \omega$
2nd	"	"	"	$\omega' = \omega + \pi$
3rd	"	"	"	$\omega' = \omega + 2\pi$
nth	"	"	"	$\omega' = \omega + (n - 1)\pi$,

in which n is an integer. For the nth position of parallelism, equation (1) becomes

$$\omega_0 = \frac{m}{m - m'}\,a + \frac{m'}{m - m'}\,(n - 1)\,\pi \ldots . (18),$$

in which ω_0 is the special value of ω when the rotating lines are parallel. If in equation (18) $n = 1$

$$\omega_0 = \theta = \frac{m}{m - m'}\,a,$$

which is the same as equation (6). Equation (18) shows that the angle between two consecutive positions of parallelism is $\frac{m'\pi}{m - m'}$. In this fraction the numerator $m'\pi$ is the angle swept through by AP before a position of parallelism coincides with a previous position of parallelism, and the denominator $m - m'$ is equal to the number of asymptotes. $\frac{\pi}{m - m'}$ is the angle between two adjacent asymptotes, such for example, as II and IV, Fig. 5.

To investigate the curve for tangents at A put for the

1st tangent	$\omega' = 0$
2nd "	$\omega' = \pi$
3rd "	$\omega' = 2\pi$
n_1th "	$\omega' = (n_1 - 1)\,\pi,$

in which n_1 is an integer. For the n_1th tangent equation (1) becomes

$$\omega_t = a + \frac{m'}{m}(n_1 - 1)\,\pi \ldots\ldots\ldots\ldots\ldots (19),$$

in which ω_t is the special value of ω when line $A'P$ coincides with $A'A$. Equation (19) shows that the angle between the tangents at A to two consecutively formed parts of the curve is $\frac{m'\pi}{m}$. Thus, in Fig. 5, the angle between the tangents at A to parts 1 and 2, or to parts 3 and 4, is $\frac{m'\pi}{m} = \frac{3}{8}\pi$. $\frac{\pi}{m}$ is the angle between two adjacent tangents at A, and m is equal to the number of tangents at A.

To investigate the curve for tangents at A' put for the

1st tangent	$\omega = 0$
2nd "	$\omega = \pi$
3rd "	$\omega = 2\pi$
n_2th "	$\omega = (n_2 - 1)\,\pi,$

in which n_2 is an integer. For the n_2th tangent equation (1) becomes

$$\omega'_t = -\frac{m}{m'}\,a + \frac{m}{m'}(n_2 - 1)\,\pi \ldots\ldots\ldots (20),$$

in which ω'_t is the special value of ω' when line AP coincides with AA'. Equation (20) shows that the angle at A' between two loops, consecutively formed, is $\frac{m}{m'}\,\pi$. In this expression $m\pi$ is the angle swept through by the rotating line $A'P$ before a position of parallelism coincides with a previous position of parallelism, $\frac{\pi}{m'}$ is the angle between two adjacent tangents at A', and m' is equal to the number of tangents at A', which is also equal to the number of loops.

The last three paragraphs show that when m and m' are expressed in terms of their least common factor,

the number of tangents at A is m,
" " " " at A', equal to the number of loops, is m',
the number of asymptotes is $m - m'$.

In Fig. 5

the number of tangents at A is $m = 8$,
" " " loops is $m' = 3$,
" " " asymptotes is $m - m' = 5$,
" angle between adjacent tangents at A is $\frac{\pi}{m} = \frac{\pi}{8}$,
" " " " " " A' is $\frac{\pi}{m'} = \frac{\pi}{3}$,
" " " " asymptotes is $\frac{\pi}{m - m'} = \frac{\pi}{5}$.

In Fig. 6

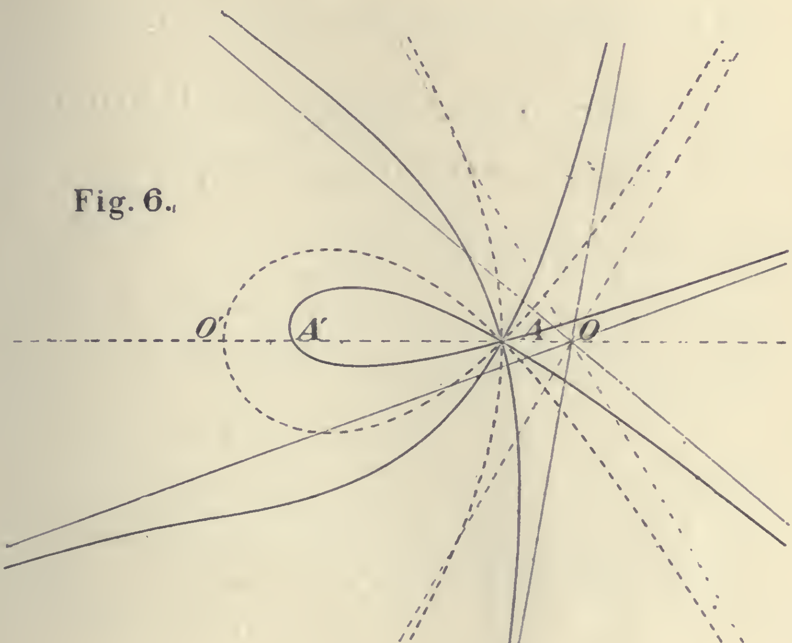
the number of tangents at A is $m = 4$,
" " " " " A' is $m' = 1$,
" " " asymptotes is $m - m' = 3$.

The dashed loop is the limiting line, and separates the region having loops from that having infinite branches. The limiting line is a portion of a curve which, just before it became critical, also had m tangents at A, m' tangents at A', and $m - m'$ asymptotes. Fig. 6 shows the whole curve dashed, of which the limiting line is a part. In Fig. 2, where $m = 2$ and $-m' = -1$, a complete curve gives place to a circle and a straight line on reaching the critical position.

The angle which a tangent, at A to the limiting line, makes with AO is by equation (8),

$$\alpha_0 = \frac{m - m'}{m}\pi = \pi - \frac{m'}{m}\pi,$$

Fig. 6.



in which $\frac{m'}{m}\pi$ is the angle between the two tangents, at A, to a loop.

In Fig. 3 is shown the complete curve represented by an equation of the form *

$$m\omega + m'\omega' = ma \ldots\ldots\ldots\ldots\ldots (2).$$

The parts are traced in the order indicated by the numbers. Parts 4 and 5 form a *branch* which passes through A', the remaining parts form *branches* which pass through A.

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* If ω can have values ranging only from a to θ, equation (2) accounts only for the lines of force that proceed from the charge m. In order to account for the lines of force that proceed from charge m' we must interchange m and m' in equation (2) and count angles in the opposite direction.

In order to investigate the curve for asymptotes put for the

1st position of parallelism	$\omega' = \omega$,
2nd " " "	$\omega' = \omega + \pi$,
nth " " "	$\omega' = \omega + (n-1)\pi$.

For the nth position of parallelism equation (2) becomes

$$\omega_0 = \frac{m}{m+m'} a - \frac{m'}{m+m'} (n-1)\pi \ldots (21).$$

To investigate the curve for tangents at A put for the

1st tangent	$\omega' = 0$,
2nd "	$\omega' = \pi$,
n_1th "	$\omega' = (n_1 - 1)\pi$.

For the n_1th tangent equation (2) becomes

$$\omega_t = a - \frac{m'}{m} (n_1 - 1)\pi \ldots\ldots\ldots (22).$$

To investigate the curve for tangents at A' put for the

1st tangent	$\omega = 0$,
2nd "	$\omega = \pi$,
n_2th "	$\omega = (n_2 - 1)\pi$.

For the n_2th tangent equation (2) becomes

$$\omega_t' = \frac{m}{m'} a - \frac{m}{m'} (n_2 - 1)\pi \ldots\ldots\ldots\ldots (23).$$

Equations (21), (22), and (23) show that

the number of branches passing through A is m,
" " " " " A' is m',
" " " asymptotes is $m + m'$,
" angle at A between adjacent branches is $\frac{\pi}{m}$,
" " " A' " " " " $\frac{\pi}{m'}$,
" " " O " " asymptotes " $\frac{\pi}{m+m'}$.

The dashed line (Fig. 3) is the limiting line, and separates the region having branches passing through A, from that having branches passing through A'.

The angle which the asymptote to the limiting line makes with OA is by equation (13)

$$\frac{m}{m+m'}\pi = \pi - \frac{m'}{m+m'}\pi,$$

in which $\frac{m'}{m+m'}\pi$ is the angle which the asymptotes to a branch passing through A', make with each other.

(*b*) *The curve representing a line of force proceeding from a system consisting of two electrified points, is the locus of the intersection of two straight lines rotating in the same plane about parallel axes, passing through those points, in such a manner that the versines of their angles of inclination to the plane of the axes change at uniform but different rates.*

Suppose A and A' (Fig. 1) to be the centres of two small spherical conductors having charges $+m$ and $-m'$, respectively. The number of lines of force leaving the mass m through the circular cone whose vertex is at A and whose semi-angle is ω is

$$N = 2\pi m\,(1 - \cos\omega).$$

The number of lines of force converging to $-m'$ through the circular cone whose vertex is at A' and whose semi-angle is ω' is

$$N' = 2\pi m'\,(1 - \cos\omega').$$

The number of lines proceeding to the right through the circle of intersection of the two co-axial cones is

$$N - N' = 2\pi m\,(1 - \cos\omega) - 2\pi m'\,(1 - \cos\omega').$$

The locus of all such circles of intersection is a tube of force, and the meridian curve of such a tube must be a line of force. If in the above equation $\omega' = 0$

$$N - N' = 2\pi m\,(1 - \cos\omega) = 2\pi m\,(1 - \cos a),$$

in which a is the special value of ω for which $\omega' = 0$. Combining the last two equations gives

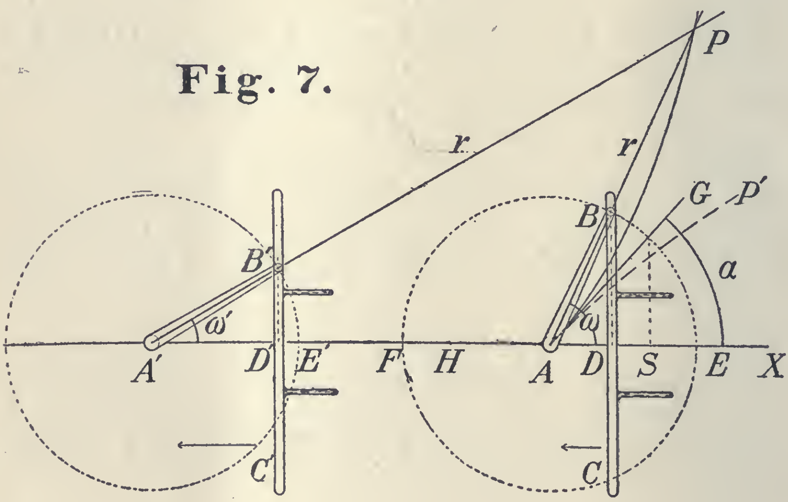
$$m\,(1 - \cos\omega) - m'\,(1 - \cos\omega') = m\,(1 - \cos a)\,..(24).$$

This is the equation of a line of force. Its direction at A makes an angle a with AX. When A and A' have charges of like sign the equation of a line of force is

$$m\,(1 - \cos\omega) + m'\,(1 - \cos\omega') = m\,(1 - \cos a)\,..(25).$$

Equations (24) and (25) were obtained from electrical considerations. In what follows it will be shown how they can be obtained from geometrical considerations.

Fig. 7.



In Fig. 7 suppose A and A' to be the traces of two axes of rotation, each perpendicular to the plane of the paper. AP and $A'P$ are two lines in the plane of the paper, which rotate in such a manner that the versines of the angles PAX and $PA'X$ change at uniform rates. This can be brought about mechanically by making AP and $A'P$ the centre lines or axes of two equal cranks AB and $A'B'$, each of which is driven by a separate slotted crosshead whose slot is perpendicular to, and whose motion is parallel to, $A'AX$. The cross-

head BC which moves the line AP, has a linear velocity m_1, and the crosshead $B'C'$ which moves line $A'P$, has a velocity m'_1, such that $\frac{m'_1}{m_1} = K$, a constant. If the crossheads move in the same direction, (as shown in the figure by the arrows) and $B'C'$ starts from the beginning E' of its stroke when BC starts from a position S at a distance ES from the beginning of its stroke, and D and D' are the respective positions of the crossheads for a general point P,
then, from the figure,

$$E'D' = K\left(ED - ES\right),$$

or

$$A'B' \text{ versin } PA'X = \frac{m'_1}{m_1} AB\left(\text{versin } PAX - \text{versin } GAX\right),$$

$$b\,(1 - \cos\omega') = b\frac{m'_1}{m_1}\Big((1 - \cos\omega) - (1 - \cos a)\Big),$$

in which

$$\omega' = \angle PA'X,\ \omega = \angle PAX,$$

$$a = \angle GAX, \text{ and } b = AB = A'B'.$$

The above equation reduces to

$$m'_1\,(1 - \cos\omega) - m_1\,(1 - \cos\omega') = m'_1(1 - \cos a)..(26).$$

When the crossheads move so as to make the lines rotate in opposite directions, the locus of the point of intersection P' is

$$m'_1\,(1 - \cos\omega) + m_1\,(1 - \cos\omega') = m'_1\,(1 - \cos a)..(27).$$

Equations (24) and (26) have the same form, but the primed constants are interchanged. This shows that the curve representing a line of force proceeding from a system consisting of two electrified points having charges of *opposite algebraic sign*, is the locus of the intersection of two straight lines rotating in the same plane about parallel axes (passing through these points) in such a manner that the versines of their angles of inclination to the plane of the axes *both increase* or *both decrease* at uniform rates; also, that the charges on the electrified points are, numerically, inversely proportional to the rates of change of the versines.

Equations (25) and (27) have the same form, and in this case also the primed constants are interchanged. This shows that the curve representing a line of force proceeding from a system consisting of two electrified points, having charges of *the same algebraic sign*, is the locus of the intersection of two straight lines rotating in the same plane about parallel axes (passing through these points), in such a manner that the versine of the angle of inclination of one of the lines to the plane of the axes, *increases or decreases* at a uniform rate, while the versine of the angle of inclination to the plane of the axes of the other line, *decreases or increases* at a uniform rate; also, that the charges on the electrified points are, numerically, inversely proportional to the rates of change of the versines.

Fig. 8.

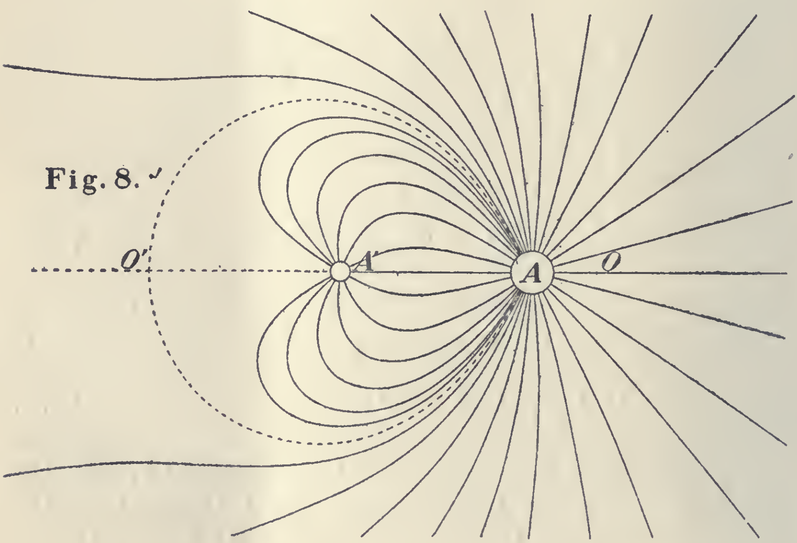


Fig. 8 shows the lines of force proceeding from a system consisting of two electrified points A and A' having charges

$m = 4$ and $-m' = -1$, respectively; and Fig. 9 shows a few of the lines of force proceeding from a system consisting of

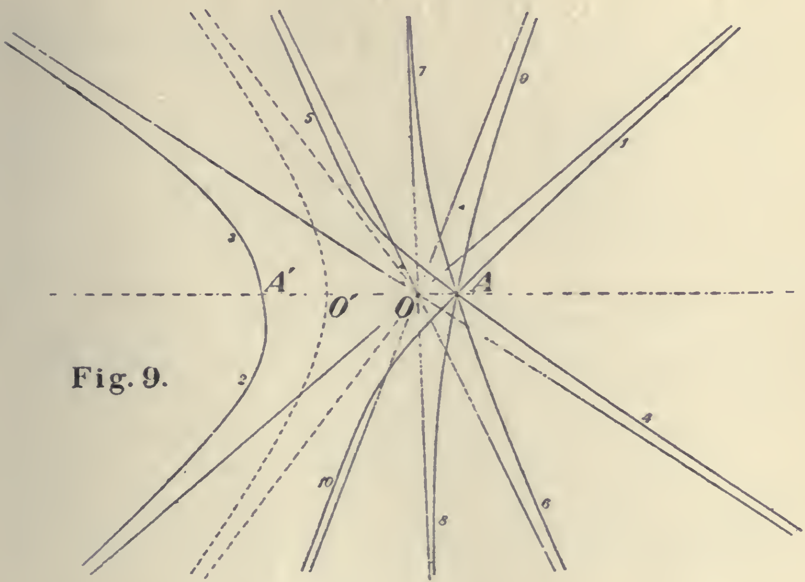


Fig. 9.

two electrified points A and A' having charges $m = 4$ and $m' = 1$ respectively.

If $m = m'$, numerically, equation (24) becomes

$$(1 - \cos \omega) - (1 - \cos \omega') = 1 - \cos a$$

or

$$\cos \omega' - \cos \omega = 1 - \cos a \ldots\ldots\ldots\ldots (28).$$

This is the equation of a closed curve passing through A and A'. A line of force is only an arc of this curve.

If $\omega = \omega' = \theta$, then, from equation (24),

$$\text{versin } \theta = 1 - \cos \theta = \frac{m}{m - m'} (1 - \cos a) \ldots (29).$$

This determines the direction of the asymptote to a line of force.

The asymptote passes through the centre of gravity of the masses m and $-m'$.

In order to show this draw a tangent PT to a line of force AP at a point P. (Fig. 4.) Also draw the two radii vectores $AP = r$ and $A'P = r'$, and the two polar subtangents AT and $A'T'$.

Then from the figure

$$AT = AP\ tan\ TPA = r\ tan\ \psi = \frac{r^2\, d\omega}{dr},$$

and

$$A'T' = A'P\ tan\ T'PA' = r'\ tan\ \psi' = \frac{r'^2\, d\omega'}{dr'}.$$

Whence

$$\frac{AT}{A'T'} = \frac{r^2\, dr'\, d\omega}{r'^2\, dr\, d\omega'}.$$

Differentiating equation (24),

$$\frac{sin\ \omega\ \ d\omega}{sin\ \omega'\ d\omega'} = \frac{m'}{m}.$$

But

$$\frac{sin\ \omega}{sin\ \omega'} = \frac{r'}{r}$$

$$\therefore \frac{AT}{A'T'} = \frac{r^2\, dr'\, d\omega}{r'^2\, dr\, d\omega'} = \frac{r^3\, dr'}{r'^3\, dr}\,\frac{m'}{m}.$$

In the limit, when $r = r'$,

$$\frac{AT}{A'T'} = \frac{AO}{A'O} = \frac{m'}{m}$$

or

$$AO \times m = A'O \times m' \ldots\ldots\ldots\ldots (30).$$

O is the point where the asymptote cuts $A'A$ produced. Equation (30) shows that the moments taken about O are equal. Hence O is the centre of gravity.

The angle θ, equation (29), can not exceed π;

and when $\theta = \pi$,

$$versin\ a_0 = 1 - \cos a_0$$

$$= \frac{m - m'}{m} (1 - \cos \pi) = 2 \frac{m - m'}{m} \ldots . (31).$$

Putting this value of a in equation (24) gives

$$m (1 - \cos \omega) - m' (1 - \cos \omega') = 2 (m - m')$$

or

$$m' \cos \omega' - m \cos \omega = m - m' \ldots\ldots\ldots . (32).$$

This is the equation of the limiting or critical line.

If $m = m'$, numerically, equation (25) becomes

$$1 - \cos \omega + (1 - \cos \omega') = 1 - \cos a$$

or

$$\cos \omega + \cos \omega' = \cos a + 1 \ldots\ldots\ldots . (33).$$

If $\omega = \omega' = \theta$

$$versin\ \theta = 1 - \cos \theta = \frac{m}{m + m'} (1 - \cos a) .. (34).$$

This gives the direction of the asymptote.

In this case also may be shown, as before, that the asymptote passes through the centre of gravity of the masses m and m'.

The angle a can not exceed π, and when $a = \pi$, equation (25) becomes

$$m (1 - \cos \omega) + m' (1 - \cos \omega') = 2m$$

or

$$m \cos \omega + m' \cos \omega' = -(m - m') \ldots\ldots . (35).$$

This is the equation of the limiting or critical line; it cuts $A'A$ (Fig. 9) in O', a point at which the repulsion due to m equals that due to m'.

If $m = m'$ in equation (35),

$$\cos \omega' = -\cos \omega = \cos (\pi - \omega)$$

or

$$\omega' = \pi - \omega \dots\dots\dots\dots\dots\dots (36).$$

This is the equation of the perpendicular bisector to $A'A$.

If in this case also we assume that the rotating lines extend in both directions from their axes, and that ω and ω' can have any values from minus infinity to plus infinity, we will get results analogous to those reached in case (a). It will be convenient in the following discussion to designate by the word *travel* (for short, *trav*) the distance moved through by the slotted cross-head while the crank moves through a corresponding angle. This word (*travel*) may be used as an angular function. Thus, by *trav* 240°, is to be understood the whole distance traveled by the crosshead in moving the crank from a position of coincidence with AX (Fig. 7) to a position making an angle 240° with AX. $Trav\ \omega = versin\ \omega$ when $\omega < \pi$. Equation (24) when written in the form

$$m\ trav\ \omega - m'\ trav\ \omega' = m\ versin\ a \dots\dots\dots (37)$$

is the equation of a curve which may have a number of loops and infinite branches, depending upon the relative values of m and m', and equation (25) when written in the form

$$m\ trav\ \omega + m'\ trav\ \omega' = m\ versin\ a \dots\dots\dots (38)$$

is the equation of a curve which may have, depending upon the relative values of m and m', a number of infinite branches, of which some pass through A, and the rest through A'.

In order to investigate the curve represented by equation (37) for asymptotes, put for the first position of parallelism

$$\omega' = \omega, \qquad \text{or} \qquad trav\ \omega' = trav\ \omega,$$

for the 2nd,

$$\omega' = \omega + \pi, \text{ or } trav\ \omega' = trav\ \omega + s,$$

for the n^{th},

$$\omega' = \omega + (n-1)\pi, \text{ or } trav\,\omega' = trav\,\omega + (n-1)s,$$

in which s is the stroke and n is an integer. Then, for the n^{th} position of parallelism

$$trav\,\omega_0 = \frac{m}{m-m'} versin\,a + \frac{m'}{m-m'}(n-1)s \ldots\ldots (39),$$

which is analogous to equation (18).

To investigate the curve for tangents at A, put for the

1^{st} tangent	$\omega' = 0,$	or $trav\,\omega' = 0$
2^{nd} "	$\omega' = \pi,$	or $trav\,\omega' = s$
n_1^{th} "	$\omega' = (n_1-1)\pi,$	or $trav\,\omega' = (n_1-1)s.$

Then, for the n_1^{th} tangent at A

$$trav\,\omega_t = versin\,a + \frac{m'}{m}(n_1-1)s \ldots\ldots\ldots (40),$$

which is analogous to equation (19).

To investigate the curve for tangents at A', put for the

1^{st} tangent	$\omega = 0,$	or $trav\,\omega = 0$
2^{nd} "	$\omega = \pi,$	or $trav\,\omega = s$
n_2^{th} "	$\omega = (n_2-1)\pi,$	or $trav\,\omega = (n_2-1)s.$

Then for the n_2^{th} tangent at A'

$$trav\,\omega_t' = -\frac{m}{m'} versin\,a + \frac{m}{m'}(n_2-1)s \ldots\ldots\ldots (41),$$

which is analogous to equation (20).

Equations (39), (40), and (41) show, in a manner similar to that shown in case (a), that

the number of tangents at A is m,
" " " loops is m',
" " " asymptotes is $m - m'$.

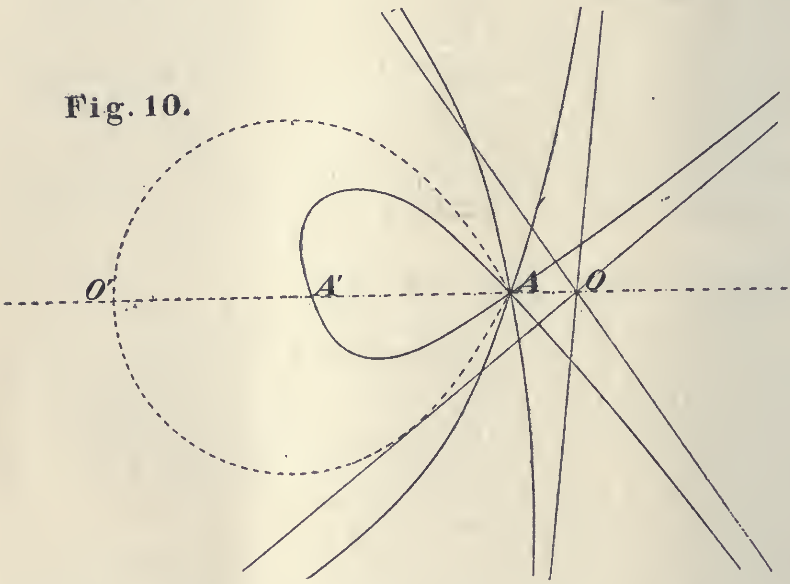
They further show, that

the difference in *trav* (used as an angular function) between the angles made with $A'AX$ by two adjacent tangents at A is $\frac{s}{m}$,

the difference in *trav* between the angles made with $A'AX$ by two adjacent tangents at A' is $\frac{s}{m'}$,

the difference in *trav* between the angles made with $A'AX$ by two adjacent asymptotes is $\frac{s}{m - m'}$.

Fig. 10.



In Fig. 10, where $m = 4$ and $-m' = -1$,

the number of tangents at A is	$m = 4$,
" " " " " A' "	$m' = 1$,
" " " asymptotes "	$m - m' = 3$.

In order to investigate the curve represented by equation (38) for asymptotes, put for the first position of parallelism

$$\omega' = \omega, \text{ or } trav\ \omega' = trav\ \omega,$$

for the 2nd,

$$\omega' = \omega + \pi, \qquad \text{or } trav\ \omega' = trav\ \omega + s,$$

for the nth,

$$\omega' = \omega + (n - 1)\,\pi, \text{ or } trav\ \omega' = trav\ \omega + (n - 1)\,s.$$

Then, for the nth position of parallelism

$$trav\ \omega_0 = \frac{m}{m + m'}\ versin\ a - \frac{m'}{m + m'}, (n - 1)\ s. (42),$$

which is analogous to equation (21).

To investigate the curve for tangents at A, put for the

1st tangent	$\omega' = 0$,	or $trav\ \omega' = 0$,
2nd "	$\omega' = \pi$,	or $trav\ \omega' = s$,
n_1th "	$\omega' = (n_1 - 1)\,\pi$,	or $trav\ \omega' = (n_1 - 1)\,s$.

Then, for the n_1th tangent at A

$$trav\ \omega_t = versin\ a - \frac{m'}{m}\,(n_1 - 1)\ s \ldots\ldots (43),$$

which is analogous to equation (22).

To investigate the curve for tangents at A', put for the

1st tangent	$\omega = 0$,	or $trav\ \omega = 0$,
2nd "	$\omega = \pi$,	or $trav\ \omega = s$,
n_2th "	$\omega = (n_2 - 1)\,\pi$,	or $trav\ \omega = (n_2 - 1)\,s$.

Then, for the n_2th tangent at A'

$$trav\ \omega'_t = \frac{m}{m'}\ versin\ a - \frac{m}{m'}\,(n_2 - 1)\ s \ldots (44),$$

which is analogous to equation (23).

Equations (42), (43), and (44) show, in a manner similar to that shown in case (a), that

the number of branches passing through A is m,
" " " branches passing through A' is m',
" " " asymptotes is $m + m'$,
the difference in *trav* between the angles made with $A'AX$ by two adjacent tangents at A is $\frac{s}{m}$,
the difference in *trav* between the angles made with $A'AX$ by two adjacent tangents at A' is $\frac{s}{m'}$,
the difference in *trav* between the angles made with $A'AX$ by two adjacent asymptotes is $\frac{s}{m + m'}$.

In Fig. 9, where $m = 4$ and $m' = 1$,

the number of tangents at A is $m = 4$,
" " " " " A' is $m' = 1$,
" " " asymptotes is $m + m' = 5$.

Issued June 30, 1896.

A STUDY OF THE KANSAS USTILAGINEAE, ESPECIALLY WITH REGARD TO THEIR GERMINATION.*

J. B. S. NORTON.

The *Ustilagineae* in Kansas are represented by the genera *Ustilago*, *Tilletia*, *Entyloma*, *Sorosporium*, *Urocystis*, and *Doassansia*. The above generic names are arranged in order of their number of representing species. Far the greater number of our 33 species belong to the genus *Ustilago*.

Scarcely enough data have been collected to show much regarding the distribution in the State. I have given the localities known except where the species is a very common one.

A few words in explanation of my objects, and methods of research in these studies will be necessary. The study has been primarily the germination of the teleutospores, and confined principally to the genus *Ustilago;* but the intention is to give as complete a list as possible of all the species of *Ustilagineae* known to occur in the State, and something of their distribution. Other observations of more or less interest and importance have been added, especially the effect of the fungus on the host plant.

The most of the work was done in the botanical laboratory of the Kansas Agricultural College, the finishing touches being added at the Missouri Botanical Garden. The list is based on specimens in the herbarium of the former, and the collections of the author. The advantages offered by the excellent collections of *Ustilagineae* in the College herbarium, and the Experiment Station library abounding in works on smuts are almost as good as one need wish for.

The material used for germination I have collected mostly about Manhattan, Kan., during the last two years.

The germination has for the most part been made in hanging drop cultures, and kept in a large moist-chamber to

* Read before The Academy of Science of St. Louis, October 19th, 1896.

secure a more equal temperature and supply of moisture. The temperature of the room has not varied much from 70° F.

Cultures of most of the smuts have been made both in water and in nutrient solutions. I have used almost always the modified Cohn solution or Pasteur solution used by Kellerman and Swingle,* and others, for this purpose, and sometimes a decoction of manure such as Brefeld used in most of his cultures of the *Ustilagineae*. Usually check cultures of corn smut were made with the others in order to detect any irregularities in them. The corn smut being common and its germination well known it was well adapted to be used as a standard.

The drawings have been rather carefully made and are not intended simply to illustrate the descriptions, but to be equally prominent with them. Indeed they may show more sometimes than I have attempted to write.

The nomenclature used is mostly that of Saccardo's Sylloge Fungorum and the arrangement much the same with the newer species added at the end. Wherever possible I have looked up the citations to original descriptions and compared them with the specimens, indicating them thus (!).

I have considered it unnecessary to describe germinations by other investigators where I have not repeated them myself, but in most cases have indicated the literature where previous germinations are recorded.

I am indebted to Prof. Hitchcock of the Kansas Agricultural College, with whom I have done most of this work, and to Dr. Trelease of the Missouri Botanical Garden, for suggestions and advice and for kindly supplying facilities which have made it possible to do the work here presented. I also wish to thank Prof. J. B. Ellis, Mr. Elam Bartholomew of Rockport, Kan., and Mr. George L. Clothier, my successor as assistant botanist in the Kansas Experiment Station, and others for the interest they have shown in sending me specimens and communicating notes of value in connection with my studies.

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* Second Annual Rept. Kas. Exp. Sta., p. 230.

I. USTILAGO.

1. U. Sorghi (Link) Pass., Thüm. Herb. Myc. Oec., n. 63. (Plate XXV. 1–5.)

Common on cultivated *Sorghum* sp.; on Kaffir corn, Manhattan (Kellerman); and on broom corn, Phillipsburg; also reported from other places on the latter. The smut usually fills every ovary on the affected plants, which are smaller than unsmutted ones.

The spores germinate in water in six or eight hours and produce promycelia 20–35 μ long and about 6 μ wide. In many cases where the water supply was not so abundant, long germ-tubes narrower than the promycelium and 500 or more μ long, were produced, the protoplasm following the end and the remainder of the tube divided by septa into cells about three diameters long. Knee joints occur in abundance and there were also a few bow joints. Conidia few.

In nutrient solutions each germinated spore is soon surrounded by a mass of extensively branched promycelia bearing many conidia. No germ-tubes or fusions are produced until the solution becomes exhausted, then long threads grow out from the promycelia and conidia as in water.

2. U. Ischaemi Fuckel, Enum. Fung. Nass., p. 22.

In the deformed inflorescence of *Andropogon provincialis*. The stems are shortened and the smutted flowers inclosed in the upper leaf sheath. The specimens are from Mr. Bartholomew of Rooks Co. He says the smut is undoubtedly perennial as it appears from year to year on a single plant on his farm.

I have not tried germination as all my material is several years old. The germination is described and figured by Brefeld.*

3. U. Austro-Americana Speg., Fungi Argentini, IV. n. 45, p. 10. (!) (Plate XXVIII. 9–12.)

Forming large hard masses in the inflorescence of *Poly-*

* Untersuchungen, V. p. 961, T. XI. f. 1–2.

gonum Pennsylvanicum, Riley and Republic counties. The spores are surrounded by a gelatinous envelope which binds them together when it hardens.

The germination in water begins after a day or two and proceeds slowly. The promycelia are small and slender, frequently branched, and irregular in shape. Conidia few.

4. U. Avenae (Pers.) Jensen, Le Charbon des Céréales, p. 4. (!)

Common on oats.

The germination of this species and the other loose smuts of the small grains (*U. laevis*, *U. Hordei*, *U. nuda*, and *U. Tritici*) has been quite fully studied and described by Kellerman and Swingle in the Second Annual Report of the Kansas Experiment Station.

5. U. laevis (K. & S.) P. Magnus, Ust. Provinz Brandenburg, p. 69. (!)

On oats, not so common as the above.

6. U. Hordei (Pers.) K. & S., Second Ann. Rept. Kans. Exp. Station.

On barley, Manhattan.

7. U. nuda (Jensen) K. & S., Second Ann. Rept. Kans. Exp. Station.

On barley, Coolidge.

8. U. Tritici (Pers.) Jensen, Second Ann. Rept. Kans. Exp. Station.

Common on wheat all over the State.

9. U. Aristidae Peck, Bull. Torr. Bot. Club, XII. p. 35. (!) (Plate XXV. 19–23.)

On *Aristida* (*purpurea?*), Hodgeman and Ellis counties. The smut fills the ovaries, and the awns are much shorter than usual and so changed that the species could not be recognized.

Germination begins almost immediately in water. After four hours a promycelium 10–12 μ long was produced. This grows rapidly for 8 or 10 hours until 30 or 40 μ long, then a conidium is formed at the apex, 3 or 4 septa appear in the promycelium and a part of the protoplasm in each cell thus formed passes into a lateral conidium at its upper end leaving a vacuole at the end next the spore. The conidia soon become detached.

In nutrient solutions the germination is much similar but slower and more vigorous.

10. U. SPERMOPHORA Berk. & Curt., Curt. Cat. N. Car., p. 123.

In the enlarged ovaries of *Eragrostis major*. In the specimens I have seen, only a few of the ovaries are smutted in each inflorescence and not the whole panicle as in most smuts of this kind.

Attempts at germination unsuccessful.

11. U. VILFAE Wint., Bull. Torr. Bot. Club, X. p. 7. (!)

Destroying the inflorescence of *Sporobolus vaginaeflorus*. Found at Manhattan, Dec., 1895.

Cultures of spores failed to germinate.

12. U. RABENHORSTIANA Kühn, Hedwigia, 1876, p. 4. (!) (Plate XXVII. 6–8, and XXVI. 4, 5.)

Common in the inflorescence of *Panicum sanguinale* and less often on *P. glabrum*. Every branch of the plant is usually smutted, a good evidence of early infection. On the latter host often only a portion of the inflorescence is infested. The smut dwarfs the host plant and causes it to branch more than normally.

No germination in water. In nutrient solutions the growth is vigorous and the promycelium branched often and irregularly, not septate, no conidia. Germinated by Kühn and Brefeld. Kühn gives figures of the germination in Rabenhorst's Fungi Europaei, Cent. 21.

13. U. REILIANA Kühn, Rabenh. Fungi Europaei, No. 1998. (!) (Plate XXV. 14–18.)

On *Sorghum* sp., Manhattan; and on *Zea Mays*, Riley, Morris, Saline, Jewell, and Geary counties; rather common.

I have already described the general appearance and effect on the latter host in a note in the Botanical Gazette, Oct. 1895.

Germination in water after 24 hours. The promycelium is medium sized, grows little and bears few conidia.

In nutrient solutions germination takes place after two or three days. The promycelium is almost as wide at the base as the spore, and bears large yeast-like colonies of conidia. The conidia are short and oval. Germination by Brefeld* and Kühn.

The spores are aggregated in masses and this species seems much like a *Sorosporium*, but until further studies of the development I have left it here.

14. U. NEGLECTA Niessl, Rab. Fungi Europ., no. 1200. (Plate XXVIII. 7, 8.)

On *Setaria glauca*, Manhattan. The smut does not affect the outward appearance of the host plant except to slightly enlarge the ovaries.

Germination usually unsuccessful. In one culture on glass plate in nutrient solution some spores at the edge of a large drop had germinated as shown in fig. 8. They could not be seen with the high power objective without displacing them but the liquid near was full of detached conidia (?) (fig. 7). These may, however, have been from some yeast in the culture. None of the spores farther from the edge showed germination.

15. U. MAYS ZEAE (DC.) Magnus, Ust. Prov. Brand., p. 72. (Plate XXV. 6–13.)

Common on all parts of *Zea Mays*, everywhere.

Germination begins in water in 18–24 hours. The promycelium is 3 or 4 celled and often bears numerous conidia, usually 2–4. The conidia are fusiform and easily detached. The whole promycelium is often detached a short distance from the spore in a few hours after production. Air conidia are abundant in dryer cultures. Fresh spores germinate very

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* Untersuchungen, V. p. 94.

readily and quickly in water even before they are quite ripe. I have found the germination in pure water much better than is described by Brefeld and others. The germination of this species is described by Brefeld,* Wolff,† and Kühn.‡

16. U. SYNTHERISMAE (Schw.) Ell. & Ev., N. A. Fungi, no. 1890.

Under this name I have placed provisionally several smuts which are much alike yet different in many ways and occupying different hosts. Those on *Panicum capillare* and *P. proliferum* I have no doubt are the same and they answer the descriptions of *U. Syntherismae* best. The smut on *Cenchrus* is different in form and size of spores and in germination, yet I am not prepared to say that it is not *U. Syntherismae*, the only smut described on this host. The smut on *Andropogon scoparius* seems to be *U. Syntherismae*, but in the germination, which, however, was under unfavorable conditions and only took place in one instance, is different from that on other hosts.

In the greatly enlarged ovaries or the whole inflorescence of *Cenchrus tribuloides* (Plate XXVI. 11–13; XXVII. 1, 2). Common all over the State. The stems of the host plant are shortened and the enlarged ovaries or inflorescence, covered with a yellowish or white membrane, project from or are enclosed by the upper leaf-sheath. If the plant is not badly affected the glumes and other floral organs grow out into long leaf-like bodies sometimes two or three inches long.

Germination as on all the hosts difficult in water. In a great many cultures only a few spores germinated. In nutrient solutions the germination takes place in one or two days, almost always sooner than in water. Promycelium short and septate, bearing conidia apically or in clusters at the septa or producing germ-tubes without conidia.

In the enclosed inflorescence of *Panicum proliferum* (Plate XXVI. 1, 2, 6–10; XXVII. 3), and *P. capillare* (Plate XXVII. 9–12), rather common on both at Manhattan.

Germination in both water and nutrient solutions usually

* Untersuchungen, V. and X.

† Brand d. Getr., p. 11.

‡ Krankheiten, pp. 36, 54.

by a long, infrequently branched septate promycelium. Knee joints abundant, and producing slender germ-tubes which often fuse with another part of the promycelium. Conidia few, never in nutrient solutions, short and frequently stalked as shown in fig. 11, Plate XXVII.

On *Andropogon scoporius.* One specimen from Manhattan found in a student's herbarium. In the inflorescence, covered by a whitish membrane.

Germination (Plate XXIX. 6–8) by a short promycelium two or three times septate, constricted at the septa and bearing few short thick conidia.

17. U. UTRICULOSA (Nees) Tul., Ust., p. 102.

On *Polygonum acre*, Rooks and Barton counties, and *P. Pennsylvanicum*, Riley. Filling the flowers with a purplish mass of spores. Smutted plants are easily distinguished by the compact appearance of the spikes.

Repeated attempts at germination unsuccessful. Saccardo gives a short description of the germination in the Sylloge Fungorum. Plowright speaks of the difficulty of germination.

18. U. ANDROPOGONIS, Kell. & Swing., Jour. Myc., 1889, p. 12. (!) (Plate XXVI. 14–17.)

Common on *Andropogon provincialis* from several places in the State, and on *A. Hallii*, Arkalon and Harper. The smut causes the host plant to flower several weeks earlier than normally, and the affected plants are about half as high as healthy ones.

No germination in water. In nutrient solutions the spores germinate after two or three days, but produce only an undivided and unbranched tube of moderate length, and no conidia.

19. U. BOUTELOUAE Kell. & Swing., Jour. Myc., 1889, p. 12. (!) (Plate XXIX. 11.)

In ovaries of *Bouteloua oligostachya*, Rooks and Riley counties.

Germination * in water in about 12 hours. A short promycelium is produced in a few hours and soon bears a small conidium on the end and then a few lateral ones. The conidia are short and sometimes stalked. Air conidia produced in older cultures.

20. U. PUSTULATA Tracy & Earle, Bull. Torr. Bot. Club, 1895, p. 175. (!)

On *Panicum proliferum*, Pottawatomie Co. (F. F. Crevacouer.)

Attempted germination was unsuccessful.

21. U. FILIFERA n. sp. (Plate XXVIII. 1, 2, 4–6; Plate XXIX. 1–4, 9, 10.)

On *Bouteloua racemosa* and *B. oligostachya*, Riley and Wabaunsee Co. †

Producing rounded protruding swellings ½–2 mm. wide and 1–12 mm. long on the leaves and sometimes stems of the host plant. Spores irregularly angled, subglobose, dark yellowish brown, rather opaque, black in mass, minutely echinulate, contents granular, $13 \times 15\ \mu$ in diameter.

The germination in water in favorable cases begins in about 12 hours. The usual manner is to form long septate tubes (about $300\ \mu$ long, the cells $2–3\ \mu \times 6–10\ \mu$) which grow rapidly in length for two or three days, these produce a few conidia and usually branch some. The branches near the spore have a tendency to grow backward in a peculiar manner.

In nutrient solutions more abundant conidia are produced. These vary from fusiform to almost spherical. Chains of air conidia were sometimes seen. These conidia vary in length as the others, but are usually shorter. The couidia are at first smaller at the apex, then bud off secondary conidia at the end, grow larger themselves and finally become septate, the whole chain of conidia forming a long irregular branch of short thick cells bearing small conidia at the sides (fig. 9, Plate XXIX.) In old cultures some of these cells become

* See Kell. & Swing., Jour. Myc., 1889, p. 12.

† Specimens also on Bouteloua sp. collected in Mexico in 1880 by Dr. E. Palmer, in Herb. Mo. Botanical Garden.

enlarged and rounded, appearing much like young teleutospores.

The smut has been found well developed the last of April and is probably perennial in the underground parts of the host. Pustules have been found on leaves just emerging from the ground. The affected parts scarcely ever send up flower stalks but when they do the smut occurs in some of the flowers or at the base of the spikelets.*

22. U. MINOR n. sp. (Plate XXVIII. 3; XXIX. 5, 12.)

On leaves of *Bouteloua hirsuta*, Manhattan, rare.

Much like the preceding but spores much smaller, 8–9 μ; contents less homogeneous.

I have examined a large number of plants of the three species of *Bouteloua* growing together, where *B. oligostachya* and *B. racemosa* were much smutted, and in almost every case *hirsuta* was free from smut. So it is quite evident that the smut does not pass from the other two species to *hirsuta*. This together with the great difference in the size of the spores seems to justify the separation of this from *U. filifera* as a distinct species. The germination is about the same as *U. filifera* but though the spores of the latter germinate very easily most of my cultures of *U. minor* have failed to grow.

II. TILLETIA.

23. T. FOETANS (B. & C.) Schröt., Beitr. Biol. Pfl., 1877, p. 365.

On wheat (*Triticum* sp.), common. A few spores of this and the next germinated in water after about a week. Conidia produced fasciculate on the end of the promycelium.

24. T. TRITICI (Bjerk.) Wint., Die Pilze.

On wheat (*Triticum* sp.) Rooks and Greeley counties.

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* Since the above was first written Schröter has described a South American Ustilago (*U. Hieronymi*) on *Bouteloua ciliata*, which is possibly the same.

25. T. Buchloeana K. & S., Jour. Myc., V. p. 11. (!)

In ovaries in the normally staminate spikelets of *Buchloe dactyloides*, Jewell Co. (Miss Dahl), Trego and Ford counties (Kellerman and Swingle).

In the early part of last year while making some germination tests preliminary to infection experiments with corn smut a culture of *Tilletia Buchloeana* was made on a glass slide in a moist chamber from material collected in Jewell Co. the previous summer. This year I have not succeeded in getting the same material to germinate. Unfortunately no drawings of the first were made and only the following note, "after nine days, No. 7, germination good, some show the characteristic conidia of *Tilletia*."

26. T. rotundata (Arth.) Ell. & Ev.*

Collected December, 1895, in ovaries of *Panicum virgatum*, Manhattan, and on herbarium specimen collected by Joseph Henry at Salina in 1886.

Attempted germination unsuccessful.

III. ENTYLOMA.

Owing to lack of suitable fresh material no germination studies of this genus were made.

27. E. Compositarum Farlow, Bot. Gaz., 1883, p. 275.

On leaves of *Ambrosia psilostachya*, Riley and Cloud; *Bidens chrysanthemoides*, Rooks; *Heterotheca Lamarckii*, Rooks; *Senecio Balsamitae*, Riley.

28. E. Menispermi Farl. & Trel., Bot. Gaz., Aug., 1883, p, 275. (!)

Common on leaves of *Menispermum Canadense*.

29. E. Physalidis (Kalchbr. & Cooke) Wint., Hedwigia, 1883, p. 130, and 1884, p. 8. (!)

On *Solanum nigrum*, Riley Co.; *Physalis pubescens*, Riley; *P. longifolia*, Rooks, Riley.

Probably on other *Solanaceae*, in the State.

* By implication in Ell. & Ev., N. A. Fungi, no. 1894, 1887, and so ascribed in Farlow & Seymour's Host Index.

IV. DOASSANSIA.

I have not accurately identified the herbarium material of this genus, and having no fresh material have not attempted germination.

30. D. Alismatis (Nees) Cornu, Ann. Sci. Nat., Ser. 6, XV. (1883), p. 285.

On *Alisma Plantago*, Rooks and Saline Co.; *Sagittaria variabilis*, Riley Co. The one on the last host may be *D. Sagittariae*.*

V. SOROSPORIUM.

31. S. atrum Peck, Bot. Gaz., 1880, p. 35. (!)

On *Carex Pennsylvanica*. Found at Manhattan by Mr. J. E. Payne in 1894.

Germination unsuccessful.

32. S. cuneatum Schofield, Sec. Ed. Webber's Appendix, Cat. Flora Neb. (!) (Plate XXVII. 4, 5.)

In enlarged stems and contracted inflorescence of *Solidago Missouriensis*, Rooks Co.; also in an old *Solidago*, Manhattan.

Germination begins in 12 hours. More or less branched tubes pointed at the ends and septate, a few conidia and in dry cultures long chains of air conidia are produced.

VI. UROCYSTIS.†

33. U. Anemonis (Pers.) Schroet., Beitr. Biol. Pfl., 1877, p. 375.

On leaves of *Anemone Caroliniana*, Rooks Co. (Bartholomew).

No material for germination.

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* A *Doassansia* on *Potamogeton* is reported from Lawrence by Mr. M. A. Barber of the State University and is probably *D. occulta*.

† The specimens on onion bulbs distributed by Mr. Bartholomew from Rooks Co., as *U. magica*, Pass., are an *Aspergillus*. I have compared it with de Thümen's specimens of *U. magica* and find no resemblance between the two.

EXPLANATION OF ILLUSTRATIONS.

Plates XXV. -XXIX.

Plate XXV. — 1–5, *U. Sorghi*, after 24 hours in water, × 600. 6-13, *U. Mays Zeae;* 6–8, germination after 22 hours in water, from fresh material collected in August, 10 days before germination, × 600; 9, part of a colony of budding conidia from one spore, in nutrient solution, × 600; 10, from one-year-old spores, 48 hours in water, × 400; 11, 12, air conidia from cultures in moist air only, on glass plate, × 180; 13, air conidia from culture in manure solution, almost exhausted, × 1000. 14–18, *U. Reiliana*, after 3 days in water, × 600. 19, *U. Aristidae* from edge of culture in nutrient solution. 20–23, Same in water.

Plate XXVI. — 1, 2, Germination of *U. Syntherismae* on *Panicum proliferum*, after several days in nutrient solution, × 500. 3, Spores, *U. Syntherismae* on *Andropogon scoparius*, × 1000. 4, 5, Spores, *U. Rabenhorstiana*, × 1000. 6, 7, Spores, *U. Syntherismae*, on *Panicum proliferum*, × 1000. 8–10, *U. Syntherismae* from *P. proliferum*, germination in water, × 500. 11-13, *U. Syntherismae* from *Cenchrus tribuloides*, germination in nutrient solution, after 3 days, × 500. 14–17, *U. Andropogonis* after 3 days in nutrient solution, × 500.

Plate XXVII. — 1, 2, Spores, *U. Syntherismae* on *Cenchrus tribuloides*, × 1000. 3, *U. Syntherismae*, germination of spore from *Panicum proliferum*, after 5 days in water, × 320. 4, 5, *Sorosporium cuneatum* in water, × 500. 6–8, *U. Rabenhorstiana*, after 3 days in nutrient solution, × 500; 7, much swollen promycelia from both ends of the spore. 9–12, *U. Syntherismae* from *Panicum capillare*, × 500; 9, germination from a mass of spores,— the ends at *a* and *b* curve downward toward the culture drop surface (water); 10, formation of knee joints; 11, shows peculiar stalked conidia; 12, old promycelium with conidia, and germ tubes proceeding from knee-joints at *a* and *b*, the former passing under a mass of spores at *c*.

Plate XXVIII. — 1, *U. filifera* after 4 days in water, × 400. 2, Same species after 48 hours in nutrient solution, × 600. 3, Air conidia (*U. minor*) after 8 days in nutrient solution, spore and ends of long filaments not shown, × 600. 4, 5, *U. filifera*, after 18 hours in water, × 500. 6, Same species, after 46 hours in nutrient solution, not a very vigorous specimen, × 600. 7, Conidia and germinating spore from culture of *U. neglecta* in nutrient material on open glass slide, × 320. 8, Same culture, germinating spores, × 60. 9–12, *U. Austro-Americana,* in water, × 500.

Plate XXIX. — 1, *U. filifera* in inflorescence of *Bouteloua racemosa*. 2, 3, Usual appearance of *U. filamenta* on *B. racemosa*. 4, Same on *B. oligostachya*. 5, *U. minor* on *B. hirsuta*. (1–5, × ½.) 6–8, *U. Syntherismae* on *Andropogon scoparius*, in nutrient solution. 9, Portion of old branch of *U. filifera* from culture in nutrient solution, × 500. 10, Spores of *U. filifera*, × 500. 11, *U. Boutelouae*, old culture in manure decoction, air-conidia grow out in branches at *a*, × 600. 12, Spores of *U. minor*, × 500.

Issued November 9, 1896.

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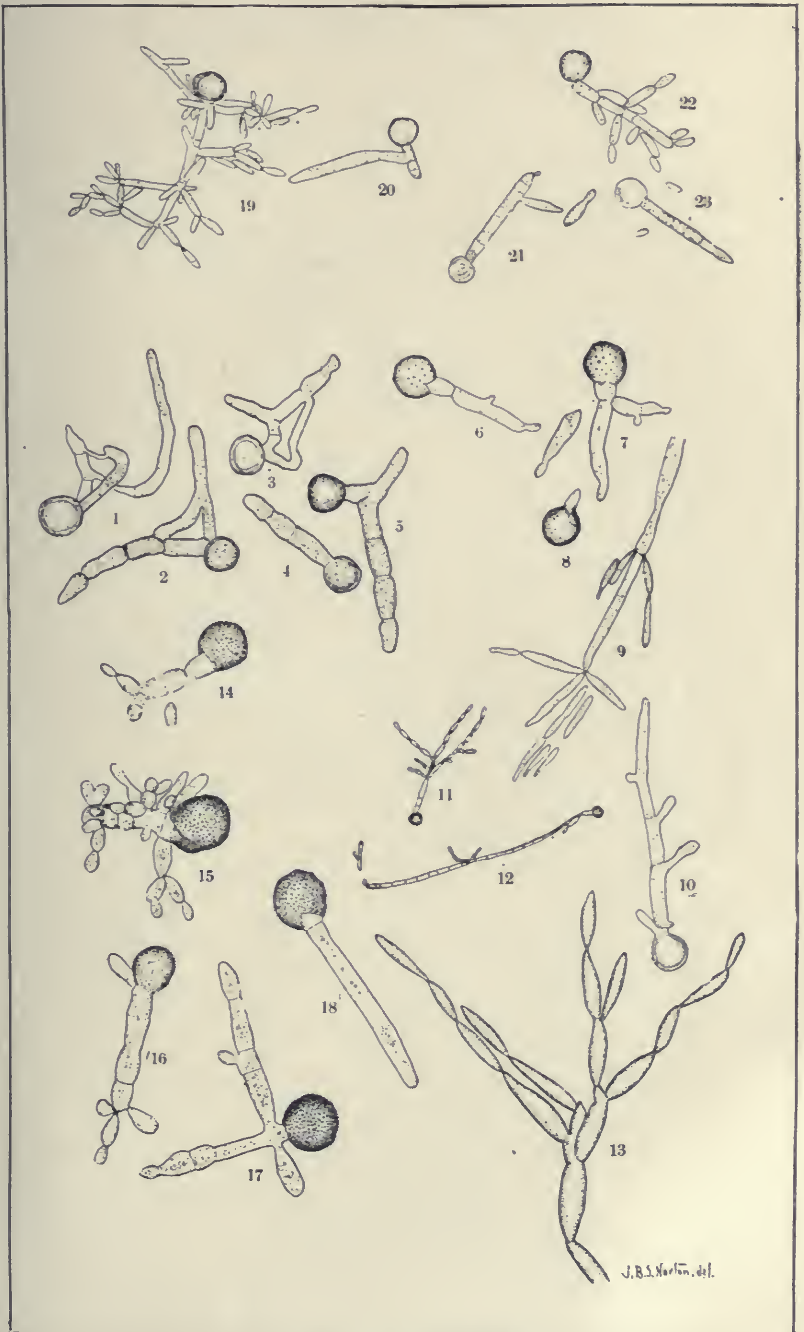
PLATE XXV.



KANSAS USTILAGINEAE.

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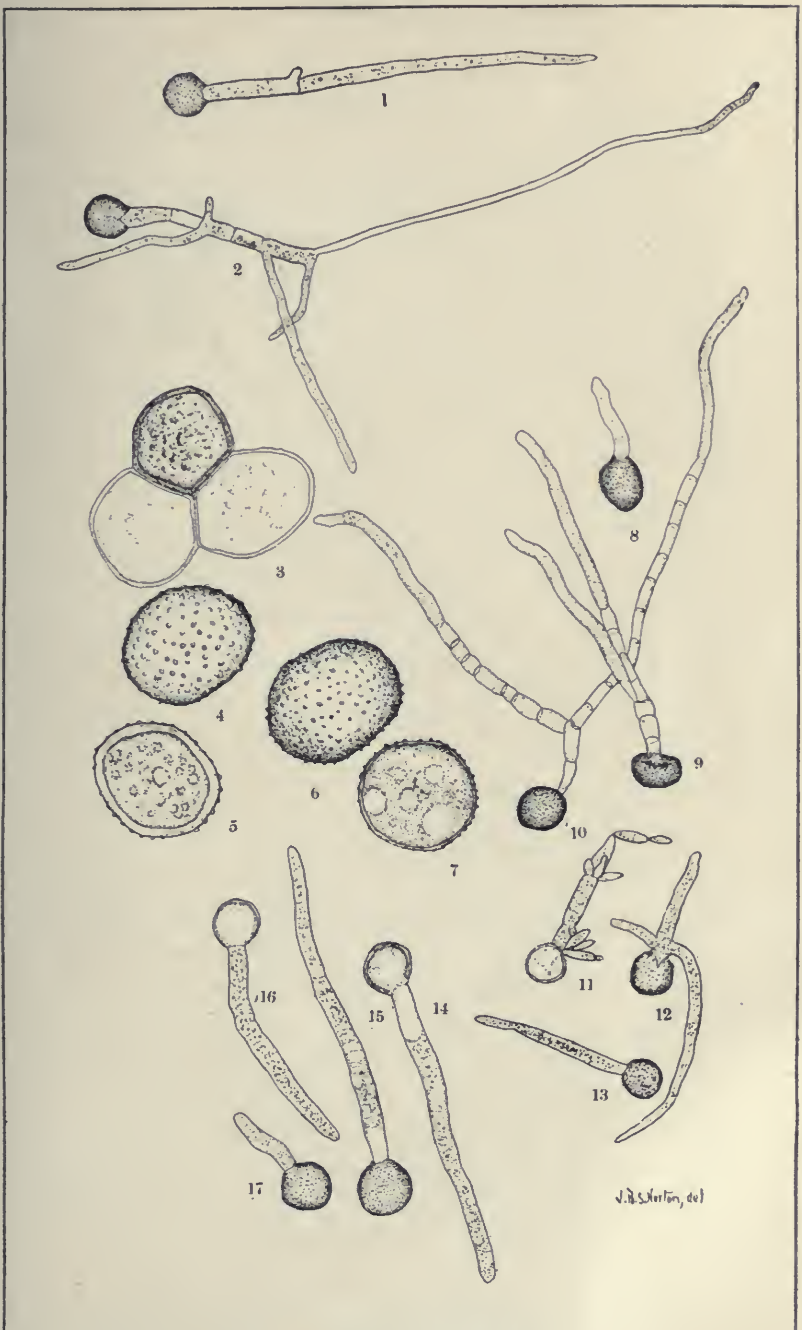
PLATE XXVI.



KANSAS USTILAGINEAE.

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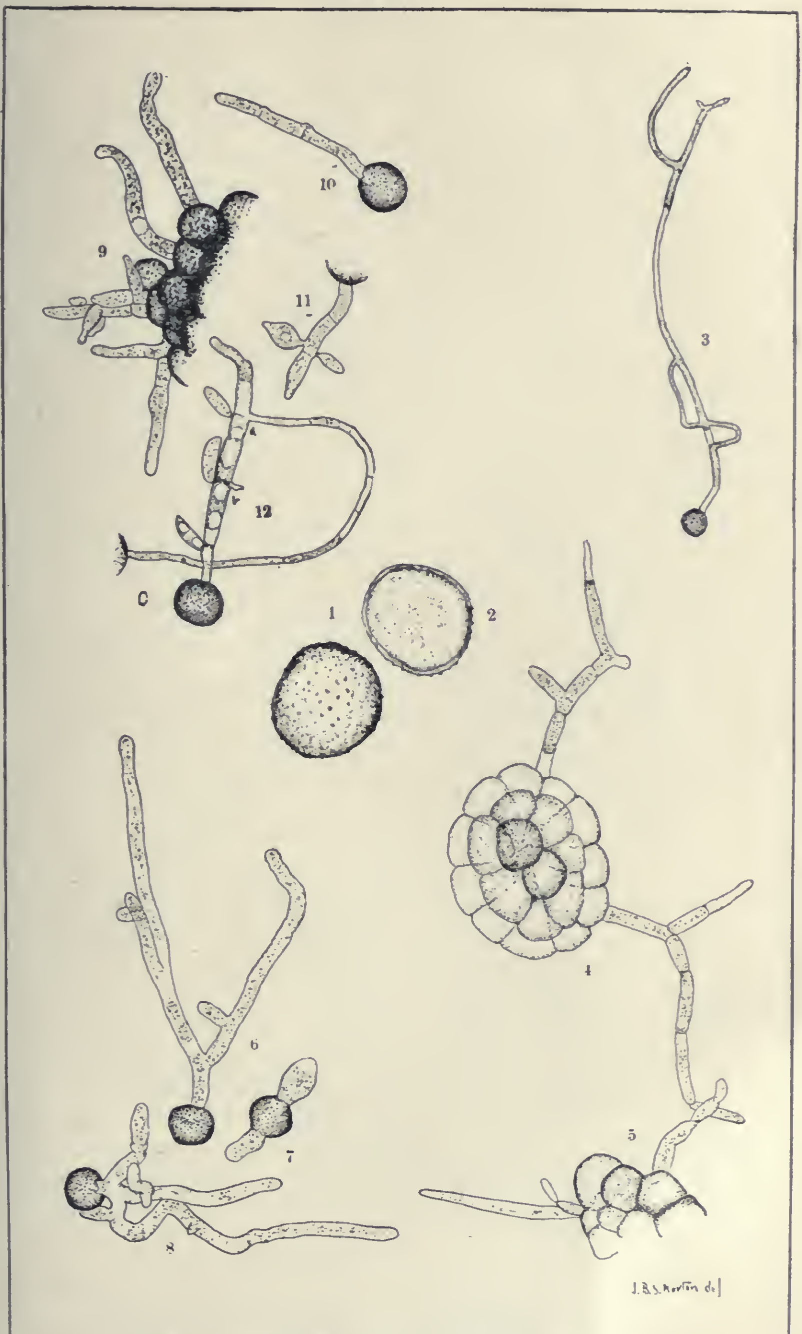
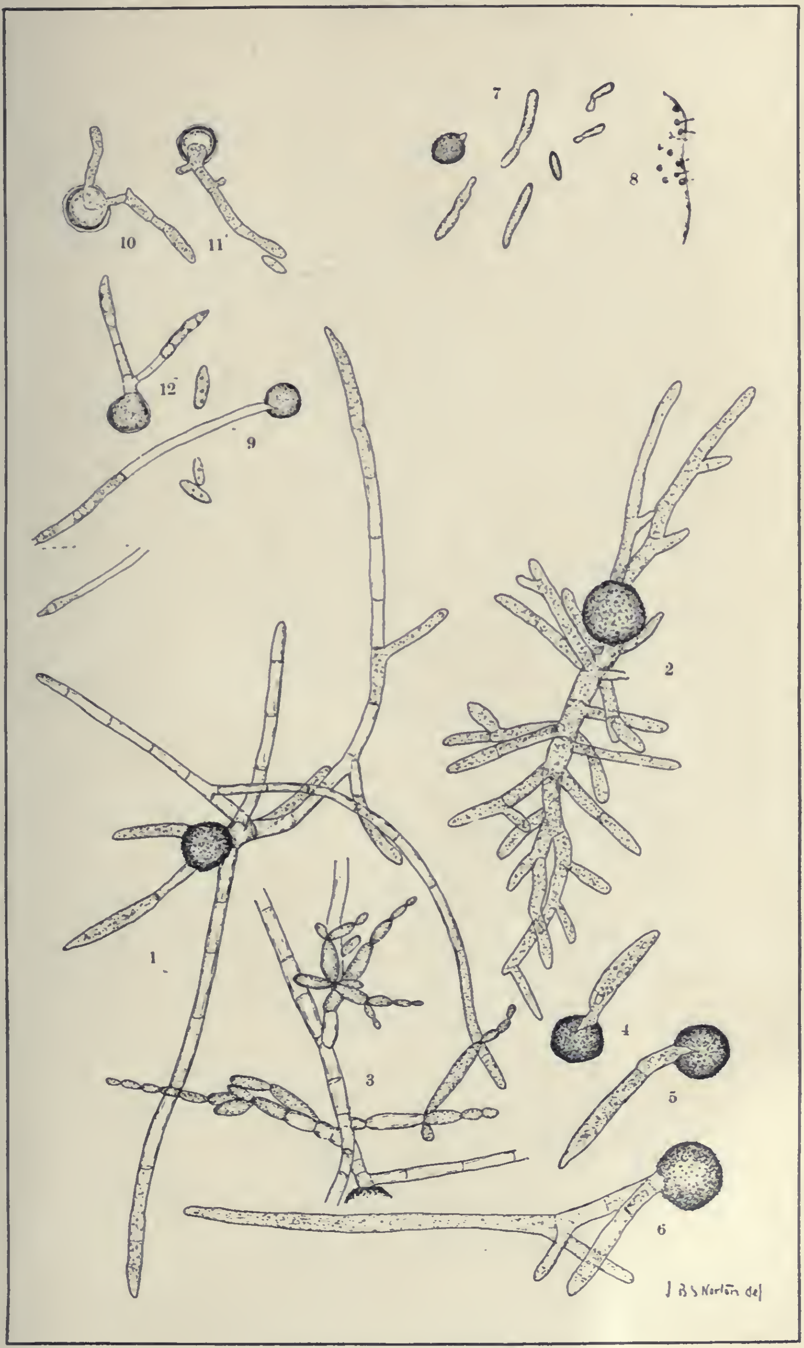
PLATE XXVII.



KANSAS USTILAGINEAE.

PLATE XXVIII.



KANSAS USTILAGINEAE.

PLATE XXIX.

KANSAS USTILAGINEAE.

FLEXURE OF TELESCOPES.*

MILTON UPDEGRAFF.

The lack of perfect rigidity of the materials of which astronomical instruments are constructed has long been recognized as one of the chief sources of the errors to which certain classes of astronomical observations are subject. Instruments of the best construction are designed with a view to avoid as far as possible errors of flexure, and in a good instrument the linear displacement of any part due to flexure is very small. But, nevertheless, in the use of telescopes in connection with divided circles for the measurement of large angles, the flexures of the telescope tube, of the circles and of the axes about which they revolve, are often appreciable even in instruments of the very best construction.

The errors of flexure arise through distortion of the divided circles and angular displacement of the line of collimation of the telescope with reference to the zero-points of the circles. The telescope tube being supported (as should always be the case) at the middle point of its length, if the deflections of the two halves of the tube are equal and in the same direction, the line of collimation will suffer no angular displacement. But if the absolute flexures of the two halves of the tube are unequal or not parallel, the line of collimation will be shifted to a position not parallel to its normal or undisturbed position and this angular displacement is called the astronomical flexure. Flexure of the axes, also, may cause angular displacement of the line of collimation.

Let us adopt as the undisturbed position of the line of collimation, with reference to the divisions of the circles, the position assumed when the line of collimation is directed to the nadir. Then suppose the telescope turned until the line

* Read in less extended form before The Academy of Science of St. Louis, June 1, 1896.

of collimation is directed to the star s, Fig. 1. If there were no astronomical flexure, the same amount of rotation of the instrument about its axis would cause the line of collimation to pierce the celestial sphere at another point as s'. Let AB be the vertical circle passing through s', s and s' being the points where the line of collimation in its disturbed and undisturbed positions pierces the celestial sphere. Draw sr perpendicular to AB and let the angle $ss'r$ be represented by γ. Thus the total flexure ss' may be resolved into the horizontal and vertical components sr and $s'r$. It is evident that both are functions of the zenith distance. Later on we shall derive formulae for correcting the observed right ascensions and declinations of stars for flexure in azimuth and zenith distance when the flexures in these two co-ordinates are known. The flexure in azimuth, arising in part from flexure of the axes and in part from non-homogeneity of the material of the telescope tube, seems not to admit of theoretical treatment, and we proceed to investigate the flexure of telescopes in zenith distance.

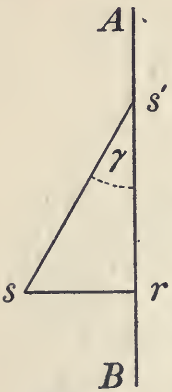


FIG. 1.

Let us assume that the telescope revolves about a single horizontal axis, that the tube is symmetrical in form and density with reference to the point of intersection of the line of collimation and the axis of revolution, and also that the weight of object-glass and eye-end are exactly equal — which is the case with meridian circle telescopes of the best construction.

In Fig. 2 let $EC'O$ be the tube of a telescope inclined at the angle θ to the vertical line VV' passing through C' the middle point of the line $E'O'$. $E'O'$ is the position which the line of collimation would have if not disturbed by flexure.

On account of its own weight and that of the eye-end and object-glass, the tube of the telescope is bent, and EO is the

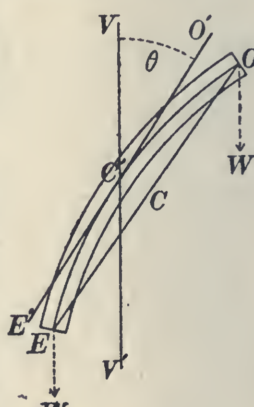


FIG. 2.

actual position of the line of collimation. Let us suppose that the two halves of the tube (before bending) are symmetrical in form, density and elasticity with reference to the point C', and let the weight W be the same at both ends. Then for the upper half of the telescope, the force tending directly to bend the tube is $W\sin\theta$ and the other component of the weight W is a compressive force $W\cos\theta$ acting in the direction OC. The direct bending force for the other half of the tube is $W\sin\theta$ and there is also a tensile force $W\cos\theta$ acting in the direction CE. The compressive force $W\cos\theta$ and the tensile force of the same amount tend to shorten and to lengthen the upper and lower halves of the tube respectively by an inappreciably small quantity. There are, however, two causes which may give rise to astronomical flexure under the conditions above specified: —

(1) Non-homogeneity of the material (usually brass) of which the telescope tube is made.

(2) The existence of a compressive strain on the upper half of the tube and of an equal tensile strain on the lower half.

We take as the normal or undisturbed position of the line of collimation that assumed when the telescope is pointed to the nadir. Little or no flexure is to be expected from either of the above causes when the telescope is directed to the zenith. Flexure due to the first cause would probably be a maximum when the telescope is horizontal, and there will be two values of the horizontal flexure — one for object-glass north and another for object-glass south. When the telescope is horizontal there can be no flexure due to the second cause since then $\theta = 90^\circ$ and $W\cos\theta = 0$. Flexure in azimuth can arise only from non-homogeneity of the material of the tube and horizontal axis and must be very small in well made instruments.

The combined flexures of the telescope and the divided circle are sometimes treated as follows:—

Let $\Delta z =$ the flexure at zenith distance z; then, we may assume

$$\Delta z = b'\sin z + a'\cos z + b''\sin 2z + a''\cos 2z \quad . \quad . \quad . \quad *$$

in which b', b'', a', a'' are constants independent of z. In practice no attempt is usually made to take account of the terms in $\sin 2z$ and $\cos 2z$ and the expression reduces to

$$\Delta z = b'\sin z + a'\cos z,$$

in which b' is the constant of sine flexure and a' the constant of cosine flexure, so called.† Or b' is the flexure at the horizon and a' that at the nadir and zenith. Now if we assume that the horizontal flexures, object-glass north and object-glass south, are the same, the constants b' and a' may be determined from observations of the nadir and of leveled collimators.

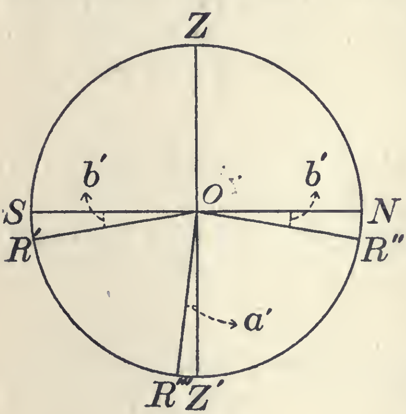


FIG. 3.

In Figure 3 let $ZSZ'N$ be the plane of the meridian, S the south collimator and N the north collimator. The collimators being leveled and their lines of collimation made parallel, the line SN is horizontal.

Let R'' be the reading on the north collimator, R' that on the south collimator, and R''' the reading on the nadir. Let $SOR' = NOR'' = b'$ and $R'''OZ' = a'$. We then have

$$R' - R''' = 90° - b' - a' \text{ and } R''' - R'' = 90° - b' + a'$$

whence,

$$b' = 90° - \frac{R' - R''}{2} \quad \text{and} \quad a' = R''' - \frac{R' + R''}{2}.$$

If the horizontal flexures, object-glass north and object-

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* See Sawitsch, *Abriss der Praktischen Astronomie*, p. 209.

† We shall show later on that there is in theory a reason for the existence of the term $b''\sin 2z$. See Equations (16) and (37).

glass south, are not equal, the value of a' deduced by this method will be illusory.

The demonstration of the rule that the astronomical flexure of a telescope in a vertical plane varies as the sine of the zenith distance is as follows:*—

It was shown above that the force tending directly to bend either half of a telescope tube varies as the sine of the zenith distance. If a weight W at one end produces a linear deflection H when the tube is horizontal, the deflection at any zenith distance z is assumed to be $H \sin z$. An equal weight at the other end which produces a horizontal deflection of H', gives at the same time a deflection of $H' \sin(180° — z) = H' \sin z$. The difference of these deflections is $(H — H') \sin z$ and the astronomical flexure is

$$\sin^{-1}\left(\frac{H - H'}{2l} \sin z\right),$$

in which $2l$ is the focal length of the telescope.

Astronomical flexure may be produced in two ways by the second cause given above:—

(1) Bending due to moments of compressive and tensile forces.

(2) Displacement of the neutral surface † by the compressive and tensile forces.

We proceed to develop by means of the commonly accepted theory of the elasticity and resistance of materials an expression for the astronomical flexure of telescopes due to the bending moments of the compressive and tensile forces.

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* See Chauvenet's *Spher. & Pract. Ast.*, Vol. II., p. 303.

† In the theory of the resistance of materials, the term neutral surface signifies that surface in a bent beam which separates the part of the beam subject to a tensile strain from that subject to a compressive strain. This surface is supposed to pass through the centers of gravity of the cross-sections of the beam; and the term neutral axis, is applied to the line in the neutral surface joining these centers of gravity. (See Weisbach, Coxe's Trans., pp. 410–413.)

While formulae of this kind will not in practice give the absolute values of the flexure, it is possible that they may throw some light on the law of variation of flexure with the zenith distance.

Let us assume that the tube is of uniform transverse section, that it is supported at the middle point of the line joining the centers of gravity of the object-glass and eye-end, that the material of the tube is homogeneous throughout and that the object-glass and eye-end are of the same weight, W. We shall consider first the flexure due to the weight of the object-glass and eye-end, and second that due to the weight of the tube itself. Then for the first case the differential equation of the neutral axis of the upper half of the tube of the telescope is, as given in Wood's *Resistance of Materials*, p. 138 and in other text-books,

$$EI\frac{d^2y}{dx^2} = -yW\cos\theta - xW\sin\theta.$$

For the lower half of the tube,

$$EI\frac{d^2y}{dx^2} = +yW\cos\theta - xW\sin\theta.$$

The zenith distance θ is taken less than 90° in each of these equations and the origin of co-ordinates is taken at the object and eye-ends respectively in the disturbed position. The x-axis is taken parallel, and the y-axis perpendicular to the undisturbed position of the line of collimation. E is the modulus of elasticity of the material of the tube and I the moment of inertia of a transverse section.

If we put

$$p^2 = \frac{W\sin\theta}{EI} \quad \text{and} \quad q^2 = \frac{W\cos\theta}{EI},$$

the above equations become

$$\frac{d^2y}{dx^2} = -p^2x - q^2y, \qquad (1)$$

$$\frac{d^2y}{dx^2} = -p^2x + q^2y. \tag{2}$$

Integrating these equations we get

$$y = K_1 e^{qx\sqrt{-1}} + K_2 e^{-qx\sqrt{-1}} - \frac{p^2}{q^2}x, \tag{3}$$

$$y = K_1' e^{qx} + K_2' e^{-qx} + \frac{p^2}{q^2}x. \tag{4}$$

By inspection of the flexure curve we see that for $x = 0$, $y = 0$; and for $x = l, \frac{dy}{dx} = 0$, l being the half length of the tube.

From (3)

$$\frac{dy}{dx} = iqK_1 e^{iqx} - iqK_2 e^{-iqx} - \frac{p^2}{q^2}. \tag{5}$$

Putting $x = l$ in (5),

$$iqK_1 e^{iql} - iqK_2 e^{-iql} - \frac{p^2}{q^2} = 0. \tag{6}$$

Putting $x = 0$ in (3),

$$K_1 + K_2 = 0. \tag{7}$$

From (6) and (7)

$$K_1 = \frac{i\frac{p^2}{q^2}}{q\left(e^{iql} + e^{-iql}\right)} \text{ and } K_2 = \frac{-i\frac{p^2}{q^2}}{q\left(e^{iql} + e^{-iql}\right)}.$$

Substituting these values in (3),

$$y = \frac{p^2}{q^2}\left(\frac{i}{q}\cdot\frac{e^{iqx} - e^{-iqx}}{e^{iql} + e^{-iql}} - x\right). \tag{8}$$

In like manner (4) becomes,

$$y = \frac{p^2}{q^2}\left(-\frac{1}{q}\cdot\frac{e^{qx} - e^{-qx}}{e^{ql} + e^{-ql}} + x\right). \qquad (9)$$

Equations (8) and (9) are the equations of the neutral axes of the upper and lower halves of the telescope tube respectively. If we put Δ for the deflection of the upper end of the tube and Δ' for that of the lower end we have, since in (8) and (9) $y = \Delta$ and Δ' for $x = l$,

$$\Delta = \frac{p^2}{q^2}\left(\frac{i}{q}\cdot\frac{e^{iql} - e^{-iql}}{e^{iql} + e^{-iql}} - l\right). \qquad (10)$$

$$\Delta' = \frac{p^2}{q^2}\left(-\frac{1}{q}\cdot\frac{e^{ql} - e^{-ql}}{e^{ql} + e^{-ql}} + l\right). \qquad (11)$$

The deflections of the upper and lower ends of the tube may be computed from (10) and (11), and then the astronomical flexure will be given by the formula,

$$h = \sin^{-1}\left(\frac{\Delta - \Delta'}{2l}\right). \qquad (12)$$

But it is more convenient to transform (10) and (11) as follows. Developing the exponential functions e^{iql}, e^{-iql}, e^{ql} and e^{-ql} in series, substituting these values and also the values of p^2 and q^2 in $\frac{p^2}{q^2}$, (10) and (11) become after reduction,

$$\Delta = \frac{1}{3}\, q^2 l^3 \tan\theta \left(1 + \frac{2}{5}\, q^2 l^2 + \frac{17}{105}\, q^4 l^4 + \frac{62}{945}\, q^6 l^6 \quad . \quad . \quad . \quad .\right), \qquad (13)$$

$$\Delta' = \frac{1}{3}\, q^2 l^3 \tan\theta \left(1 - \frac{2}{5}\, q^2 l^2 + \frac{17}{105}\, q^4 l^4 - \frac{62}{945}\, q^6 l^6 \quad . \quad . \quad . \quad .\right). \qquad (14)$$

Since $q^2 = \frac{W\cos\theta}{EI}$, $q^2 l^2$ will always be a small quantity in case of a telescope of ordinary construction. Therefore these series converge rapidly and the absolute deflections Δ

and Δ' may be conveniently and accurately computed by (13) and (14). Subtracting (14) from (13) we get,

$$\Delta - \Delta' = \frac{4}{15}\, q^4 l^5 \tan\theta \left(1 + \frac{31}{189}\, q^4 l^4 \quad . \quad . \quad . \quad . \quad . \right), \qquad (15)$$

in which only the first term of the series will be appreciable. Neglecting all terms except the first and substituting for q^2 its value, we have

$$\Delta - \Delta' = \frac{2}{15}\, l^5 \left(\frac{W}{EI}\right)^2 \sin 2\theta, \qquad (16)$$

from which the difference of deflection may be computed with convenience and accuracy. From (16) we see that $\Delta - \Delta'$ is always positive for direct observations since 2θ can never be greater than 180°, and hence the flexure of the upper half of the tube is always theoretically greater than that of the lower half.

For observations by reflection $\Delta - \Delta'$ is negative. The position of the telescope when pointed to the nadir being taken as the undisturbed position, the flexure is zero at the zenith and the horizon and is a maximum at zenith distances of 45°.

Flexure of this kind will diminish both zenith-distances and nadir-distances (as measured) and hence will not be eliminated by taking the mean of observations direct and reflected. While it will not in theory give rise to a discordance Reflected minus Direct it does not follow that it will not so do in practice.

Substituting in Eq. (12) the value of $\Delta - \Delta'$ given by (16) we have,

$$h = \sin^{-1}\left[\frac{l^4}{15}\left(\frac{W}{EI}\right)^2 \sin 2\theta\right]. \qquad (17)$$

The astronomical flexure varies directly as W^2 and inversely as $(EI)^2$

If in Eqs. (13) and (14) we put $\theta = 90°$ we get,

$$\Delta = \Delta' = \frac{l^3}{3}\frac{W}{EI}, \qquad (18)$$

which is the formula for the deflection of a horizontal beam fixed at one end and loaded at the other.*

We now pass to the case of flexure due to the weight of the tube of the telescope. Let the weight per unit of length be w. Then, the origin of co-ordinates being taken, as before, in one case at the object-end and in the other case at the eye-end of the telescope, we have as the weight on any section, wx. The components perpendicular and parallel to the line of collimation will be $wx \sin\theta$ and $wx \cos\theta$, θ being as before the angle which the line of collimation in its undisturbed position makes with the vertical. In Figure 4 let OX and OY be the axes of co-ordinates for the upper half of the tube.

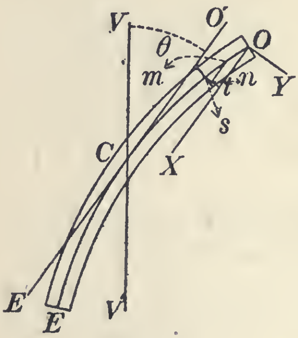

FIG. 4.

Evidently the moment on any transverse section, as that passing through the point s, will be $\frac{1}{2}wx^2\sin\theta$ very nearly. We here assume sO to be a straight line, which when the deflection is small may be done without appreciable error. The case of the longitudinal component is however less simple, since in this case, except for sections near O, we cannot assume sO to be a straight line. If we assume the curve CsO to be an arc of a circle, the lever arm of the compressive force for any section would be $\frac{1}{4}y$, while on the assumption of a straight line the lever arm for any section would be $\frac{1}{2}y$. The problem seems not to admit of direct and rigorous solution since a knowledge of the equation of the curve CsO is needed in forming its differential equation. Evidently, however, the mean value of the lever arm of the compressive force is somewhere between $\frac{1}{2}y$ and $\frac{1}{4}y$, and we adopt $\frac{1}{3}y$. This gives as the moment of the longitudinal component of the weight on any section $\frac{1}{3}wxy\cos\theta$. We shall see later that whatever error there may be in this assumption will not for our purpose seriously affect the result.

We then get as the approximate differential equations of

* See Wood's *Resistance of Materials*, p. 109.

the flexure curves for the upper and lower halves of the tube respectively,

$$EI\frac{d^2y}{dx^2} = -\frac{1}{3}\,wxy\cos\theta - \frac{1}{2}\,wx^2\sin\theta,$$

$$EI\frac{d^2y}{dx^2} = +\frac{1}{3}\,wxy\cos\theta - \frac{1}{2}\,wx^2\sin\theta.$$

If we put $a = \frac{1}{3}\frac{w\cos\theta}{EI}$ and $b = \frac{1}{2}\frac{w\sin\theta}{EI}$, these become

$$\frac{d^2y}{dx^2} = -axy - bx^2, \qquad (19)$$

$$\frac{d^2y}{dx^2} = +axy - bx^2. \qquad (20)$$

It is evident on inspection that Eq. (19) is satisfied by the relation

$$y = -\frac{b}{a}x, \qquad (21)$$

which is a particular solution, so called.

If to this value of y be added that given by solving (19) with the term bx^2 put equal to zero, the sum put equal to y will, according to a well known theorem of Differential Equations, be the complete or general solution of (19). We have now to solve the differential equation,

$$\frac{d^2y}{dx^2} = -axy. \qquad (22)$$

Putting $y = e^t$ and $\frac{dt}{dx} = u$, we have, $\frac{dy}{dx} = e^t\frac{dt}{dx}$ and

$$\frac{d^2y}{dx^2} = e^t\left(\frac{dt}{dx}\right)^2 + e^t\frac{d^2t}{dx^2},$$

and Eq. (22) becomes

$$\frac{du}{dx} + u^2 = -ax,$$

which is a special case of Riccati's Equation not integrable in finite terms.

Returning to Eq. (22) and integrating it in series we get,

$$y = \frac{x^{\frac{1}{2}}}{\sqrt[3]{\frac{3}{2}}}\left[CJ_{\frac{1}{3}}(u) + C_1 J_{-\frac{1}{3}}(u)\right], \qquad (23)$$

in which $u = \frac{2}{3} x^{\frac{3}{2}} a^{\frac{1}{2}}$ and J is the well known functional symbol of Bessel. Then we have, according to the above theorem, from (21) and (23) as the complete solution of Eq. (19),

$$y = \frac{x^{\frac{1}{2}}}{\sqrt[3]{\frac{3}{2}}}\left[CJ_{\frac{1}{3}}(u) + C_1 J_{-\frac{1}{3}}(u)\right] - \frac{b}{a}x. \qquad (24)$$

Now $J_{\frac{1}{3}}$ and $J_{-\frac{1}{3}}$ each represent a series in general form as follows,

$$J_n(u) = \frac{u^n}{2^n \Gamma(n+1)}\left[1 - \frac{u^2}{4(n+1)} + \frac{u^4}{32\,(n+1)\,(n+2)} - \frac{u^6}{384\,(n+1)\,(n+2)\,(n+3)} \quad . \quad . \quad . \quad .\right].$$

On substituting in (24) the values of $J_{\frac{1}{3}}(u)$ and $J_{-\frac{1}{3}}(u)$ we find in the resulting expression for y a term in the coefficient of C_1 which does not contain x, while each term in the coefficient of C does contain x. Since we know by the conditions of the problem that $y = 0$ for $x = 0$, we find on putting $x = 0$

$$C_1 = 0,$$

and Eq. (24) reduces to,

$$y = \frac{x^{\frac{1}{2}}}{\sqrt[3]{\frac{3}{2}}}\, CJ_{\frac{1}{3}}(u) - \frac{b}{a}x. \qquad (25)$$

Differentiating Eq. (25),

$$\frac{dy}{dx} = C\left(\frac{3}{2}\right)^{-\frac{1}{3}}\left[x^{-\frac{1}{2}}J_{\frac{1}{3}}(u) - a^{\frac{1}{2}}xJ_{\frac{4}{3}}(u)\right] - \frac{b}{a}. \qquad (26)$$

Differentiating (26) and reducing,

$$\frac{d^2y}{dx^2} = -C\left(\frac{3}{2}\right)^{-\frac{1}{3}} a x^{\frac{3}{2}} J_{\frac{1}{3}}(u). \qquad (27)$$

Combining Eqs. (25) and (27) to eliminate the constant of integration C we get,

$$\frac{d^2y}{dx^2} = -axy - bx^2,$$

which shows that Eq. (25) is correct.

From the conditions of the problem we know that $\frac{dy}{dx} = 0$ for $x = l$, the half length of the tube, and substituting l for x in Eq. (26) we have,

$$C\left(\frac{3}{2}\right)^{-\frac{1}{3}}\left[l^{-\frac{1}{2}}J_{\frac{1}{3}}(u_1) - a^{\frac{1}{2}}lJ_{\frac{4}{3}}(u_1)\right] - \frac{b}{a} = 0, \qquad (28)$$

in which $u_1 = \frac{2}{3}l^{\frac{3}{2}}a^{\frac{1}{2}}$.

Eqs. (25) and (28) then give on eliminating C,

$$y = \frac{b}{a}\left[\frac{x^{\frac{1}{2}}J_{\frac{1}{3}}(u)}{l^{-\frac{1}{2}}J_{\frac{1}{3}}(u_1) - a^{\frac{1}{2}}lJ_{\frac{4}{3}}(u_1)} - x\right], \qquad (29)$$

which is the approximate equation of the neutral axis of the upper half of the tube. From Eq. (20) we deduce in the same manner, as the equation of the elastic curve of the lower half of the tube,

$$y = \frac{b}{a}\left[-\frac{x^{\frac{1}{2}} J_{\frac{1}{3}}(u')}{l^{-\frac{1}{2}} J_{\frac{1}{3}}(u_1') - l\,(-a)^{\frac{1}{2}} J_{\frac{4}{3}}(u_1')} + x \right]. \quad (30)$$

in which $u' = \frac{2}{3}x^{\frac{3}{2}}(-a)^{\frac{1}{2}}$ and $u_1' = \frac{2}{3}l^{\frac{3}{2}}(-a)^{\frac{1}{2}}$.

Now if we put Δ_1 and Δ_1' for the deflections of the upper and lower halves of the tube respectively, since $y = \Delta_1$ for $x = l$ in (29) and $y = \Delta_1'$ for $x = l$ in (30), we have

$$\Delta_1 = \frac{b}{a}\left(\frac{l^{\frac{1}{2}} J_{\frac{1}{3}}(u_1)}{l^{-\frac{1}{2}} J_{\frac{1}{3}}(u_1) - a^{\frac{1}{2}} l J_{\frac{4}{3}}(u_1)} - l \right), \quad (31)$$

$$\Delta_1' = \frac{b}{a}\left(-\frac{l^{\frac{1}{2}} J_{\frac{1}{3}}(u'_1)}{l^{-\frac{1}{2}} J_{\frac{1}{3}}(u_1') - l\,(-a)^{\frac{1}{2}} J_{\frac{4}{3}}(u'_1)} + l \right). \quad (32)$$

By evaluating the Bessel's Functions the values of Δ_1 and Δ_1' may be computed from (31) and (32). More convenient formulae may be deduced as follows. Substituting for a and b their values as given above, Eq. (31) may be written in this form:—

$$\Delta_1 = \frac{3}{2} l \tan\theta \left(\frac{1}{1 - a^{\frac{1}{2}} l^{\frac{3}{2}} X} - 1 \right), \quad (33)$$

in which

$$X = \frac{J_{\frac{4}{3}}(u_1)}{J_{\frac{1}{3}}(u_1)}.$$

Now by the calculus of Gamma Functions

$$\Gamma(p + 1) = p\Gamma(p),$$

$$J_{\frac{4}{3}}(u_1) = \frac{u_1^{\frac{4}{3}}}{2^{\frac{4}{3}}\Gamma(\frac{7}{3})}\left[1 - \frac{3}{7}\left(\frac{u_1}{2}\right)^2 + \frac{9}{140}\left(\frac{u_1}{2}\right)^4 - \frac{9}{1820}\left(\frac{u_1}{2}\right)^6 \;\ldots\ldots\right],$$

$$J_{\frac{1}{3}}(u_1) = \frac{u_1^{\frac{1}{3}}}{2^{\frac{1}{3}}\Gamma(\frac{4}{3})}\left[1 - \frac{3}{4}\left(\frac{u_1}{2}\right)^2 + \frac{9}{56}\left(\frac{u_1}{2}\right)^4 - \frac{9}{560}\left(\frac{u_1}{2}\right)^6 \;\ldots\ldots\right],$$

and

$$X = \frac{3}{8}u_1\left[1 + \frac{9}{28}\left(\frac{u_1}{2}\right)^2 + \frac{81}{560}\left(\frac{u_1}{2}\right)^4 + \frac{13851}{203840}\left(\frac{u_1}{2}\right)^6 \;\ldots\right].$$

Substituting this value of X in (33) and reducing we get

$$\Delta_1 = \frac{3}{8}al^4\tan\theta\left(1 + \frac{2}{7}al^3 + \frac{23}{280}a^2l^6 + \frac{43}{1820}a^3l^9 \;\ldots\right). \quad (34)$$

And in the same way we get from Eq. (31), for the lower half of the tube.

$$\Delta_1' = \frac{3}{8}al^4\tan\theta\left(1 - \frac{2}{7}al^3 + \frac{23}{280}a^2l^6 - \frac{43}{1820}a^3l^9 \;\ldots\ldots\right). \quad (35)$$

In the case of any telescope of ordinary construction al^3 is a very small quantity and these series converge very rapidly. Therefore the deflections Δ_1 and Δ'_1 may be accurately and conveniently computed from Eqs. (34) and (35). Subtracting we get

$$\Delta_1 - \Delta_1' = \frac{3}{8}al^4\tan\theta\left(\frac{4}{7}al^3 + \frac{43}{910}a^3l^9 \;\ldots\right),$$

or $$\Delta_1 - \Delta_1' = \frac{3}{14}a^2l^7\tan\theta\left(1 + \frac{43}{520}a^2l^6 \;\ldots\ldots\right). \quad (36)$$

Only the first term of this series will ever be appreciable. Neglecting the others and putting for a its value and for wl, W_1, we have

$$\Delta_1 - \Delta'_1 = \frac{l^5}{84}\left(\frac{W_1}{EI}\right)^2 \sin 2\theta, \qquad (37)$$

which has the same form as Eq. (16).

$\Delta_1 - \Delta'_1$ is always positive for direct observations, is a maximum for $\theta = 45°$, and is zero for $\theta = 0°$ or $90°$.

If in Eqs. (34) and (35) we put $\theta = 90°$, then

$$\Delta_1 = \Delta'_1 = \frac{l^3}{8}\frac{W_1}{EI},$$

which is the well-known formula for the deflection of a horizontal, uniformly loaded beam, fixed at one end and free at the other.* The formula for the astronomical flexure is

$$h_1 = \sin^{-1}\left[\frac{l^4}{168}\left(\frac{W_1}{EI}\right)^2 \sin 2\theta\right]. \qquad (38)$$

If in the differential equations (19) and (20) the value of a had been made $\frac{1}{2}\frac{w\cos\theta}{EI}$ instead of $\frac{1}{3}\frac{w\cos\theta}{EI}$ we should have as the coefficient of the right hand member of (37) $\frac{3}{112}$ instead of $\frac{1}{84}$. While (37) gives theoretically the law of variation with the zenith distance of the astronomical flexure due to the weight of the tube it can hardly be expected to give even a rough approximation to its absolute value.†

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* See Wood's *Resistance of Materials*, p. 110.

† For an attempt to deduce from the theory of the elasticity and resistance of materials formulae for computing the astronomical flexure of telescopes, see an article by V. Baggi in the *Astronomische Nachrichten* Nr. 3285.

Furthermore a rigorous solution of the problem makes necessary a solution of the differential equation

$$\frac{d^2y}{dx^2} = -p^2x - q^2y - axy - bx^2.$$

which takes into account at once the effect of the weight of the tube and that of the object-glass. But on comparing the numerical coefficients of (16) and (37) we see that the astronomical flexure due to the weight of the tube is probably not more than one-tenth of that due to the weight of the object glass and eye-end, supposing that $W = W_1$. The computed values, therefore, of the sum of the astronomical flexures due to both causes will not after all be *theoretically* very uncertain on account of the lack of rigor in the derivation of Eq. (37).

We shall now consider the displacement of the neutral axis by the compressive and tensile forces. In the above investigation it has been assumed that the neutral axis passes through the center of gravity of each transverse section of the tube and hence that I is constant.

In the case of a telescope tube or beam whose transverse section is constant and symmetrical with reference to a horizontal line, the beam being fixed at one end and free at the other and acted upon by a force at the free end perpendicular to the axis of the beam before flexure and in a vertical plane, according to the generally accepted theory the neutral axis passes through the center of gravity of each section.* This results from the assumption (shown by experiment to be approximately correct) that the modulus of elasticity is the same for compression that it is for tension.

But when the beam is also subject to a force acting parallel to the axis of the beam before flexure, the neutral axis no longer passes through the centers of gravity of the sections of the beam. The amount of this displacement of the neutral axis by the longitudinal force may be computed by the formula,

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* See Weisbach's *Mechanics of Engineering*, p. 413, Coxe's Translation.

$$D = \frac{I \cot\theta}{Kx},^{*} \qquad (39)$$

in which D is the displacement, I the moment of inertia of the section with reference to a horizontal line passing through its center of gravity, θ the angle which an oblique force makes with the axis of the beam before flexure, K the area of section, and x the abscissa of the center of gravity of the section.

In case of a compressive longitudinal force the neutral axis will be moved toward the side of the beam which is in tension and in case of a tensile force in the opposite direction. With equal longitudinal forces in compression and in tension, the displacement of the neutral axis in the two halves of a telescope is opposite in direction and may be assumed to be equal in amount. Now the minimum value of the moment of inertia of a section with reference to a horizontal line in the plane of the section is the moment of inertia with reference to the horizontal line through the center of gravity

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* Professor DeVolson Wood in his *Resistance of Materials* (p. 91) gives as the expression for the linear displacement of the neutral axis in case of a beam subjected to an oblique force, P,

$$h = \frac{Pl}{cEK} \cos\theta.$$

In which h is the displacement and $c = \frac{l}{\rho}$, ρ being the radius of curvature of the flexure curve at the point of whose abscissa is x.

Now $\rho = \frac{dx^2}{d^2y}\left(1 + \frac{dy^2}{dx^2}\right)^{\frac{3}{2}}$ and since in this case $\frac{dy}{dx}$ is a very small quantity we may put $\frac{1}{\rho} = \frac{d^2y}{dx^2}$. By equation (1) this becomes $\rho = -\frac{1}{p^2x + q^2y}$ or $\rho = -\frac{EI}{Wx\sin\theta + Wy\cos\theta}$, and the above expression for h becomes

$$h = -\frac{I}{K\ (x\tan\theta + y)}.$$

Now y is a very small quantity and may be neglected in the case of a telescope without appreciable error and we get, omitting the minus sign,

$$h = \frac{I\cot\theta}{Kx} = D.$$

From this formula the linear displacement of any point of the neutral axis whose abscissa is x may be computed.

of the section. But in deducing the above formulae for the absolute deflections of the two halves of the telescope tube it was assumed that the moment of inertia I has the same minimum value throughout the length of the tube.

Therefore the deflections computed from these formulae must be too large, and the error may be assumed to be the same for each half of the tube provided that the neutral axis, in the absence of longitudinal forces, passes through the center of gravity of each section. If the above statements are true, the astronomical flexure is not appreciably affected in theory by the longitudinal forces.

If, however, the co-efficients of elasticity for tension and compression are not equal, the curve of the neutral axis does not pass through the center of gravity of the sections, in the absence of the longitudinal forces, and their effect will be in case of one-half of the tube to move the neutral axis nearer to the center of gravity and in the other case further from it. In one case the moment of inertia will be diminished and in the other increased with corresponding increase and diminution of the absolute flexures. This would give rise to astronomical flexure.

Until the undisturbed position of the neutral axis is more accurately known, further analytical investigation of the matter seems for our purpose to be impracticable. It must be recognized, however, that herein lies a possible cause of astronomical flexure of telescopes.

In computing a few numerical results from the above formulae I have taken first the case of the telescope of a modern 5-inch Repsold Meridian circle. The focal length is 57.6 in., clear aperture of the object glass 4.80 in. and the thickness of the walls of the brass tube about 0.075 inches. The interior diameter of the tube is taken as 4.80 inches and the weight of the object-glass with cell and the terminal flange on the tube is taken as 35 lbs., the weight of the micrometer and other parts at the eye-end being the same. I have taken the weight of each half of the tube minus the terminal flange as 10 lbs. The astronomical flexure as computed from these data by the above formulae is 0″.01. The weights and dimensions assumed are approximate only, and since the flexure varies as $\left(\frac{W}{EI}\right)^2$ it is possible that more exact data would give a result considerably different from the above.

I have also taken the case of a solid rectangular brass prism 6 feet long and 2 inches square supported at and turning about its center on a horizontal axis like a telescope tube, two faces of the prism being in vertical planes. The deflections and astronomical flexures have been computed for every ten degrees of zenith distance (1) with a load of 100 lbs. at the end and (2) with an uniformly distributed load of 100 lbs. on each half of the prism. The displacement of the neutral axis D has been computed for the load of 100 lbs. at the ends for $x = 18$ inches. The results are arranged in the following table:—

Z. D. = θ.	Approx. Deflection for load at ends.	Approx. Deflection for dist. load.	$\Delta - \Delta'$.	$\Delta_1 - \Delta_1'$.	$\Delta - \Delta'$ Plus $\Delta_1 - \Delta_1'$.	Astronomical flexure.	*D.*
0°	0in.000	0in.000	+0in.00000	+0in.00000	+0in.00000	0″.00	0in.0000
10	0 .022	0 .008	18	2	20	0 .56	0 .1050
20	0 .043	0 .016	35	3	38	1 .11	0 .0509
30	0 .063	0 .024	47	4	51	1 .56	0 .0321
40	0 .081	0 .031	53	5	58	1 .76	0 .0221
45	0 .090	0 .034	54	5	59	1 .80	0 .0185
50	0 .097	0 .036	53	5	58	1 .76	0 .0155
60	0 .110	0 .041	47	4	51	1 .56	0 .0107
70	0 .119	0 .045	35	3	38	1 .11	0 .0067
80	0 .125	0 .047	18	2	20	0 .56	0 .0033
90	0 .127	0 .048	+0 .00000	+0 .00000	+0 .00000	0 .00	0 .0000

The experience of investigators of the elasticity and resistance of materials has shown that formulae deduced from theory do not give results which agree accurately with the results of experiments.* That the action of materials subject to strains is more or less capricious has been abundantly

* Weisbach says, "Except as exhibiting approximately the laws of phenomena, the theory of the strength of materials has many practical defects."

proven by experiment. In this case, however, we are concerned with the difference of two flexures, and relatively small errors in the absolute deflections may cause large astronomical flexures. We have shown above that the astronomical horizontal flexure may be assumed to vary as the sine of the zenith distance, and also that there is a small theoretical astronomical flexure which varies as the sine of twice the zenith distance. Again, the effect of the displacement of the neutral axis by the longitudinal forces seems to be uncertain.

The tube of the telescope of a meridian circle as ordinarily constructed consists of two tubular brass castings of the same size and shape, which are bolted to a hollow cubical brass portion which is cast in one piece with the horizontal axis of the instrument. When the telescope is in an inclined position the greatest strain comes where the parts are fastened together with screws.* This tends of course to make the flexures uncertain.

According to formulae (17) and (37) the flexure due to the compressive and tensile forces varies inversely as the square of the coefficient of elasticity of the material of the tube. Now the coefficient of elasticity of some kinds of steel is more than three times as large as that of brass.† If, therefore, there is any danger of appreciable flexure errors arising from the compressive and tensile forces it is advisable to construct meridian circle telescopes of steel instead of brass, provided that steel is as nearly homogeneous as brass.

It is not the purpose of this paper to discuss the various methods used for determining the astronomical flexure of telescopes by observation or experiment, but we shall touch briefly upon certain results of observation which seem to be of interest in connection with the foregoing theory. The only practicable way of determining the flexure is by observation or experiment, yet there has never been devised any method for getting the flexure of a meridian

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* See Harkness on *Flexure of Meridian Instruments, Appendix III. to Washington Obs'ns for 1882*, p. 14.

† See Wood's *Resistance of Materials*, pp. 310–311, and Weisbach's *Mechanics of Engineering*, Translated by Coxe, p. 403.

circle telescope at all zenith distances which has proven satisfactory on general application. The flexure of such a telescope is usually small and is not easily separated from other errors of the instrument in zenith distance, errors of refraction tables and systematic errors of division. Furthermore, the flexure of a telescope may not be constant but probably varies with time, temperature or the manner of using the instrument.* Observers, therefore, instead of attempting to determine and allow for this troublesome class of errors, have usually tried to adopt some method of observing by which they may be eliminated.† The founder of that celebrated firm of instrument-makers, the Repsolds of Hamburg, constructed the telescopes of his meridian circles so that the object-glass and eye-end could be interchanged, thinking that the mean of observations in declination on any star made before and after the change would be free from errors of flexure. It is evident that that term of the flexure which varies as sin θ would be eliminated by this method, but that the term which varies as sin 2θ would not (see p. 251). A better method for eliminating flexure errors is that of Bessel, the star being observed four times — direct and reflected circle West and the same circle East. It does not, however, in theory eliminate the term of the flexure which depends on sine 2θ. Assuming the perfect homogeneity of the telescope tube the 2θ term of the flexure affects zenith distances and nadir distances alike and gives rise to no discrepancy Reflected minus Direct. But the sine flexure — that is the term depending on sine θ — does, when unallowed for, give rise to a difference $R - D$ amounting to twice the flexure itself since this flexure term increases measured zenith distances and diminishes nadir distances or *vice versa*.

It is conceivable that in the same way that the sin θ term arises from non-homogeneity of the tube, the 2θ term may not be the same for supplementary zenith distances — that is for a star direct and reflected. Also flexure arising from displacement of the neutral axis of the tube or any other

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* See *V. J. S. der Ast. Gesell. 31 Jahrgang Erstes Heft*, p. 41.

† See Valentiner's *Handwörterbuch der Astronomie*, pp. 575–592.

effect arising from displacement of the neutral axis by action of the compressive and tensile forces upon the two halves of the tube when in an inclined position may, on account of non-homogeneity of material, differ for supplementary zenith distances.

That these causes and their effects must exist is sufficiently clear. The question is whether the effects are likely to be appreciable.

The $R—D$ discordance found many years ago to exist in case of the Greenwich Transit Circle was considered by Sir G. B. Airy to be due to refraction of the light in passing from the cool air outside to the warmer air surrounding the mercury basin.* More recent researches at Greenwich seem to show that the discrepancy is due to instrumental error.† A similar discrepancy has been found in observations made with the transit circle at the Cape of Good Hope.

After correcting the observations for sine flexure by the formula $h = 1''.3 \sin Z.D.$ the results for $R — D$ at Greenwich as given by Professor Turner in *Mon. Not. R. A. S.*, Vol. LIV., p. 487, are as follows: —

$Z.D.$	$R — D$
25°	+0″.06
30	+0 .20
35	+0 .28
40	+0 .26
45	+0 .12
50	+0 .03
55	—0 .21
60	—0 .28

On account of mechanical difficulties, observations by reflection are not made at Greenwich outside of the above limits of zenith distance.

The results for $R — D$ at the Cape of Good Hope after being corrected for sine flexure by the formula $h = — 0''.46 \sin Z.D.$ are as follows: ‡—

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* *Memoirs R. A. S.*, Vol. XXXII., pp. 9-17.

† *Mon. Not. R. A. S.*, Vol. LIV., p. 486.

‡ Introduction to *Cape Catalogue of Stars for 1885*, p. XVII.

Z.D.	*R.—D.*	*Z.D.*	*R.—D.*
+ 9° 10′	—0″.24	—12° 19′	+0″.19
+12 31	+0 .17	—17 35	0 .00
+17 31	+0 .37	—23 10	+0 .35
+22 40	+0 .50	—27 6	+0 .29
+27 53	+0 .69	—32 39	+0 .26
+32 33	+0 .44	—37 27	+0 .17
+36 42	+0 .34	—42 16	+0 .41
+43 28	+0 .76	—47 23	+0 .59
+47 52	+1 .04	—52 19	+1 .15
		—56 57	+1 .05

During the years 1885–7, I made at the Washburn Observatory of the University of Wisconsin with a 5-inch Repsold meridian circle about 700 observations on more than 100 *Berliner Jahrbuch* stars for the purpose of determining the latitude and the errors of the instrument in declination. A description of the instrument, which is one of the finest in the world, may be found in Vol. II. of the *Publications of the Washburn Observatory* and a detailed account of the manner in which the observations were made is given in Vol. V. of the same Publications. No stars were observed by reflection because the instrument was not provided at that time with apparatus for the purpose. The results were published in Vol. V. of the *Publications of the Washburn Observatory* in June, 1887. The fact that latitudes vary periodically was not known until four or five years later. In order to give some idea of the accuracy of these observations the results for latitude from the four groups of stars observed, are given below, as published in 1887 (see *Publications Washburn Observatory*, Vol. V., p. 5* of Appendix), together with the mean epoch of the observations on each group and the quantities necessary to reduce the observed latitudes to the mean latitude, quantities computed from Chandler's formula published in 1892.*

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* See *Astronomical Journal*, No. 277.

No. of Group.	Mean Epoch.	Observed Latitude.		$\Delta\varphi$	Observed Mean Lat.	Weight.	No. Obs'ns.
I	June 25, 1885	43° 4′ [36″.63]	36″.81	−0″.20	[36″.43]*		200
		37 .01		−0″.20	43° 4′ 36 .81	1	
II	Dec. 7, 1886	36 .81		+0 .04	36 .85	2	195
III	Feb. 20, 1887	36 .75		+0 .09	36 .84	2	121
IV	May 4, 1887	36 .83		+0 .03	36 .86	2	224
							740

Mean Latitude from these Observations 43° 4′ 36″.84±0.022.

The latitudes from the different pairs of stars grouped, and arranged according to the zenith distance of the stars observed are as follows:—

0° — 10°	43° 4′	36″.75	±0″.06	11 pairs
10 — 20		36 .81	0 .04	11 "
20 — 30		36 .82	0 .04	8 "
30 — 40		36 .86	0 .06	7 "
40 — 60		36 .83	0 .06	6 "
60 — 70		36 .81	0 .08	4 "
70 — 75		36 .71	0 .08	5 "

The mean latitude derived from seven years' work with the same instrument (1884 to 1890 inclusive) agrees exactly with the mean latitude given above. The results for each of the seven years, as printed in Vol. VI., *Publications of the Washburn Observatory*, p. 145, are given below: —

1884.0	43° 4′	36″.79
1885.0		36 .73
1886.0		36 .77
1887.0		36 .84
1888.0		36 .92
1889.0		36 .92
1890.0		36 .90
Mean	43° 4′	36″.84

* This result for latitude is deduced from observations by another observer.

These values of the latitude have not been corrected for periodic variation, but the length of time over which the observations extend, makes probable its almost complete elimination from the mean result. This latitude depends on *B. J.* stars only and the observations were made by seven or eight different observers. The close agreement between this value of the latitude and that deduced from the observations of Groups I, II, III and IV, together with the small probable error of the latter (± 0″.022), seem to indicate for these determinations a high degree of accuracy.

Now the latitude being known, and neglecting for the present the errors of the *B. J.* declinations of the stars, the errors by which these observations in declination are affected may be easily determined by taking the difference between the observed latitudes and the corresponding true values of the latitude. If it be assumed that all errors except flexure have been allowed for then this process will give the flexure for all zenith distances at which stars have been observed. The means of the residuals found in this way were taken for each ten degrees of zenith distance and the results with probable errors are given in the table below: * —

Mean Z. D.	N. Stars Circ. W. and S. Stars Circ. E.	N. Stars Circ. E. and S. Stars Circ. W.	Number of Stars.
4°.1	+ 0″.21 ± 0″.07	+ 0″.62 ± 0″.10	17
13 .7	+ 0 .51 ± 0 .05	+ 0 .81 ± 0 .04	14
25 .4	+ 0 .39 ± 0 .07	+ 1 .24 ± 0 .06	13
34 .5	+ 0 .60 ± 0 .07	+ 1 .02 ± 0 .08	17
44 .1	+ 0 .41 ± 0 .06	+ 0 .62 ± 0 .11	10
56 .3	— 0 .06 ± 0 .12	+ 0 .57 ± 0 .11	8
66 .0	+ 0 .06 ± 0 .09	+ 0 .12 ± 0 .10	11
73 .2	+ 0 .26 ± 0 .17	+ 0 .18 ± 0 .20	10

The horizontal flexure of the telescope had been determined as about + 0″.11 Circle W. and + 0″.38 Circle E., but no correction for horizontal flexure was applied to the observations. The division errors of the lines under the microscopes during observation of the nadir point had been care-

* See *Washburn Obs'y Publications*, Vol. V., p. 12.* Appendix.

fully determined and corrections for them applied, but no other corrections for division error were used. All other instrumental errors were, as far as known, very accurately corrected. The Pulkowa refraction tables which were used have been shown to need no correction at Madison * and the effect of errors of the tabular *B. J.* places of the stars used is small. It is evident from the above table that these errors in declination do not vary as the sine of the zenith distance. They do vary much more nearly as the sine of double the zenith distance. The law of change is more or less the same whichever side of the telescope is in tension or compression.

Later observations with the same instrument after being corrected for sine flexure and division errors give similar results excepting that the absolute size of the residuals is considerably reduced.† All of these observations indicate that the eye-end of the instrument bends more than the object-glass, while our theory indicates that the object-end should, for direct observations, have the greatest absolute flexure. Since, however, the theory cannot be expected to give even roughly the absolute value of the astronomical flexure, this result is not to be considered as anomalous. The question is as to what extent the *law of change* of the flexure with the zenith distance as given by theory agrees with the results of observation.

In conclusion it may be said that assuming symmetry in the form and homogeneity of the material of the tube, and equality in weight of the object and eye-ends of the telescope, the flexure will be zero at the horizon and at the zenith and nadir. It will be a maximum at zenith distances of 45° and 135°, in so far as the moments of the compressive and tensile forces are concerned, according to the theory of elasticity and resistance of materials. According to the same theory it is possible that the compressive and tensile forces may produce astronomical flexure by displacement of the neutral surface. In a general way these forces acting in opposite directions on the two halves of the telescope tube when in an inclined posi-

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* See *Publications of the Washburn Observatory*, Vol. IX., p. 203.

† The same, Vol. VIII., p. 36.

tion may be expected to have some effect on the position of the line of collimation.

Assuming that the material of the tube is non-homogeneous, the effect produced by the tensile and compressive forces is unknown in theory. We now have also to deal with the sine flexure which is assumed to be a maximum at the horizon. It is usually determined at the horizon and allowed for on the supposition that it decreases toward the zenith with the sine of the zenith distance.

When the sine-flexure and all other known errors have been determined and as accurately corrected as possible there usually appears a small systematic residual error whose cause has never as yet been determined in any particular case. Three instances of this have been given above. To indicate to what extent this residual error may be due to the unsymmetrical action of gravity on the telescope tube is the purpose of the foregoing discussion.

Derivation of Formulae for Correcting Observations in Right Ascension and Declination for Flexure of the Telescope in Zenith Distance and Azimuth.

When the vertical and horizontal flexures of an equatorial telescope are known for the zenith distance ζ, the observed right ascension and declination of a star at that zenith distance may be corrected for flexure by means of formulae which we proceed to derive. In the figure let O be the position of the observer, $NESW$ the horizon, Z the zenith, P the north pole, and s a star. Applying to the spherical triangle sPZ in the figure, the following general equations which hold for the spherical triangle ABC,

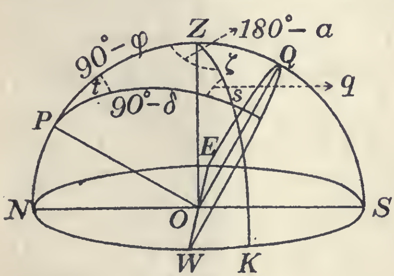

Fig. 5.

$$\sin a \sin B = \sin A \sin b \qquad \text{(a)}$$

$$\cos a = \cos b \cos c + \sin b \sin c \cos A \qquad \text{(b)}$$

$$\sin a \cos B = \cos b \sin c - \cos c \sin b \cos A \qquad (c)$$
$$\sin A \cos b = \cos B \sin C + \cos C \sin B \cos a, \qquad (d)$$

we get,

$$\cos\delta \sin q = \cos\phi \sin a \qquad (1)$$
$$\cos\delta \sin t = \sin\zeta \sin a \qquad (2)$$
$$\sin\delta = \sin\phi \cos\zeta - \cos\phi \sin\zeta \cos a \qquad (3)$$
$$\cos\delta \cos q = \sin\phi \sin\zeta + \cos\phi \cos\zeta \cos a \qquad (4)$$
$$\cos\delta \cos t = \cos\phi \cos\zeta + \sin\phi \sin\zeta \cos a \qquad (5)$$
$$\sin a \sin\phi = \sin t \cos q + \cos t \sin q \sin\delta \qquad (6)$$
$$\sin a \cos\zeta = \cos t \sin q + \sin t \cos q \sin\delta. \qquad (7)$$

Differentiating Eq. (3) regarding δ and ζ as variable, we have,

$$\cos\delta \, d\delta = - \sin\phi \sin\zeta \, d\zeta - \cos\phi \cos\zeta \cos a \, d\zeta.$$

This by means of Eq. (4) reduces to,

$$d\delta = - \cos q \, d\zeta. \qquad (8)$$

Differentiating (2) regarding δ, t and ζ as variable, we have,

$$\cos\delta \cos t \, dt - \sin\delta \sin t \, d\delta = \cos\zeta \sin a \, d\zeta.$$

By (4),

$$\cos\delta \, dt = \sin q \, d\zeta.$$

But $t = \theta - a$ (see Chauvenet's *Spher. & Pract. Ast.* Vol. I., p. 64), and $dt = - da$, hence,

$$\cos\delta \, da = - \sin q \, d\zeta. \qquad (9)$$

Differentiating (3), regarding δ and a as variable, we have,

$$\cos\delta \, d\delta = + \cos\phi \sin\zeta \sin a \, da.$$

By (1),

$$d\delta = \sin q \sin\zeta \, da. \qquad (10)$$

Differentiating (5), regarding δ, t and a as variable, we have,

$$-\sin\delta\cos t\, d\delta - \cos\delta \sin t\, dt = -\sin\zeta\sin\phi\sin a\, da.$$

By (10) and (6),

$$\cos\delta\, dt = \sin\zeta\cos q\, da,$$

or,

$$\cos\delta\, da = -\sin\zeta\cos q\ da. \qquad (11)$$

We then have from (8), (10), (9) and (11),

$$\left.\begin{aligned} \Delta\delta &= \sin q\sin\zeta\, da - \cos q\, d\zeta \\ \cos\delta\ \Delta a &= -\cos q\sin\zeta\, da - \sin q\, d\zeta \end{aligned}\right\}, \qquad (12)$$

in which $\Delta\delta$ and Δa are the sum of the differentials in δ and a respectively which depend upon the differentials in a and in ζ.

If h_1 and h_2 represent the vertical and horizontal flexures respectively, in arc, of a great circle we may, since they are small quantities, substitute them in eqs. (12) for $d\zeta$ and $\sin\zeta da$ respectively.

We then have to second powers of h_1 and h_2

$$\begin{aligned} \Delta\delta &= h_2\sin q - h_1\cos q \\ \cos\delta\ \Delta a &= -h_2\cos q - h_1\sin q. \end{aligned}$$

Issued November 21, 1896.

GEOMETRICAL PROPERTIES OF THE LINES OF FORCE PROCEEDING FROM

(*a*) A SYSTEM CONSISTING OF AN ELECTRIFIED PLANE AND AN ELECTRIFIED LINE PARALLEL TO THE PLANE.

(*b*) A SYSTEM CONSISTING OF AN ELECTRIFIED PLANE AND AN ELECTRIFIED POINT.*

WM. H. ROEVER.

(*a*) *The curve representing a line of force proceeding from a system consisting of an electrified plane and an electrified line parallel to the plane, is the locus of the intersection of two straight lines having motions in a plane which is perpendicular to the electrified line; one line having a motion of uniform rotation about the electrified line as an axis, and the other a motion of uniform translation perpendicular to itself and parallel to the electrified plane.*

The force at a distance r from an electrified straight line whose charge is λ per unit length is $f = \frac{2\lambda}{r}$. The flow of force from a unit length of line is $\frac{2\lambda}{r} \times 2\pi r = 4\pi\lambda$. Hence the flow of force from a unit length of line between two planes which intersect in the line and make an angle ω with each other is

$$N = 4\pi\lambda \frac{\omega}{2\pi} = 2\lambda\omega.$$

The force at a finite distance from an infinite electrified plane whose charge is σ per unit area is $F = 2\pi\sigma$. Hence the flow

* Read before The Academy of Science of St. Louis, December 7, 1896.

of force from a rectangular portion of this plane whose length is x and whose width is unity is

$$M = 2\pi\sigma x.$$

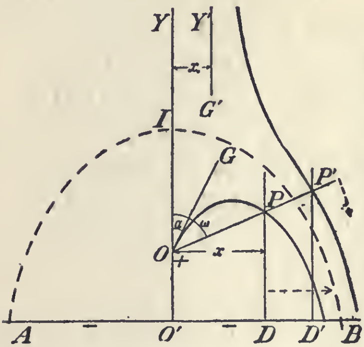

FIG. 1.

In Fig. 1. let O be the trace of an electrified straight line and AB the trace of an electrified plane, both of which are perpendicular to the plane of the paper. Through the line whose trace is O pass two planes, whose traces are OY and OP respectively; OY is perpendicular to AB and OP makes an angle $\omega = \angle YOP$ with OY. Also at a distance $x = O'D$ from O pass a plane whose trace is DP, which is perpendicular to AB. The flow of force through the angle ω from a unit length of the electrified line is

$$N = 2\lambda\omega,$$

in which λ is the charge per unit length of the electrified line whose trace is O. The flow of force through the rectangular prism determined by the planes OY and DP, and two planes perpendicular to the line O and at a unit's distance apart, is

$$M = 2\pi\sigma x,$$

in which σ is the charge per unit area of the electrified plane whose trace is AB. Then if the line and plane have charges of *unlike signs*, the flow of force between the plane OY and the line of intersection P of the planes OP and DP is $N - M = 2\lambda\omega - 2\pi\sigma x$. If in this equation we make $N - M$ constant we confine P to a certain path. This path is the right section of a cylindrical surface which bounds a tube of force. Hence the locus of P is a line of force whose equation is

$$\lambda\omega - \pi\sigma x = K \qquad (1),$$

in which K is a constant. If in equation (1) $x = 0$

$$K = \lambda\omega = \lambda a,$$

in which a is the special value of ω for which $x = 0$. Substituting this value of K, equation (1) becomes

$$\lambda(\omega - a) = \pi\sigma x \qquad (2),$$

which is the equation of a line of force whose direction at O makes an angle a with OY. If in equation (1) $\omega = 0$

$$K = -\pi\sigma x = -\pi\sigma x_0.$$

Substituting this value of K, equation (1) becomes

$$\pi\sigma(x - x_0) = \lambda\omega \qquad (3).$$

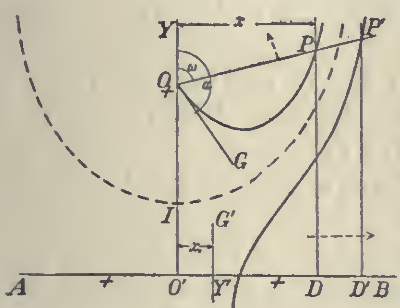

FIG. 2.

This is the equation of a line of force which never reaches O but approaches an asymptote $Y'G'$ (Fig. 1.) which is parallel to OY and at a distance x_0 from O. If, as in Fig. 2, the line and plane have charges of *like signs* the equation of a line of force is

$$\lambda\omega + \pi\sigma x = K' \qquad (4),$$

in which K' is a constant. If in equation (4) $x = 0$

$$K' = \lambda\omega = \lambda a.$$

Substituting this value of K', equation (4) becomes

$$\lambda(\omega - a) = -\pi\sigma x \qquad (5).$$

If in equation (4) $\omega = \pi$

$$K' = \lambda\pi + \pi\sigma x = \lambda\pi + \pi\sigma x_0.$$

Substituting this value of K', equation (4) becomes

$$\pi\sigma\,(x - x_0) = \lambda\,(\pi - \omega) \qquad (6).$$

For $\omega = \pi - \omega'$ and $a = \pi - a'$ equation (5) becomes

$$\lambda\,(\omega' - a') = \pi\sigma x,$$

which is the same as equation (2). Also, for $\omega = \pi - \omega$ equation (6) becomes

$$\pi a\,(x - x_0) = \lambda\omega',$$

which is the same as equation (3). This shows that the lines of force proceeding from a system consisting of an electrified plane and an electrified line parallel to the plane, are curves of the same kind whether the charges are of like or of unlike signs.

Since the force at any point due to an electrified plane is independent of the distance of the point from the plane, it follows that the lines of force of the above system are the same regardless of the distance of the electrified line from the electrified plane.

The preceding equations were obtained from electrical considerations. In what follows it will be shown how they can be obtained from geometrical considerations.

In Fig. 1. O is the trace of an axis of rotation which is perpendicular to the plane of the paper; OP and DP are two straight lines in the plane of the paper. OP rotates about O with a uniform angular velocity a and PD moves in a direction perpendicular to itself, which direction is parallel to AB, with a uniform linear velocity v. If OP rotates about O in a $\left\{\begin{matrix}\text{right handed}\\ \text{left handed}\end{matrix}\right\}$ direction and DP moves to the $\left\{\begin{matrix}\text{right}\\ \text{left}\end{matrix}\right\}$, and if PD has a position OY when OP has a position OG, then the locus of the point of intersection P is expressed by the equation

$$\frac{\omega - a}{a} = \frac{x}{v},$$

in which $\omega = \angle YOP$, $a = \angle YOG$ and $x = O'D$. Now $a = 2\pi n' = \pi n$, in which n is the number of half rotations made by OP in a unit of time. For this value of a the above equation becomes

$$v(\omega - a) = \pi n x \qquad (7).$$

If, however, PD has a position $Y'G'$ (which is parallel to YO and at a distance x_0 from it) when OP has a position OY, then the locus of the point of intersection P' is expressed by the equation

$$\frac{x - x_0}{v} = \frac{\omega}{a}.$$

Putting for a its value πn this equation becomes

$$\pi n (x - x_0) = v\omega \qquad (8).$$

Equations (7) and (8) may be simultaneously expressed in the general form

$$v\omega - \pi n x = K_1 \qquad (9),$$

in which K_1 is a constant.

If, as in Fig. 2, OP rotates about O in a $\left\{\begin{matrix}\text{left handed}\\ \text{right handed}\end{matrix}\right\}$ direction and PD moves to the $\left\{\begin{matrix}\text{right}\\ \text{left}\end{matrix}\right\}$, and if PD has a position OY when OP has a position OG, then the locus of the point of intersection P is expressed by the equation

$$v(\omega - a) = -\pi n x \qquad (10).$$

If, however, OP has a position OO' when DP has a position $G'Y'$, then the locus of the point of intersection P' is expressed by the equation

$$\pi n (x - x_0) = v (\pi - \omega) \qquad (11).$$

Equations (10) and (11) may be simultaneously expressed in the general form

$$v\omega + \pi n x = K_1' \qquad (12),$$

in which K_1' is a constant.

Equations (9) and (12) represent identical curves in the same manner as do equations (1) and (4).

Equations (2), (3), (5), (6) have the same forms as equations (7), (8), (10), (11) respectively and this shows: —

I. That the curve representing a line of force proceeding from a system consisting of an electrified plane and an electrified line parallel to the plane, is the locus of the intersection of two straight lines having motions in a plane which is perpendicular to the electrified line; one line having a motion of uniform rotation about the electrified line as an axis, and the other a motion of uniform translation perpendicular to itself and parallel to the electrified plane.

II. That the constants σ, λ, v and $a = \pi n$ are related by the equation

$$\frac{\lambda}{\sigma} = \frac{\pi v}{a} = \frac{v}{n} \qquad (13).$$

III. That if the electrified line be considered as being above the electrified plane

1. The system having electric charges of unlike signs corresponds to the case in which OP has $\left\{ \begin{matrix} \text{right handed} \\ \text{left handed} \end{matrix} \right\}$ rotation and PD has a motion to the $\left\{ \begin{matrix} \text{right} \\ \text{left} \end{matrix} \right\}$. Fig. 1.

2. The system having electric charges of like signs corresponds to the case in which OP has $\left\{\begin{matrix}\text{left handed}\\ \text{right handed}\end{matrix}\right\}$ rotation and PD has a motion to the $\left\{\begin{matrix}\text{right}\\ \text{left}\end{matrix}\right\}$. Fig. 2.

Fig. 3 shows the lines of force proceeding from a system consisting of one electrified plane AB and an electrified line O parallel to this plane.* In the figure $\frac{\lambda}{\sigma\pi} = \frac{v}{n\pi} = r_0 = OI.$ These are the curves that would be seen by looking at the wheel of a passing wagon through a picket fence. In this

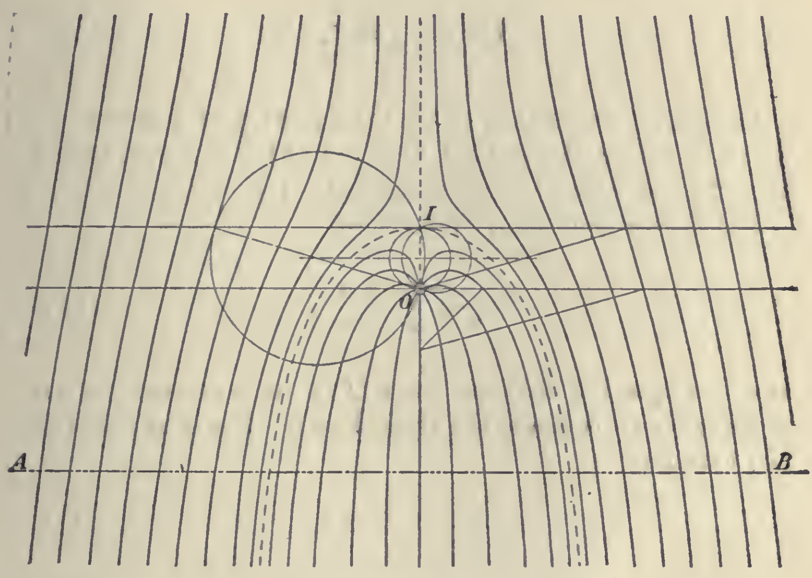

FIG. 3.

case, however, the concave portions of the curves would be upward regardless of the direction in which the wagon is moving, so long as the wheel receives its rotary motion by rolling on the ground.

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* The lines of force do not extend beyond (below in Fig. 3.) the electrified plane, but terminate in it. The equations, however, represent curves which extend indefinitely beyond the electrified plane.

For $a = 0$ equation (2) becomes

$$\lambda\omega = \pi\sigma x \qquad (14).$$

This result is also obtained by making $x_0 = 0$ in equation (3). This is the equation of the *limiting* or *critical line.* This line is the right section of the cylindrical surface, which separates the lines of force terminating in the electrified line from those which never reach it. In Fig. 3 the dashed line whose vertex is I is the critical line. The critical line must cut OY in a point at which the force due to the electrified plane balances that due to the electrified line. For this point

$$OI = r_0 = \frac{\lambda}{\pi\sigma} \qquad (15).$$

Inspection shows that (2) is the equation of a line of force which is *inside* the critical line and (3) is the equation of a line of force which is *outside* the critical line.

For $\omega = \pi$ equation (2) becomes

$$x_1 = \frac{\lambda}{\sigma} - \frac{a}{\pi}\frac{\lambda}{\sigma} \qquad (16),$$

in which x_1 is the distance from O to the asymptote of a line of force which is inside the critical line. For $\omega = \pi$ equation (3) becomes

$$x_{11} = \frac{\lambda}{\sigma} + x_0 \qquad (17),$$

in which $x_{11} - x_0$ is the distance between the two parallel asymptotes to a line of force which is outside the critical line. For $a = 0$ equation (16) becomes

$$x'_1 = \frac{\lambda}{\sigma} = \pi r_0 \qquad (18),$$

which is also obtained by making $x_0 = 0$ in equation (17). Hence the distance from O to the asymptote of the critical line is x_1'.

For $\omega = \frac{\pi}{2}$ equation (3) becomes $x - x_0 = \frac{1}{2}\frac{\lambda}{\sigma}$; from equation (17) $x_u - x_0 = \frac{\lambda}{\sigma}$. This shows that a line of force outside the critical line and the two asymptotes of this line of force cut two equal intercepts from the line OX, which passes through O and is parallel to AB.

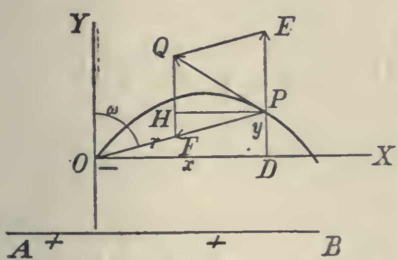

FIG. 4.

In Fig. 4. let O, as before, be the trace of the electrified line and AB the trace of the electrified plane. Through O draw OX parallel to AB and OY perpendicular to AB. At any point P draw the arrows $PE = 2\pi\sigma$ and $PF = \frac{2\lambda}{r}$ representing the forces due to the electrified plane and the electrified line respectively. On PE and PF construct the parallelogram $PEQF$; the diagonal PQ will represent the magnitude and direction of the resulting force at P. PQ is the tangent to a line of force at the point P. Then if $OP = r$, $PD = y$, $OD = x$ and $\angle YOP = \omega$ the slope of PQ is

$$S = \frac{dy}{dx} = -\frac{QH}{HP} = -\frac{PE - FH}{HP} = -\frac{2\pi\sigma - \frac{2\lambda}{r}\cos\omega}{\frac{2\lambda}{r}\sin\omega}.$$

But $\cos\omega = \frac{y}{r} = \frac{y}{\sqrt{x^2 + y^2}}$ and $\sin\omega = \frac{x}{r} = \frac{x}{\sqrt{x^2 + y^2}}$;

therefore

$$S = \frac{dy}{dx} = \frac{\lambda y - \pi\sigma(x^2 + y^2)}{\lambda x} \qquad (19).$$

When integrated this expression becomes

$$\lambda \text{ arc sin } \frac{x}{\sqrt{x^2 + y^2}} - \sigma\pi x = C$$

or

$$\lambda\omega - \pi\sigma x = C,$$

in which C is the constant of integration. This is the same as equation (1). It shows that the analogy of considering force as flowing is correct.

The slope of a line of force at any point (x, y) is given by equation (19), which written in another form is

$$\left(y - \frac{1}{2}\frac{\lambda}{\pi\sigma}\right)^2 + \left(x + \frac{1}{2} S \frac{\lambda}{\pi\sigma}\right)^2 = \frac{1}{4}\frac{\lambda^2}{\pi^2\sigma^2}\left(1 + S\right)^2 \quad (20),$$

or

$$r = r_0 (\cos\omega - S \sin\omega) \qquad (20a).$$

If S is a constant this is the equation of a circle which passes through O $(x = 0, y = 0)$ and I $\left(x = 0, y = \frac{\lambda}{\pi\sigma}\right)$. This shows that a circle passing through O and I cuts lines of force in points at which they (the lines of force) have the same slope S. The slope of a tangent to this circle at the point O is S. For $S = 0$ equation (20) becomes

$$\left(y - \frac{1}{2}\frac{\lambda}{\pi\sigma}\right)^2 + x^2 = \frac{1}{4}\frac{\lambda^2}{\pi^2\sigma^2},$$

which is the equation of a circle whose diameter is $OI = r_0 = \frac{\lambda}{\pi\sigma}$. This circle cuts lines of force in points at which they have no slope. Fig. 3 shows several of the circles. The perpendicular bisector of OI is the locus of the centres of all the circles.

Fig. 3 shows that all the lines of force which are outside the critical line have points of inflection. For the locus of such points of inflection

$$\frac{d^2\lambda}{dx^2} = \frac{d}{dx}\left(yx^{-1} - \frac{\pi\sigma}{\lambda}\left(x + y^2x^{-1}\right)\right)$$

$$= \frac{\frac{2\pi^2\sigma^2}{\lambda}\, y\,(x^2 + y^2) - 2\pi\sigma\,(x^2 + y^2)}{\lambda x^2} = 0 \quad (21).$$

Therefore

$$y = \frac{\lambda}{\pi\sigma} = r_0 = OI, \quad \text{or} \quad r = \frac{r_0}{\cos\omega}$$

or the locus of the points of inflection is a straight line parallel to AB and passing through I.

A circle through O and I cuts each line of force which is outside the critical line in two points at which the slopes are the same. Hence the point of inflection must be between these two points. As the two points approach each other they approach the point of inflection, and reach it simultaneously. Therefore a circle through O and I is tangent to some line of force at its point of inflection.

If S is the slope of a tangent then

$$S' = -\frac{1}{S} = -\frac{dx}{dy} = \frac{\lambda x}{\pi\sigma\,(x^2 + y^2) - \lambda y}$$

is the slope of a normal at the same point. The equation of a normal at the point (x', y') is

$$y - y' = \frac{\lambda x'}{\pi\sigma\,(x'^2 + y'^2) - \lambda y'}\,(x - x') \quad (22).$$

If $y' = \frac{\lambda}{\pi\sigma}$ this equation becomes

$$y = \frac{\lambda}{\pi\sigma} + \frac{\lambda x'}{\pi\sigma\left(x'^2 + \frac{\lambda^2}{\pi^2\sigma^2}\right) - \frac{\lambda^2}{\pi\sigma}}\,(x - x').$$

The intercept of this line on the axis OY is $y = 0$. Therefore normals to the lines of force at their points of inflection pass through the origin O.

If $y' = 0$ equation (22) becomes

$$y = \frac{\lambda}{\pi\sigma x'}\,(x - x').$$

The intercept of this line on the axis OY is $y = -\frac{\lambda}{\pi\sigma} = -r_0$.

Therefore normals to lines of force at points in which they are cut by the axis OX pass through a point in the axis OY which is as far below O as I is above O.

If we assume that the rotating line OP (Fig. 1.) extends in both directions from its axis and that ω can have any value from minus infinity to plus infinity, equation (1) represents a curve which has an infinite number of branches, of which only

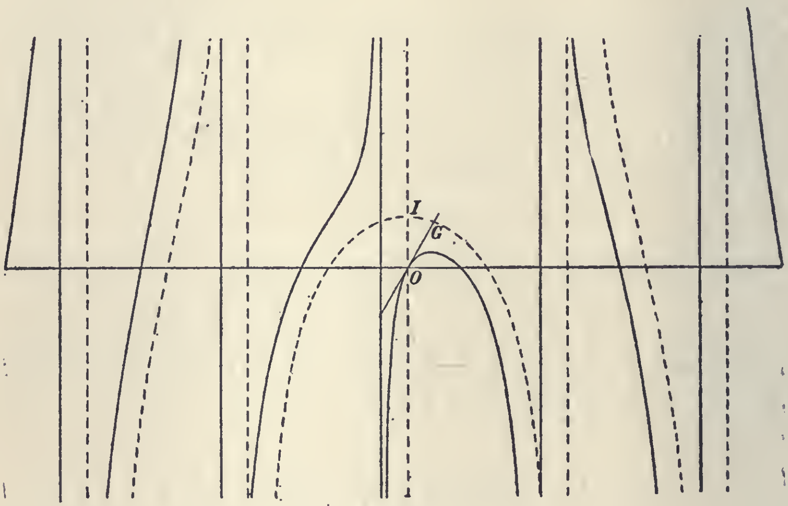

FIG. 5.

one passes through the point O. Fig. 5, which explains itself, shows a portion of the complete curve represented by equation (1).

In order to investigate this curve for asymptotes put for the

1st asymptote		$\omega = \pi$
2nd	"	$\omega = 2\pi$
n_ath	"	$\omega = n_a \pi$

then for the n_ath asymptote equation (2) becomes

$$x_a = n_a \frac{\lambda}{\sigma} - \frac{a}{\pi} \frac{\lambda}{\sigma} \qquad (23)$$

or if we consider equation (3) put for the

1^{st} asymptote		$\omega = 0$
2^{nd}	"	$\omega = \pi$
n_a^{th}	"	$\omega = (n_a - 1)\pi$

then for the n_a^{th} asymptote equation (3) becomes

$$x_a = (n_a - 1)\frac{\lambda}{\sigma} + x_0 \qquad (24),$$

in which x_a is the distance from O to the n_a^{th} asymptote. For $n_a = 1$ equation (23) becomes $x_a = \frac{\lambda}{\sigma} - \frac{a}{\pi}\frac{\lambda}{\sigma} = x_1$, which is the same as equation (16). For $n_a = 1$ equation (24) becomes $x_a = x_0$. Equations (23) and (24) show that $x_0 = \frac{\lambda}{\sigma}(1 - \frac{a}{\pi})$, in which a is the angle which the tangent at O makes with OY. The dashed curve (Fig. 5) is a portion of the complete curve of which the critical line is a part. For $a = 0$ equation (23) becomes $x'_a = n_a \frac{\lambda}{\sigma}$ and for $x_0 = 0$ equation (24) becomes $x_a' = (n_a - 1)\frac{\lambda}{\sigma}$ in which x'_a is the distance from O to the n_a^{th} asymptote of the dashed curve.

(*b*) *The curve representing a line of force proceeding from a system consisting of an electrified plane and an electrified point, is the locus of the intersection of two straight lines having motions in a plane which passes through the electrified point and is perpendicular to the electrified plane; one line having a motion of rotation about the electrified point and the other a motion of translation perpendicular to itself and parallel to the electrified plane. The rotation is such that the versine of the angle which the rotating line makes with O Y (a line which passes through the electrified point and is perpendicular to the electrified plane) changes at a uniform rate, and the translation is such that if the moving line were the meridian line of a* *cylinder of revolution whose axis is OY, the area of cross-section of the cylinder would change at a uniform rate.*

The force at a distance r from an electrified point whose charge is m is $f = \frac{m}{r^2}$. The flow of force through a circular cone whose vertex is m and whose semi-angle is ω is

$$N = \frac{m}{r^2} \times 2\pi (1 - \cos \omega) r^2 = 2\pi m \text{ versin } \omega.$$

The flow of force from a circular area of an electrified plane whose charge is σ per unit area is

$$M = 2\pi\sigma \times \pi x^2,$$

in which x is the radius of the circle.

In Fig. 1. let O represent the electrified point and AB the trace of the electrified plane which is perpendicular to the plane of the paper. Through O draw two lines, one YO perpendicular to the plane AB and the other OP making an angle $\omega = \angle YOP$ with YO. Also at a distance $x = O'D$ from O draw a line PD parallel to YO. The flow of force from the mass m through the circular cone whose axis is OY and whose meridian line is OP is

$$N = 2\pi m \text{ versin } \omega.$$

The flow of force through the circular cylinder whose axis is OY and whose meridian line is PD is

$$M = 2\pi^2\sigma x^2.$$

Then if the point and plane have charges of *unlike signs* the flow of force through the circle of intersection of the cone and the cylinder is $N - M = 2\pi m \text{ versin } \omega - 2\pi^2\sigma x^2$. If $N - M$ is constant the circle of intersection is confined to a definite path. This path is the bounding surface to a tube of force, and the meridian curve of this tube must be a line of force. Hence the equation of a line of force is

$$m \text{ versin } \omega - \pi\sigma x^2 = K \qquad (25),$$

in which K is a constant. If in equation (25) $x = 0$

$$K = m \text{ versin } \omega = m \text{ versin } \alpha,$$

in which α is the special value of ω for which $x = 0$. Substituting this value of K, equation (25) becomes

$$m (\text{versin } \omega - \text{versin } \alpha) = \pi\sigma x^2 \qquad (26).$$

For $\omega = 0$ equation (25) becomes

$$K = -\pi\sigma x^2 = -\pi\sigma x_0^2.$$

Substituting this value of K, equation (25) becomes

$$\pi\sigma (x^2 - x_0^2) = m \text{ versin } \omega \qquad (27).$$

If the point and plane have charges of *like signs* the equation of a line of force is

$$m \text{ versin } \omega + \pi\sigma x^2 = K' \qquad (28),$$

in which K' is a constant. For $x = 0$ this equation becomes

$$K' = m \text{ versin } \alpha.$$

Substituting this value of K', equation (28) becomes

$$m (\text{versin } \omega - \text{versin } \alpha) = -\pi\sigma x^2 \qquad (29).$$

For $\omega = \pi$ equation (28) becomes

$$K' = 2m + \pi\sigma x_0^2$$

Substituting this value of K', equation (28) becomes

$$\pi\sigma (x^2 - x_0^2) = m (2 - \text{versin } \omega) \qquad (30).$$

For versin $\omega = 2 -$ versin ω' and versin $\alpha = 2 -$ versin α' equation (29) becomes

$$m\ (\text{versin}\ \omega' - \text{versin}\ \alpha') = \pi\sigma x^2,$$

which is the same as equation (26). Also, for versin $\omega = 2 -$ versin ω' equation (30) becomes

$$\pi\sigma\ (x^2 - x_0^2) = m\ \text{versin}\ \omega',$$

which is the same as equation (27). This shows that the lines of force proceeding from a system consisting of an electrified plane and an electrified point are curves of the same kind whether the changes are of like or of unlike signs. (Figs. 1 and 2.) In this case also the lines of force are the same regardless of the distance of the electrified point from the electrified plane.

The preceding equations were obtained from electrical considerations. In what follows it will be shown how they can be obtained from geometrical considerations.

In Fig. 1. the straight line OP rotates about O and the straight line PD moves in a direction perpendicular to itself, which direction is parallel to AB. OP rotates about O in such a manner that the versine of the angle ω, which it makes with OY (a perpendicular to AB, through O), changes at a uniform rate. This motion could be brought about mechanically by making OP the center line or axis of a crank to be driven by a slotted crosshead, which has a slot perpendicular to and a uniform linear motion parallel to OY. Let s denote the length of stroke of the crosshead and u the portion of that stroke through which the crosshead moves in a unit of time. Then su is the velocity of the crosshead. PD moves in such a manner that if it were the meridian line of a circular cylinder whose axis is OY, the area of cross section of this cylinder would change at a uniform rate. Let $\Delta = \pi v^2$ denote the increment by which this area changes in a unit of time. Then if PD starts from a position of coincidence with OY, its distance from OY at the end of a unit of time will be $x = v$. Now if OP rotates in a $\left\{ \begin{matrix} \text{right handed} \\ \text{left handed} \end{matrix} \right\}$ direction and

PD moves to the $\left\{\begin{matrix}\text{right}\\ \text{left}\end{matrix}\right\}$, and if PD has a position OY when OP has a position OG, then the locus of the point of intersection P is expressed by the equation

$$\frac{\frac{s}{2}(\text{versin}\,\omega - \text{versin}\,\alpha)}{su} = \frac{\pi x^2}{\varDelta}$$

or

$$v^2(\text{versin}\,\omega - \text{versin}\,\alpha) = 2ux^2 \qquad (31),$$

in which $\omega = \angle YOP$, $\alpha = \angle YOG$ and $x = O'D$. If, however, OP has a position OY when PD has a position $Y'G'$, then the locus of the point of intersection P' is expressed by the equation

$$\frac{\pi x^2 - \pi x_0^2}{\varDelta} = \frac{\frac{s}{2}\,\text{versin}\,\omega}{su}$$

or

$$2u(x^2 - x_0^2) = v^2\,\text{versin}\,\omega \qquad (32),$$

in which x_0 is the distance between the parallel lines YO and $Y'G'$. Equations (31) and (32) may be simultaneously expressed in the general form

$$v^2\,\text{versin}\,\omega - 2ux^2 = K_1 \qquad (33),$$

in which K_1 is a constant. If, as in Fig. 2, OP rotates about O in a $\left\{\begin{matrix}\text{left handed}\\ \text{right handed}\end{matrix}\right\}$ direction and PD moves to the $\left\{\begin{matrix}\text{right}\\ \text{left}\end{matrix}\right\}$, and if PD has a position OY when OP has a position OG, then the locus of the point of intersection is expressed by the equation

$$v^2(\text{versin}\,\omega - \text{versin}\,\alpha) = -2ux^2 \qquad (34).$$

If, however, OP has a position OO' when PD has a position

$G'Y'$, then the locus of the point of intersection is expressed by the equation

$$2u\,(x^2 - x_0^2) = v^2\,(2 - \text{versin}\,\omega) \qquad (35).$$

Equations (34) and (35) may be simultaneously expressed in the general form

$$v^2\,\text{versin}\,\omega + 2ux^2 = K'_1 \qquad (36),$$

in which K'_1 is a constant.

Equations (33) and (36) represent identical curves.

Equations (26), (27), (29), (30) have the same forms as equations (31), (32), (34), (35) respectively, and this shows: —

I. That the curve representing a line of force proceeding from a system consisting of an electrified plane and an electrified point, is the locus of the intersection of two straight lines having motions in a plane which passes through the electrified point and is perpendicular to the electrified plane; one line having a motion of rotation about the electrified point and the other a motion of translation perpendicular to itself and parallel to the electrified plane. The rotation is such that the versine of the angle which the rotating line makes with OY (a line which passes through the electrified point and is perpendicular to the electrified plane) changes at a uniform rate, and the translation is such that if the moving line were the meridian line of a cylinder of revolution whose axis is OY, the area of cross section of the cylinder would change at a uniform rate.

II. That the constants σ, m, v and u are related by the equation

$$\frac{m}{\sigma} = \frac{\pi v^2}{2u} = \frac{\Delta}{2u} \qquad (37).$$

III. That if the electrified point be considered as being above the electrified plane

1. The system having electric charges of unlike signs corresponds to the case in which OP has $\left\{\begin{matrix}\text{right handed}\\ \text{left handed}\end{matrix}\right\}$ rotation and $P\,D$ has a motion to the $\left\{\begin{matrix}\text{right}\\ \text{left}\end{matrix}\right\}$. Fig. 1.

2. The system having electric charges of like signs corresponds to the case in which OP has $\left\{\begin{matrix}\text{left handed}\\ \text{right handed}\end{matrix}\right\}$ rotation and $P\,D$ has a motion to the $\left\{\begin{matrix}\text{right}\\ \text{left}\end{matrix}\right\}$. Fig. 2.

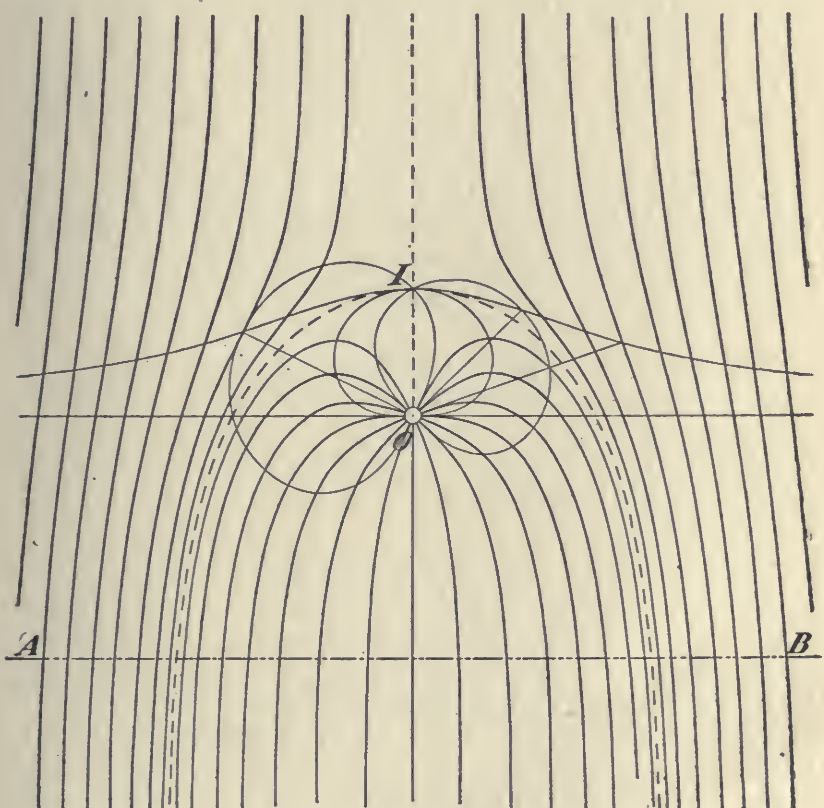

Fig. 6.

Fig. 6 shows the lines of force proceeding from a system consisting of an electrified plane AB and an electrified point O.

For $\alpha = 0$ equation (26) becomes

$$m \text{ versin } \omega = \pi\sigma x^2 \qquad (38).$$

This result is also obtained by making $x_0 = 0$ in equation (27). This is the equation of the *limiting* or *critical line.* This line is the meridian curve of the surface of revolution which separates the lines of force terminating in the electrified point from those which never reach it. The dashed line in Fig. 6 is the critical line. For the point I in which the critical line cuts OY, $\frac{m}{r^2} = 2\pi\sigma$ or

$$OI = r_0 = \sqrt{\frac{m}{2\pi\sigma}} \qquad (39).$$

Inspection shows that (26) is the equation of a line of force which is *inside* the critical line and (27) is the equation of a line of force which is *outside* the critical line.

For $\omega = \pi$ equation (26) becomes

$$x_1^2 = \frac{m\,(2 - \text{versin } \alpha)}{\pi\sigma} \qquad (40),$$

in which x_1 is the distance from O to the asymptote of a line of force which is inside the critical line. For $\omega = \pi$ equation (27) becomes

$$x_{11}^2 = \frac{2m}{\pi\sigma} + x_0^2 \qquad (41),$$

in which $(x_{11} - x_0)$ is the distance between the two parallel asymptotes to a line of force which is outside the critical line.

For $\alpha = 0$ equation (40) becomes

$$x'_1 = \sqrt{\frac{2m}{\pi\sigma}} = 2r_0 \qquad (42),$$

which is also obtained by making $x_0 = 0$ in equation (41).

Hence x'_1 is the distance from O to the asymptote of the critical line.

For $\omega = \frac{\pi}{2}$ equation (27) becomes $\pi x^2 - \pi x_0^2 = \frac{m}{\sigma}$; from equation (41) $\pi x_{11}^2 - \pi x_0^2 = \frac{2m}{\sigma}$. This shows that a line of force outside the critical line and the two asymptotes to this line of force are meridian curves of co-axial surfaces of revolution which cut from a plane OX (through O and parallel to plane AB) two annuli of equal areas.

In Fig. 4. let O represent the electrified point and AB the trace of the electrified plane. Through O draw OX parallel to AB and OY perpendicular to AB. At any point P draw the arrows $PE = 2\pi\sigma$ and $PF = \frac{m}{r^2}$ representing the forces due to the electrified plane and the electrified point respectively. On PE and PF construct the parallelogram $PEQF$; the diagonal PQ will represent the magnitude and direction of the resulting force. PQ is tangent to a line of force at P. Then from the figure the slope of PQ is

$$S = \frac{dy}{dx} = -\frac{QH}{HP} = -\frac{PE - FH}{HP} = -\frac{2\pi\sigma - \frac{m}{r^2}\cos\omega}{\frac{m}{r^2}\sin\omega}$$

But

$$\cos\omega = \frac{y}{r} = \frac{y}{\sqrt{x^2+y^2}} \quad \text{and} \quad \sin\omega = \frac{x}{r} = \frac{x}{\sqrt{x^2+y^2}}$$

Therefore,

$$S = \frac{dy}{dx} = \frac{my - \pi\sigma\,(x^2+y^2)^{\frac{3}{2}}}{mx} \qquad (43).$$

When integrated this expression becomes

$$m\left(-1 + \frac{y}{\sqrt{x^2+y^2}}\right) + \pi\sigma x^2 = C$$

or

$$m \text{ versin } \omega - \pi\sigma x^2 = C,$$

in which C is the constant of integration. This is the same as equation (25). It shows that in this case also, the analogy of considering force as flowing is correct.

When S is constant (43) is the equation of a curve which cuts lines of force in points at which they (the lines of force) have the same slope S. The polar equation of this curve, when referred to O as a pole and OY as an initial line, is

$$r = \pm r_0 \sqrt{\cos \omega - S \sin \omega} \qquad (43a).$$

This equation represents a curve which has two loops, one of which is represented by + and the other by —. (Fig. 6.) The + loop alone has the property of cutting lines of force in points at which they have the same slope. For $\omega = 0$, $r = \pm r_0$. This shows that the plus loop cuts OY in I and the minus loop cuts OY in a point which is as far below O as I is above O. For $r = 0$, $\cos \omega = S \sin \omega$ or $\cot \omega_1 = S$. This is the equation of a tangent at O. The curve is symmetrical with respect to this tangent. This tangent is parallel to the tangents to lines of force at points in which they are cut by the plus loop. When r is a maximum $\sin \omega = - S \cos \omega$ or $\tan \omega_2 = - S$. This shows that the longest radius vector is perpendicular to the tangent at O. For $\omega = \omega_2 + \omega'$ equation (43a) becomes

$$r = \pm r_0 (1 + S^2)^{\frac{1}{4}} \sqrt{\cos \omega'} \qquad (43b)$$

in which $r_1 = r_0 (1 + S^2)^{\frac{1}{4}}$ is the longest radius vector. Equation (43b) represents the curve referred to O as a pole and its longest radius vector as an initial line. Since $\cos (+\omega') = \cos (-\omega')$ it follows that the longest radius vector is an axis of symmetry. For $S = 0$ either equation (43a) or equation (43b) becomes

$$r = \pm r_0 \sqrt{\cos \omega} \qquad (43c).$$

Since $\tan \omega_2 = - S$, $\cos \omega_2 = \dfrac{1}{\sqrt{1 + S^2}} = \dfrac{r_0^{\,2}}{r_1^{\,2}}$ or dropping the subscripts

$$r = \pm \frac{r_0}{\sqrt{\cos\ \omega}} \qquad (43d).$$

This equation represents the locus of the verticies of the curves represented by equation (43a).

Fig. 6 shows curves represented by the equations:

$r = r_0 \sqrt{\cos\ \omega - 2 \sin\ \omega}$, $\quad r = r_0 \sqrt{\cos\ \omega + \sin\ \omega}$,
and $r = r_0 \sqrt{\cos\ \omega}$, $\quad$ in which $OI = r_0$.

Fig. 6 shows that all the lines of force which are outside the critical line have points of inflection. For the locus of such points

$$\frac{d^2y}{dx^2} = \frac{d}{dx}\left(\frac{y}{x} - \frac{2\pi\sigma}{m}\frac{(x^2+y^2)^{\frac{3}{2}}}{x}\right) =$$

$$\frac{6\pi\sigma}{m}\frac{(x^2+y^2)^{\frac{3}{2}}}{x^2}\left(\frac{2\pi\sigma}{m}(x^2+y^2)^{\frac{1}{2}}\,y - 1\right) = 0 \qquad (44)$$

Therefore,

$$y\sqrt{x^2+y^2} = \frac{m}{2\pi\sigma} \quad \text{or} \quad yr = r_0^{\,2} \qquad (45)$$

or

$$r = \pm \frac{r_0}{\sqrt{\cos\ \omega}} \qquad (45a).$$

Equation (45a) represents a curve which has two branches. The plus branch is the locus of the points of inflection. The curve is symmetrical with respect to the axis OY and the branches are symmetrical with respect to the axis OX. For $\omega = 0$, $r = \pm\ r_0$ and for $\omega = \frac{\pi}{2}$, $r = \pm\ \infty$. Hence the locus of the points of inflection passes through I and approaches the axis OX as an asymptote. (Fig. 6.)

Equation (45a) is the same as equation (43d). Hence the locus of the points of inflection is the locus of the verticies of the curves represented by equation (43a). The second form of equation (45) suggests an easy method of construction.

The curve represented by equation (43) is tangent to some line of force at its point of inflection.

The slope of a normal to a line of force at the point (x', y') is

$$S' = -\frac{1}{S} = \frac{mx'}{2\pi\sigma\,(x'^2 + y'^2)^{\frac{3}{2}} - my'}$$

Hence the equation of a normal is

$$y - y' = \frac{mx'}{2\pi\sigma\,(x'^2 + y'^2)^{\frac{3}{2}} - my'}\,(x - x') \qquad (46).$$

The condition that the point (x', y') shall be a point of inflection is $y'\sqrt{x'^2 + y'^2} = \frac{m}{2\pi\sigma}$. For this condition equation (46) becomes

$$y = y' + \frac{y'}{x'}\,(x - x'),$$

from which $y = 0$ when $x = 0$. This shows that normals to lines of force at their points of inflection pass through the origin O.

If in this case also we assume that the rotating line extends in both directions from its axis and that ω can have any value from minus infinity to plus infinity, we get results analogous to those reached in case (a). It will be convenient in the following discussion to designate by the word *travel* (for short, *trav*) the distance moved through by the slotted cross-head while the crank moves through a corresponding angle. This word (*travel*) may be used as an angular function. Trav ω = versin ω when $\omega < \pi$.* Equation (25) written in the form

$$m \text{ trav } \omega - \pi\sigma x^2 = K$$

* See Trans. Acad. Sci. of St. Louis. Vol. VII. No. 9. Page 224.

represents a curve which has an infinite number of branches, of which only one passes through O. (Fig. 7.)

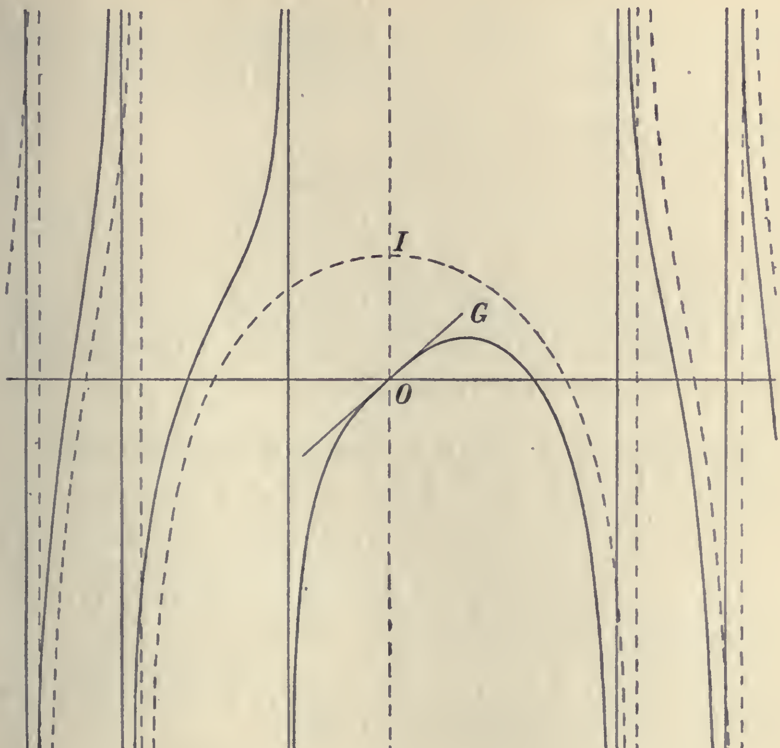

FIG. 7.

In order to investigate this curve for asymptotes put for the

1^{st} asymptote		trav $\omega = 2$
2^{nd}	"	trav $\omega = 4$
n_a^{th}	"	trav $\omega = 2n_a$

then for the n_a^{th} asymptote the equation m (trav ω — versin a) $= \pi\sigma x^2$ becomes

$$x_a{}^2 = 2n_a \frac{m}{\pi\sigma} - \frac{m}{\pi\sigma} \text{ versin } a \qquad (47)$$

or if we consider the equation $\pi\sigma (x^2 - x_0^2) = m \text{trav } \omega$ put for the

1st asymptote		trav $\omega = 0$
2nd	"	trav $\omega = 2$
n_a^{th}	"	trav $\omega = (n_a - 1)\, 2$

then from the above equation

$$x_a^2 = 2\,(n_a - 1)\,\frac{m}{\pi\sigma} + x_0^2 \qquad (48),$$

in which x_a is the distance from O to the n_a^{th} asymptote. For $n_a = 1$ equation (47) becomes the same as equation (40). For $n_a = 0$ equation (48) becomes $x_a^2 = -\frac{2m}{\pi\sigma} + x_0^2$. The dashed curve (Fig. 7) is a portion of the complete curve of which the limiting line is a part. For $a = 0$ equation (47) becomes $x'_a = 2n_a\frac{m}{\pi\sigma}$ and for $x_0 = 0$ equation (48) becomes $x'_a = 2\,(n_a - 1)\,\frac{m}{\pi\sigma}$, in which x'_a is the distance from O to the n_a^{th} asymptote of the dashed curve.

A comparison of case (b) with case (a) will show a complete analogy of the corresponding equations.

Issued January 19, 1897.

RESULTS OF DOUBLE STAR OBSERVATIONS MADE WITH THE EQUATORIAL OF THE MORRISON OBSERVATORY.

Henry S. Pritchett.

During the summer of 1896, by permission of the Director, Professor C. W. Pritchett, I was enabled to use the $12\frac{1}{2}$ inch equatorial of the Morrison Observatory in observing double stars. The following observations made at that time were in continuation of a systematic series of measures of double stars begun at this observatory in 1880.

The observations made in 1880, 1881 and 1884, together with a description of the instrument, the method of observing and the value of the micrometer screw are printed in Vol. I. of the publications of the Morrison Observatory.

It may be said in brief that the eyes were held so that the line joining them was either parallel to or perpendicular to the line joining the stars.

Just before the measures were begun the micrometer had been fitted with Burnham's illuminating apparatus, a gift to the observatory from its founder, Mrs. Morrison-Fuller.

An observation on each night consisted of from 3 to 5 settings of the position-circle and two readings of the double distance.

PROBABLE ERROR.

The probable error of a single observation, both in position-angle and distance, is shown in the following table. The observations have been separated into two groups, the first including all measures in which the distance was less than 2″, and the second, measures in which the distance exceeded that limit.

These groups are denoted below by the letters A and B, and the probable errors in position-angle and distance by p_a

and p_s respectively. The resulting values of these probable errors are as follows:—

Group.	Average Distance.	p_a	p_s
A	1″.7	± 1°.71 = ± 0″.049	± 0″.073
B	4 .2	± 0 .61 = ± 0 .042	± 0 .067

These results show a greater accuracy in the settings of the position-circle which give the relative directions of the component stars than in the settings of the micrometer which determine their angular distance apart. This experience is so general among double star observers that there seems little room to doubt the superior accuracy of the measures of position-angle.

PERSONAL EQUATION.

The personal errors which occur in measures of close double stars bear so large a proportion to the quantities measured that the need of investigation of the relative personal errors of observers would seem to be more necessary in this class of observations than in any other. As a basis for such a determination of relative equations by systematic observers of double stars, and the consequent deduction of some sort of systematic corrections which shall render the observations more comparable, the observation from time to time of a selected list of double stars of small relative motion is very desirable. Such lists have been proposed by O. Struwe (Viertel jahrschrift Bd. XI, 227) and by Stone (A. N. 2201). The first of these lists has been well observed by a number of observers and I am at present comparing these observations to determine whether they show systematic differences between the observers.

The results of the comparison as far as I have been able as yet to carry it seem to indicate the following:—

1. Systematic differences between observers do not seem to depend on the aperture of the telescope used.

2. A small per cent of observers (generally when the instruments are of poor definition) measure distances systematically larger than the average.

3. Systematic differences in measures of position-angle seem less serious than in measures of distance. In other words the errors in measurement of position-angle seem mostly accidental.

In illustration the following comparison of the measures of two observers is added. The observations were made by my father and myself in 1880–81, and as the observations refer to practically the same epoch, they are strictly comparable. In the table which follows P denotes C. W. Pritchett and H denotes H. S. Pritchett and the results are given in the sense P-H.

COMPARISONS OF MEASURES OF DISTANCE.

Number of Obs'ns.	Limiting. Distances.	Per Eq. (P-H).
20	Below 1″.5	+ 0″.13
35	1″.5 to 3″.0	+ 0 .12
35	3″.0 to 6″.0	+ 0 .15
32	Above 6″.0	+ 0 .13

COMPARISONS OF MEASURES OF POSITION-ANGLE.

Number of Obs'ns.	Limiting. Pos.-Angles.	Per Eq. (P-H).
33	0° to 90°	— 0°.20
15	90° to 180°	+ 0 .97
25	180° to 270°	— 0 .48
34	270° to 360	+ 0 .28

In these comparisons the distances have been grouped without regard to position-angle, and the position-angles without regard to distance. The individual comparisons however indicate no systematic error in either co-ordinate which is a function of the other.

The results show a systematic difference in measures of distance which is apparently constant for all distances.

The comparison of position-angles on the other hand show small differences (except in one case depending on a small number of observations) and these differences are, I think, purely accidental, in spite of the similarity of sign in the first and third, and second and fourth, quadrants.

The following tables give the individual results. The powers employed were 300, 600 and 800 and these are indicated by the letters C, D and E respectively.

In the Mean Results, which follow the individual observations, I have added for comparison my observations of these same pairs made in 1880, 1881 and 1884.

The Right Ascensions and Declinations refer to the Equinox 1900.0.

Date.	Sid. Time.	Pos. Ang.	Distance.	Eyepiece.	Remarks.
Σ 1998, ξ Scorpii A. B.					
$\alpha = 15^h\ 58^m.9$			$\delta = -11° 5'$		
	h	°	″		
1896.576	16.2	217.91	1.12	D	
Σ 1998, ξ Scorpii $\frac{A+B}{2}$, C.					
1896.567	16.5	62.29	7.18	C	
.576	16.5	65.16	6.90	D	
ν Scorpii A. B.					
$\alpha = 16^h\ 16^m.2$			$\delta = -19° 12'$		
1896.589	16.7	6.60	0.90	E	
.603	17.1	8.23	0.87	E	
ν Scorpii $\frac{A+B}{2}$, $\frac{C+D.}{2}$					
1896.587	17.0	337.90	40.97	C	
ν Scorpii C. D.					
1896.587	17.2	50.13	2.09	C	
.589	17.1	51.90	1.93	D	
.603	17.4	50.90	2.25	E	

Date.	Sid. Time.	Pos. Ang.	Distance.	Eyepiece.	Remarks.

Σ 2021.

$\alpha = 16^h\ 8\ .6$ $\delta = +13°\ 47'$

	h	°	″		
1896.606	17.2	333.60	3.77	E	
.613	17.3	333.84	3.91	E	

Σ 2022.

$\alpha = 16^h\ 8^m.6$ $\delta = +26°\ 55'$

1896.606	17.5	140.52	2.36	E	
.613	17.6	133.55	2.57	E	

Σ 2023.

$\alpha = 16^h\ 9.6$ $\delta = +5°\ 47$

1896.592	16.9	228.76	1.84	C	
.598	17.6	231.36	2.05	D	

Σ 2032, σ Coronae

$\alpha = 16^h\ 10^m.9$ $\delta = +34°\ 7'$

1896.584	16.6	210.90	4.12	D	
.589	17.4	209.93	4.08	C	
.595	17.0	211.10	4.06	D	

Σ 2041.

$\alpha = 16^h\ 20^m.3$ $\delta = +1°\ 28'$

1896.598	17.4	4.00	2.45	D	Good.

Date.	Sid. Time.	Pos. Ang.	Distance.	Eyepiece.	Remarks.

Σ 2055, λ Ophiuchi.

$\alpha = 16^h\ 25^m.9$ $\delta = +2°\ 12'$

Date.	Sid. Time.	Pos. Ang.	Distance.	Eyepiece.	Remarks.
	h	°	″		
1896.581	16.6	48.53	1.61	D	Poor.
.598	17.0	53.33	1.63	D	Good.

Σ 3105.

$\alpha = 16^h\ 26^m.5$ $\delta = -6°\ 50'$

Date.	Sid. Time.	Pos. Ang.	Distance.	Eyepiece.	Remarks.
1896.598	17.0	49.06	0.82	E	

Σ 3107.

$\alpha = 16^h\ 53^m.8$ $\delta = +4°\ 4'$

Date.	Sid. Time.	Pos. Ang.	Distance.	Eyepiece.	Remarks.
1896.592	17.2	96.74	1.34	D	
.598	18.0	95.46	1.38	D	Fair.

Σ 2120.

$\alpha = 17^h\ 0^m.8$ $\delta = +28°\ 14'$

Date.	Sid. Time.	Pos. Ang.	Distance.	Eyepiece.	Remarks.
1896.595	17.1	244.10	6.87	D	
.585	17.3	245.06	6.50	C	

36 Ophiuchi.

$\alpha = 17^h\ 9^m.2$ $\delta = -26°\ 27'$

Date.	Sid. Time.	Pos. Ang.	Distance.	Eyepiece.	Remarks.
1896.567	17.9	192.96	4.06	C	
.612	17.8	196.05	4.18	E	
.632	17.7	194.93	4.04	D	

Date.	Sid. Time.	Pos. Ang.	Distance.	Eyepiece.	Remarks.

Σ 2156.

$\alpha = 17^h\ 18^m.8$ $\delta = -0°\ 45'$

	h	°	″		
1896.581	16.8	36.83	3.32	D	Poor.
.592	17.3	39.26	3.36	D	
.595	17.6	37.00	3.28	D	Good.

Σ 2171.

$\alpha = 17^h\ 23^m.7$ $\delta = -9°\ 55'$

1896.595	17.4	68.13	1.86	D	
.587	17.8	67.93	......	D	

Σ 2173.

$\alpha = 17^h\ 25^m.2$ $\delta = -0°\ 59'$

1896.581	17.1	160.86	1.30	D	
.592	17.5	159.06	0.95	D	Poor.
.598	18.3	165.23	1.42	E	

Σ 2244.

$\alpha = 17^h\ 52^m.0$ $\delta = +0°\ 7'$

1896.581	17.8	278.23	0.94	D	
.598	18.2	275.06	0.87	D	Fair.

Date.	Sid. Time.	Pos. Ang.	Distance.	Eyepiece.	Remarks.

Σ 2220, μ Herculis A. B.

$\alpha = 17^h\ 42^m.5$ $\delta = +27°\ 47'$

Date.	Sid. Time.	Pos. Ang.	Distance.	Eyepiece.	Remarks.
	h	°	″		
1896.584	16.8	243.28	31.93	D	

Σ 2220, μ Herculis B. C.

Date.	Sid. Time.	Pos. Ang.	Distance.	Eyepiece.	Remarks.
1896.584	17.6	50.23	......	D	Poor.
.598	17.6	54.98	......	E	
.606	17.8	52.70	0.70	E	

Σ 2262, τ Ophiuchi.

$\alpha = 17^h\ 57^m.5$ $\delta = -8°\ 11'$

Date.	Sid. Time.	Pos. Ang.	Distance.	Eyepiece.	Remarks.
1896.581	17.4	253.62	2.10	D	Good.
.592	18.0	258.33	1.98	D	Poor.
.595	17.9	257.21	1.93	D	Good.

Σ 2272, 70 Ophiuchi.

$\alpha = 18^h\ 0^m.4$ $\delta = +2°\ 32'$

Date.	Sid. Time.	Pos. Ang.	Distance.	Eyepiece.	Remarks.
1896.567	16.8	290.95	2.36	C	
.576	16.8	291.13	2.34	D	
.581	17.3	288.46	2.14	C	
.592	17.7	286.74	2.12	D	Poor.
.595	18.2	288.91	1.97	D	

Date.	Sid. Time.	Pos. Ang.	Distance.	Eyepiece.	Remarks.

Σ 2286.

$\alpha = 18^h\ 5^m.3$ $\delta = +0°\ 31'$

Date.	Sid. Time.	Pos. Ang.	Distance.	Eyepiece.	Remarks.
	h	°	"		
1896.592	18.2	317.60	2.32	C	Poor.
.595	17.4	315.20	2.14	D	

Σ 2303.

$\alpha = 18^h\ 14^m.6$ $\delta = -8°\ 3'$

Date.	Sid. Time.	Pos. Ang.	Distance.	Eyepiece.	Remarks.
1896.595	17.0	224.23	2.37	D	

Σ 2306, A. B.

$\alpha = 18^h\ 16^m.5$ $\delta = -15°\ 8'$

Date.	Sid. Time.	Pos. Ang.	Distance.	Eyepiece.	Remarks.
1896.606	17.8	220.25	11.54	E	
.612	18.2	220.82	11.58	E	

Σ 2306, B. C.

Date.	Sid. Time.	Pos. Ang.	Distance.	Eyepiece.	Remarks.
1896.606	18.1	73.43	0.83	E	
.612	18.5	59.08	0.81	E	

Σ 2311.

$\alpha = 18^h\ 17^m.5$ $\delta = +11°\ 23'$

Date.	Sid. Time.	Pos. Ang.	Distance.	Eyepiece.	Remarks.
1896.598	18.3	159.06	5.64	D	
.632	18.1	160.00	5.21	D	

Date.	Sid. Time.	Pos. Ang.	Distance.	Eyepiece.	Remarks.

O Σ 358.

$\alpha = 18^h\ 31^m.5$ $\delta = +16°\ 55'$

	h	°	″		
1896.612	18.6	194.37	1.93	E	
.633	18.4	195.30	2.02	E	

Σ 2541.

$\alpha = 19^h\ 31.3$ $\delta = -10°\ 39'$

1896.633	18.9	333.20	4.32	E	

Σ 2545.

$\alpha = 19^h\ 33^m.3$ $\delta = -10°\ 23'$

1896.633	18.6	322.10	3.70	E	

β 151, β Delphini A. B.

$\alpha = 20^h\ 32.9$ $\delta = +14°\ 15'$

1896.633	19.2	1.80	0.45	E	

β Delphini A. D.

1896.633	19.5	333.00	37.23	E	

MEAN RESULTS.

Star.	R. A.	Dec.	Epoch.	No. of Nights.	Pos. Ang.	Dist.
	h m	° ′			°	″
Σ 1998 ξ Librae. A. B.	15 58.9	−11 5	1880.875 1896.576	3 1	189.58 217.91	1.10 1.12
Σ 1998 $\frac{A+B}{2}$. C.			1880.535 1896.571	2 2	65.31 63.72	7.07 7.04
ν Scorpii A. B.	16 16.2	−19 12	1880.549 1896.596	2 2	0.45 7.41	0.51 0.88
ν Scorpii $\frac{A+B}{2}$, $\frac{C+D}{2}$			1880.541 1896.587	1 1	336.31 337.90	40.83 40.97
ν Scorpii C. D.			1880.541 1896.593	1 3	48.46 50.98	1.96 2.09
Σ 2021	16 8.6	+13 47	1881.481 1896.610	2 2	331.96 333.72	3.85 3.84
Σ 2022	16 8.6	+26 55	1881.548 1896.610	1 2	136.61 137.03	2.29 2.46
Σ 2023	16 9.6	+5 47	1881.516 1896.595	2 2	231.44 230.06	1.72 1.94
Σ 2032, σ Coronae.	16 10.9	+34 7	1884.528 1896.589	2 3	204.71 210.64	3.74 4.09
Σ 2041	16 20.3	+1 28	1881.508 1896.598	2 1	5.05 4.00	2.58 2.45
Σ 2055, λ Ophiuchi.	16 25.9	+2 12	1881.516 1896.590	2 2	37.91 50.93	1.48 1.62
Σ 3105	16 26.5	−6 50	1880.556 1896.598	2 1	52.28 49.06	0.65 0.82
Σ 3107	16 53.8	+4 4	1880.556 1896.595	2 2	100.69 96.10	1.33 1.36
Σ 2120	17 0.8	+28 14	1884.556 1896.590	1 2	250.33 244.58	5.52 6.68
36 Ophiuchi.	17 9.2	−26 27	1880.540 1896.604	2 3	200.71 194.65	4.21 4.09
Σ 2156	17 18.8	−0 45	1880.544 1896.589	3 3	34.75 37.69	3.15 3.32
Σ 2171	17 23.7	−9 55	1880.555 1896.591	2 2	68.62 68.03	1.51 1.86
Σ 2173	17 25.2	−0 59	1896.590	3	161.72	1.22

Star.	R. A.	Dec.	Epoch.	No. of Nights.	Pos. Ang.	Dist.
	h m	° ′			°	″
Σ 2244	17 52.0	+0 7	1880.570	2	271.90	1.01
			1896.590	2	276.65	0.91
Σ 2220 A. B.	17 42.5	+27 47	1896.584	1	243.28	31.93
Σ 2220 B. C.			1896.596	3	232.63	0.70
Σ 2262 τ Ophiuchi.	17 57.5	−8 11	1896.589	3	256.39	2.00
Σ 2272 70 Ophiuchi.	18 0.4	+2 32	1884.518	3	35.89	2.18
			1896.582	5	289.24	2.19
Σ 2286	18 5.3	+0 31	1880.551	2	318.25	2.49
			1896.593	2	316.40	2.23
Σ 2303	18 14.6	−8 3	1880.561	2	222.08	2.79
			1896.595	1	224.23	2.37
Σ 2306 A. B.	18 16.5	−15 8	1880.634	3	220.75	12.06
			1896.609	2	220.54	11.56
Σ 2306 B. C.			1880.634	3	64.20	0.91
			1896.609	2	66.25	0.82
Σ 2311	18 17.5	+11 23	1880.573	1	161.56	6.49
			1896.615	2	159.53	5.43
O Σ 358	18 31.5	+16 55	1896.622	2	194.83	1.98
Σ 2541	19 31.3	−10 39	1880.615	2	332.03	3.65
			1896.633	1	333.20	4.32
Σ 2545	19 33.3	−10 23	1880.615	2	320.38	3.56
			1896.633	1	322.10	3.70
β Delphini A. B.	20 32.9	+14 15	1896.633	1	1.80	0.45
β Delphini A. D.			1896.633	1	333.00	37.23

NOTES.

Σ 2021. This is a system apparently in slow orbital revolution.

1829.48	315°.5	3″.20	Σ
54.63	321 .2	3 .67	De
71.42	327 .2	3 .94	Ha
81.48	332 .0	3 .85	P
96.61	333 .7	3 .84	P

Σ 2022. The observations indicate no appreciable change in 40 years. Struve's observation of 1830 appears erroneous.

Σ 3105. The only observations I have found of this close pair are the following: —

1830.91	59°.4	0″.41	Σ
70.05	53 .2	0 .50	De
80.56	52 .3	0 .65	P
96.60	49 .1	0 .82	P

Σ 2120. It has been hitherto difficult to pronounce definitely as to the motion of these stars but the following observations seem to indicate that the change in position — angle and distance is due to a rectilinear movement of the smaller star: —

1829.60	11°.4	3″.83	Σ
51.97	306 .9	2 .19	Σ
67.16	269 .3	3 .26	De
76.50	256 .6	4 .59	Ha
84.56	250 .3	5 .52	P
96.59	244 .6	6 .68	P

Σ 2156. Probably a binary of long period. Change in angle in 77 years only 6°.

Σ 2173. A binary system in quick motion, the plane of the moving body passing nearly through the sun.

Σ 2272 (70 Ophinchi). This is one of the most interesting of the binary systems, and one to which special interest has been drawn by the paper of Dr. See, A. J., 363. The following measures give a very safe position for 1896: —

1896.39	292°.3	2″.19	6n	Hussey
.51	291 .3	2 .40	3n	Aitken
.58	289 .2	2 .19	5n	Pritchett
.66	287 .1	2 .12	9n	Schur
.74	288 .6	2 .19	6n	Leavenworth
1896.59	289 .7	3 .22		Mean

Σ 2286. Has changed but 6° in 65 years.

Σ 2311. Probably a case of rectilinear motion.

1830.30	170°.7	8″.65	Σ
65.50	165 .1	6 .72	De
80.57	161 .6	6 .49	P
96.61	159 .5	5 .43	P

O Σ 358. Probably a binary.

1845.41	227°.0	1″.23	*O. Σ*
71.90	204 .7	1 .72	De
96.62	194 .8	1 .98	P

Σ 2541. The observations of different observers show considerable discrepancies, but the change is due probably to rectilinear motion.

1828.76	343°.3	2″.45	Σ
51.86	338 .4	3 .61	Σ
67.90	331 .5	3 .42	De
80.61	332 .0	3 .65	P
96.63	333 .2	4 .32	P

Issued April 22, 1897.

NORTH AMERICAN BEES — DESCRIPTIONS AND SYNONYMS.*

CHARLES ROBERTSON.

PROSOPIS F.

PROSOPIS ILLINOENSIS Rob.

Prosopis Illinoisensis Robertson, Canadian Entomologist, XXVIII, 138, ♂, 1896.

The spelling of this name in the place cited is a typographical error.

COLLETES Latr.

COLLETES ROBERTSONII D. T.

Colletes punctata Robertson, Trans. Am. Ent. Soc. XVIII, 62, ♂, 1891 (nec Mocs.).

Colletes robertsonii Dalla Torre, Cat. Hym. X, 44, 1896.

COLLETES BREVICORNIS ♂.†

Black, clothed with rather long, thin whitish pubescence; vertex shining, sparsely punctured; clypeus densely punctured, convex; labrum with two median tubercles; mandibles, except base, rufous; antennae short, third joint longest, clavate; mesonotum and scutellum shining, rather strongly punctured, more sparsely on the disc; metathorax with the usual transverse series of pits, a triangular shining space beyond, otherwise reticulated, but surface nearly concealed by long pubescence; wings hyaline, nervures and stigma testaceous, tegulae dull; legs slender, black, with long whitish pubescence, especially on anterior femora and tibiae; apical joints and spurs ferruginous; abdomen shining at base, which is rather strongly punctured, the punctures more dense and finer on following segments; bases of second and third segments somewhat constricted; apical margins of first and sec-

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* Presented by title April 5, 1897.

† All names not followed by author's initial are of new species.

ond segments depressed and somewhat reflexed, the margins of following segments less reflexed, and becoming dull testaceous; narrow fascia on first segment, becoming wider on following; beneath the segments have widely emarginate margins with narrow rather dull fasciae. Length 8 mm.

Illinois; one ♂ specimen.

Easily distinguished by the short antennae having the third joint longest.

Sphecodes Latr.

The males of this genus are often entirely black, or nearly so, and in collections are likely to be found mixed with males of black species of *Halictus*, from which they are sometimes hard to distinguish. From most males of *Halictus* they may be separated by their shorter antennae. From those in which the antennae of the males are short, like *Halictus pectoralis*, the male *Sphecodes* may be distinguished by the flagellum being submoniliform. As a rule the second submarginal cell is narrower than in *Halictus*, and with its sides more parallel, less narrowing towards marginal.

Sphecodes dichrous Smith.

Sphecodes dichroa Smith, Brit. Mus. Cat. Hym. I, 38, ♀ (nec ♂), 1853.
Sphecodes arvensis Patton, Am. Ent. III, 230, ♂♀, 1880.
Halictus scabrosus Provancher, Nat. Can. XIII, 200, ♂, 1882, Faun. Ent. Can., 700.
Sphecodes dichroa Provancher, Nat. Can. XIII, 257, ♀, 1882, Faun. Ent. Can., 724.

I have 19 ♀ and 18 ♂ specimens, and have taken the sexes in copula. Patton says that the female of *S. arvensis* differs from that of *S. dichroa* in having the tip of the abdomen black. He does not state, however, that he had identified that species. The black at tip of the abdomen is sometimes wanting, and, when present, is so variable in extent as to indicate that its presence or absence is of little significance. Provancher's description of the female agrees with that of Patton's *S. arvensis*, while the male is redescribed as an *Halictus*. The male is entirely black, with antennae rather strongly moniliform, the fourth joint longer than the fifth, and longer than the second and third together. The male described by Smith evidently does not belong here.

SPHECODES CONFERTUS Say.

Sphecodes confertus Say, Bost. Jour. I, 392, ♀, 1837, Lec. Edit. II, 771.
Sphecodes falcifer Patton, Am. Ent. III, 230, ♂ ♀, 1880.

I have 48 ♀ specimens. In the female the fourth segment of the abdomen is usually red, but sometimes partly or wholly black. The fifth is usually black, but occasionally almost entirely red. Patton says *S. falcifer* may be distinguished from *S. confertus* by the fourth segment being red. The specimens with only three red segments agree with Say's description in the characters mentioned by him. This species is smaller than *S. dichrous*. The most definite characters are those mentioned by Patton: the unarmed mandibles and the emarginate labrum.

SPHECODES MANDIBULARIS Cress.

Sphecodes mandibularis Cresson, Trans. Am. Ent. Soc. IV, 250, ♀, 1872.
Sphecodes mandibularis Provancher, Addit. Faun. Ent. Can. Hym., 335, ♂♀, 1889.

Twenty-two ♀ and 13 ♂ specimens are referred to this species. The female has the mandibles honey yellow, rufous at tips, inner edge presenting a distinct tooth or dentiform angle; labrum short and rounded, testaceous or black; vertex and disc of mesothorax sparsely punctured, the latter shining and with a greenish reflection; semicircular inclosure of metathorax with a more or less salient rim, coarsely reticulated or with irregular longitudinal rugae; wings hyaline, nervures testaceous or black; flagellum testaceous, especially beneath; legs dull testaceous or black, tarsi paler; abdomen often entirely red, or with the last three segments more or less black. The male has rather conspicuous white pubescence on the sides; flagellum testaceous, somewhat dusky above; wings whitish, with pale nervures, and the tarsi pale; abdomen sometimes entirely black, or with the basal segments more or less yellow.

SPHECODES STYGIUS Rob.

Sphecodes stygius Robertson, Trans. Am. Ent. Soc. XX, 145, ♂♀, 1893.

I refer 12 ♀ and 17 ♂ specimens to this species. This closely resembles *S. mandibularis*. The mandibles in the female are entire or toothed; vertex and mesonotum blacker and more closely punctured than in *S. mandibularis;* antennae, tegulae, wing veins and legs darker. These distinctions are even more evident in the males. The males of *S. mandibularis* have more of the white pubescence, and the abdominal markings are also paler, being yellowish instead of reddish. In the female the abdomen shows the same variations as in *S. mandibularis.*

SPHECODES RANUNCULI.

♀.— Head and thorax black, abdomen entirely red; vertex and face, including clypeus, densely and evenly punctured; mandibles bidentate, rufous towards tips; labrum short, entire; flagellum dull ferruginous beneath; mesonotum closely and strongly punctured, more sparsely on the disc, which is shining; scutellum shining, with a median punctured line; metathorax coarsely reticulated, without defined inclosure, presenting a small truncation; wings hyaline, increasing fuscous clouded towards tips, stigma fuscous, nervures and tegulae exteriorly dull testaceous, second submarginal cell unusually narrowed towards marginal, about one-half; legs black, apical joints of tarsi dull ferruginous; abdomen shining, almost impunctate at base, the punctures increasing in size and number towards the apex; second segment depressed basally. Length 8 mm.

♂.— Resembles the female; antennae, mandibles and labrum blacker; antennae long, second and third joints subequal, fourth usually longer than fifth and longer than second and third together; wings more hyaline, dusky at tips; metathorax presenting a semicircular inclosure with rugae usually longitudinal; mesonotum more closely punctured and with central raised line more evident; seventh segment of abdomen evident, broadly rounded. Length 8 mm.

Illinois, 1 ♀, 8 ♂ specimens.

This species may be distinguished from *S. dichrous* by its smaller size, more dense punctuation of mesonotum and clypeus, and second submarginal cell more narrowing towards marginal.

SPHECODES HERACLEI ♀.

Black, shining, first three abdominal segments red; head coarsely and closely punctured, less closely on clypeus and vertex; the latter with a conspicuous median tubercle reaching from occiput nearly to anterior ocellus; labrum short and rounded, black; mandibles except base rufous, strongly dentate; antennae black; the head and thorax with thin pale pubescence; rather close on collar and tubercles; mesonotum coarsely punctured, the punctures close anteriorly, sparse on the disc; metathorax, as well as the whole thorax beneath, coarsely reticulated, the disc with semi-circular inclosure; wings except base dusky, tegulae and nervures dark; legs black, tibial spurs whitish. Length 7 mm.

Illinois; one specimen.

This species is distinguished from *S. confertus* Say by the punctures of the mesonotum being not "equally close set," by its entire labrum, dentate mandibles, and tuberculate vertex, clouded wings, etc. Other specimens may not show the red color of abdomen to be limited as indicated in the description.

SPHECODES DAVISII ♂.

Black, opaque, the base of abdomen shining; head, thorax and legs with rather long, whitish pubescence, more close on clypeus, cheeks and thorax beneath; mandibles, except base, rufous; antennae dull ferruginous beneath, short, joints increasing in length from second to fourth; fourth and following joints subequal; mesonotum rather closely and strongly punctured, with median and lateral raised lines; metathorax strongly reticulated, with a semicircular inclosure; tegulae testaceous exteriorly; wings hyaline, nervures testaceous, stigma black; legs black, apical joints of tarsi ferruginous; abdomen almost impunctate at base, towards apex closely and finely punctured, first and fourth segments at apex and the second and third entirely ferruginous. Length 10 mm.

Michigan; one ♂ specimen.

Dedicated to Mr. G. C. Davis, of Michigan Agricultural College, from whom the specimen was received. No reliance need be placed on the definite limitation of the red color of abdomen in the description of a single specimen. This is the largest male *Sphecodes* I have seen.

SPHECODES CLEMATIDIS.

♀.— Black, first four segments of abdomen red. Head as broad as thorax; face closely punctured, vertex and clypeus more sparsely punctured; occiput transversely striate; mandibles bidentate, rufous at apex; flagellum dull ferruginous; mesonotum and scutellum shining, with rather sparse punctures, especially on the disc; metathorax coarsely reticulated, disc with semicircular inclosure; wings slightly clouded, more hyaline at base and apex; nervures and tegulae testaceous, stigma dull; second submarginal cell not narrowing above; abdomen shining, almost impunctate, segments 2–4 finely and closely punctured, fifth more coarsely punctured; apical margins of first four segments shining and impunctate, slightly depressed. Length 8 mm.

♂.— Resembles the female; a little more closely punctured; third joint of antennae little longer than second, fourth as long as second and third together and equaling following joints; inclosure of metathorax poorly defined; second submarginal cell more narrowing above; first two abdominal segments yellowish red, third partly so, remaining segments black. Length 6 mm.

Illinois; one ♂, one female specimen.

Somewhat resembles *S. ranunculi*, but is less slender, more sparsely and finely punctured, second submarginal cell not narrowing above, abdomen black at tip, and with second segment not depressed basally.

SPHECODES PYCNANTHEMI ♀.

Head and thorax black, first three, or more, segments of abdomen red; head broad, closely and finely punctured, clypeus black or dull ferruginous, with sparse coarse punctures, labrum semicircular, entire, testaceous; mandibles bidentate or simple, honey yellow or rufous at base, black at tips; flagellum dull ferruginous, more or less testaceous beneath, mesonotum shining, sparsely and rather finely punctured, as well as scutellum; metathorax truncate, disc short, with poorly defined inclosure presenting rather fine irregular longitudinal rugae; below the metathorax is reticulated, but not coarsely so, upper part of truncation with a triangular space which is smooth and shining; wings slightly dusky, nervures, stigma and tegulae rather dull testaceous; legs black or dull ferruginous, abdomen shining, finely punctured towards apex, first three segments red or yellowish red, the remaining segments the same, or blackish. Length 5–6 mm.

Illinois; 2 ♀ specimens.

This species is separated from *S. mandibularis* and *S. stygius* on account of its large size and the unusually short disc of metathorax.

SPHECODES SMILACINAE ♀.

Entirely black, shining; head closely and finely punctured, the clypeus with more coarse sparse punctures; mandibles bidentate, dull rufous; labrum dull testaceous, short, slightly emarginate; flagellum dull testaceous beneath; mesonotum and scutellum shining, sparsely punctured, punctures coarser than on head; disc of metathorax with irregular longitudinal raised lines, smooth and shining beyond; wings fusco-hyaline, nervures, stigma and tegulae dull, second submarginal cell short, hardly narrowed above; legs dull ferruginous; abdomen shining, segments one and two impunctate, third finely punctured at base. Length 5 mm.

Illinois; one ♀ specimen.

HALICTUS Latr.

HALICTUS FOXII Rob.

Halictus gracilis Robertson, Trans. Am. Ent. Soc. XVII, 316, ♂♀, 1890 (nec Morawitz).
Halictus foxii Robertson, Trans. Am. Ent. Soc. XXII, 117, 1895.
Halictus gracillimus Dalla Torre, Cat. Hym. X, 63, 1896.

HALICTUS 4-MACULATUS Rob.

Halictus 4-maculatus Robertson, Trans. Am. Ent. Soc. XVII, 316, ♂♀, 1890.
Halictus macoupinensis Robertson, Trans. Am. Ent. Soc. XXII, 1895.

According to Dalla Torre, Cat. Hym., X, 65, *Halictus quadrimaculatus* Scheuck is the same as *H. interruptus* Panz.

HALICTUS NYMPHAEARUM Rob.

Halictus palustris Robertson, Trans. Am. Ent. Soc. XVII, 317, ♂♀, 1890 (nec. Mor.).
Halictus nymphaearum Robertson, Trans. Am. Ent. Soc. XXII, 117, 1895.
Halictus paludicola Dalla Torre, Cat. Hym. X, 75, 1896.

HALICTUS CEPHALOTES Dalla Torre.

Halictus cephalicus Robertson, Am. Nat. XXVI, 270, ♂♀ 1892 (nec. Mor.).

Halictus cephalotes Dalla Torre, Cat. Hym. X, 57, 1896.

HALICTUS CORIACEUS Sm.

Halictus coriaceus Smith, Brit. Mus. Cat. Hym. I, 70, ♀, 1853.

Halictus subquadratus Smith, Brit. Mus. Cat. Hym. I, 72, ♂, 1853.

HALICTUS LIGATUS Say.

Halictus ligatus Say, Bost. Journ. Nat. Hist. I, 396, ♂♀, 1837, Lec. Edit. II, 774.

Halictus poeyi Lepeletier, Hist. Ins. Hym. II, 271, ♂, 1841, Cuba.

Halictus capitosus Smith, Brit. Mus. Cat. Hym. I, 67, ♀, 1853.

Halictus armaticeps Cresson, Trans. Am. Ent. Soc. IV, 250, ♀, 1872.

Halictus texanus Cresson, Trans. Am. Ent. Soc. IV, 251, ♂♀, 1872.

Halictus ornatipes Cresson, Trans. Am. Ent. Soc. IV, 252, ♂, 1872.

Halictus townsendi Cockerell, Ann. and Mag. Nat. Hist. Ser. 6, XVIII, 293, ♀, 1896.

This is a common, widely distributed and variable species. I have examined specimens from Ct., N. Y., Va., Fla., Cuba, Tenn., Ill., Montana, Wash., Cal., So. Cal. Local specimens vary in length, in the females from 7 to 11 mm., in the males from 6 to 10 mm. The wings are more or less hyaline. Local males have the legs as in Say's description with the middle and hind tibiae spotted, or these parts may be wholly yellow, and even the femora almost entirely so.

Florida specimens, *H. capitosus* Sm., seem to run a little larger, with the wings less hyaline, and the mesonotum a little more finely punctured. They barely form a geographical race, and that is more than can be said of the other forms, as far as present indications go.

H. texanus is based on individuals in which the ground color indicates more or less of ferruginous. Such specimens occur in Illinois, and I have seen them in material from Montana.

HALICTUS SMILACINAE ♀.

Form rather slender; head dark blue green; face densely and finely punctured; clypeus produced, with a purplish reflection, sparsely and coarsely punctured; mandibles rufous at tips; antennae short, the scape long; mesonotum dark green, finely roughened, rather sparsely punctured; metathorax long, strongly retracted, sharply truncate, the truncation subcordate; disc with irregular raised lines reaching the apex; wings hyaline, nervures, stigma, and tegulae exteriorly pale testaceous; legs black or dull ferruginous, pubescence pale; hind spurs with about three long teeth; abdomen black, with slight metallic reflection, shining, segments one and two minutely punctured basally, a triangular patch on each side of base of second, and third and fourth segments clothed with rather close pale pubescence; margins of segments not testaceous. Length 7 mm.

Illinois; two ♀ specimens.

HALICTUS TESTACEUS ♀.

Head and thorax greenish; apex of clypeus, labrum, mandibles, except base, flagellum beneath, nervures, stigma, tegulae, knees, tibiae, except blotches on middle, tarsi and abdomen entirely pale testaceous; face finely and densely punctured, clypeus purplish, more sparsely and coarsely punctured; mesonotum shining, minutely roughened, with minute sparse punctures; metathorax shining, strongly retracted, sharply truncate, posterior face subcordate, disc finely longitudinally roughened; hind spurs with about three long teeth; abdomen shining, with shining margins of segments, impunctate, clothed with thin, pale pubescence, which is more abundant towards apex. Length 5 mm.

Illinois; two ♀ specimens.

AUGOCHLORA Sm.

AUGOCHLORA PURA Say.

Halictus purus Say, Bost. Journ. I, 395, ♀♂, 1837, Lec. Edit. II. 773.
Augochlora pura Smith, Brit. Mus. Cat. Hym. I, 82, 1853.
Augochlora pura Provancher, Nat. Can. XIII, 206, ♀, 1882.
Augochlora pura Provancher, Faun. Ent. Can. Hym., 706, ♀, 1883.
Augochlora labrosa Robertson, Trans. Am. Ent. Soc. XX, 146, ♀♂, 1893.
Augochlora robertsoni Cockerell, Can. Ent. XXIX, 69, 1897.

♀. — Green, reflecting bluish or purplish; abdomen shining, more evidently tinged with brassy or cupreous; head densely and finely punctured, clypeus coarsely and more sparsely punctured, anterior margin black; eyes deeply and rather acutely emarginate; process of labrum subquadrate; middle of mandibles more or less rufous, a greenish spot at base; antennae black, flagellum paler beneath; mesonotum densely and evenly punctured; metathorax with disc short, longitudinally striate, truncation rounded above; wings subhyaline, nervures, stigma and tegulae exteriorly testaceous; legs brownish, sometimes quite black, tibiae and tarsi sometimes ferruginous yellow; hind spurs finely serrate; anterior, and sometimes middle, femora reflecting more or less greenish beneath; narrow margins of abdominal segments black, sometimes wanting, abdomen beneath blackish. Length 7–9.

♂.— Resembles the female, more bluish, more sparsely punctured, labrum and mandibles honey yellow, flagellum beneath and tegulae testaceous, tibiae and tarsi usually yellow, hind tibiae sometimes darker in the middle and reflecting a little metallic, femora bluish or greenish, sometimes with the trochanters quite pale and showing only a little bluish beneath; ventral segments entire, middle ones greenish. Length 6–8 mm.

Illinois, New York, Mass.; 41 ♀, 8 ♂ specimens.

AUGOCHLORA CONFUSA.

Augochlora pura Robertson, Trans. Am. Ent. Soc. XX, 146, ♀♂, 1893.

♀.— Resembles female of preceding, but a little smaller, face and mesonotum reticulated on the sides, face narrower, emargination of eyes less acute; process of labrum smaller, more rounded; mandibles darker, rufous at tips; disc of matathorax longer, more coarsely rugose, sometimes bordered by salient rim; truncation very narrow, rounded above; second submarginal cell short; legs more uniformly dark, all the femora, and sometimes tibiae, metallic; abdomen less shining, more pubescent, segments without black edges, venter usually reflecting greenish.

♂.— Differs from male of preceding in characters common to both sexes, in its clypeus anteriorly and labrum being paler, femora and middle of tibiae darker and more metallic, tarsi, except apical joints, paler, ventral segments not metallic, fourth widely emarginate.

Illinois; 52 ♀, 11 ♂ specimens.

Agapostemon Guerin.

Widely distributed over the United States are four species of this genus, whose females have been described in such a way that it is not difficult to determine them, but whose males have been so inadequately described and identified that the names, even when having distinct priority, can hardly be regarded as available. It is proposed in this paper to adopt the names of the females, and to indicate as fully as possible the characters which distinguish the species.

Agapostemon viridulus F. occurs from Canada to Georgia and west to Washington, Utah and Texas.

Agapostemon radiatus Say occurs from Canada to Georgia and west to Dakota, Kansas and Texas.

Agapostemon splendens Lep. ranges from Canada to Florida and west to Nebraska and Texas.

Agapostemon texanus Cress. is distributed from Massachusetts to Georgia and west to Vancouver and Southern California.

The males are much alike, especially in their ornaments, and these common characters are almost the only ones mentioned in the descriptions, whence the difficulty in determining to which one of the four species the descriptions relate. I shall now indicate the common characters of these males of *Agapostemon*, and in the descriptions under synonyms shall only mention those which are important in making the distinctions between the species.

Head and thorax golden green; mandibles except tips, labrum, clypeus anteriorly and scape in front yellow; flagellum fulvous beneath, joints submoniliform; head and thorax densely punctured; nervures, stigma and tegulae testaceous, the latter with a yellow spot in front, legs yellow, middle and hind tibiae exteriorly, and hind femora at tip above marked with black; abdomen black, middle of first and basal margins of segments 2–5 with yellow fasciae.

In the males of *A. viridulus* and *A. texanus* the abdomen has only five fasciae, while in *A. radiatus* and *A. splendens* it has six. But the apical segments are often retracted so that the sixth fascia is usually concealed, and sometimes also the fifth. Provancher's *A. tricolor*, which is evidently *A. radiatus* ♂ and six banded, is described as having only four fasciae.

AGAPOSTEMON VIRIDULUS F.

Apis viridula Fabricius, Ent. Syst. II, 342, ♀, 1793.
Megilla viridula Fabricius, Syst. Piez., 333, ♀, 1804.
Halictus viridula Say, Bost. Journ. I, 394, ♀, 1837, Lec. Edit. II, 772.
Halictus dimidiatus Lepeletier, Hist. Ins. Hym. II, 283, ♀, 1841.
Agapostemon nigricornis Smith, Brit. Mus. Cat. Hym. I, 86, ♀ (non ♂ ?), 1853.
Augochlora radiata Provancher, Nat. Can. XIII, 205, ♀, 1882.
Augochlora radiata Provancher, Faun. Ent. Can. Hym., 705, ♀, 1883.
Agapostemon viridula Cresson, Synopsis, 309, ♀, 1887.
Agapostemon nigricornis Cresson, Synopsis, 309, ♀, 1887.
Agapostemon bicolor Robertson, Trans. Am. Ent. Soc. XX, 148, ♀♂, 1893.
Agapostemon viridula Robertson, Trans. Am. Ent. Soc. XXII, 118, 1895.
Augochlora radiata Dalla Torre, Cat. Hym. X, 96, *in part*, 1896.
Agapostemon virescens Dalla Torre, Cat. Hym. X, 98, ♀ *in part*, 1896.

♀.— Head and thorax golden green, the abdomen black.

♂.— Wings hyaline; trochanters black, with a more or less greenish reflection; femora black at base behind; front tibiae, except a spot beneath and rarely a small one above, yellow; middle tibiae with a black or fuscous spot exteriorly and within; hind femora hardly more thickened than the others; hind tibiae straight, with a black spot at base, another on middle, sometimes wanting, and a little brownish at tip; metathorax rather evenly reticulated but not coarsely so; abdomen five-fasciate, last ventral segment with central longitudinal carina, third from last of equal length, not thickened or emarginate, segments black with testaceous margins, 2–5 with basal angles more or less yellow, the ventral surface usually two-spotted, often with four, more rarely with 6 or 8 spots. Length 10–12 mm.

90 ♀, 60 ♂ specimens; Can., Vt., N. H., Mass., Ct., N. Y., Pa., Md., Va., N. C., Ga., La., Tex., Mich., Ill., Neb., Ks., Col., Utah, Idaho, Wash.

In the Systema Piezatorum, 333, the *Megilla viridula* is distinctly credited by Fabricius to North America, while his *Apis virescens*, Syst. Ent., 378, is only credited to America. It is an absurd affectation of authority to give this name to the Cuban species, before it is shown that Fabricius did not mean that his species came from the continent of North America, that he did not know where it came from, or that the description of *Apis viridula* does not apply to the North American species. However, the localities in the American part of Dalla Torre's catalogue should always be verified.

Provancher's *Augochlora radiata*, described as having the abdomen "noir bleuatre," evidently belongs here and not under *Agapostemon radiatus*.

AGAPOSTEMON RADIATUS Say.

Halictus radiatus Say, Bost. Journ. I, 394, ♀, 1837, Lec. Edit. II, 772.
Halictus tricolor Lepeletier, Hist. Ins. Hym. II, 289, ♂, 1841.
Augochlora radiata Smith, Brit. Mus. Cat. Hym. I, 80, ♀, 1853.
? *Agapostemon tricolor* Smith, Brit. Mus. Cat. Hym. I, 86, ♂, 1853.
Agapostemon tricolor Provancher, Nat. Can. XIII, 203, ♂, 1882.
Agapostemon tricolor Provancher, Faun. Ent. Can. Hym., 703, ♂, 1883.
Agapostemon radiatus Cresson, Synopsis, 293, ♀, 1887.
Agapostemon radiatus Robertson, Trans. Am. Ent. Soc. XX, 147, ♀♂, in part, 1893.
Augochlora radiata Dalla Torre, Cat. Hym. X, 96, ♀, in part, 1896.

♀.— Golden green; wings hyaline, slightly clouded at apex; disc of metathorax strongly longitudinally rugose, without triangular inclosure.

♂.— Wings hyaline, apical margins slightly clouded; disc of metathorax more irregularly rugose or reticulated, truncation often strongly notched above; trochanters yellow, sometimes dark above and behind, especially the posterior ones; femora at base yellow, or with a slight trace of black, a spot at apex above, sometimes wanting on anterior pair, posterior femora rather strongly incrassate; tibiae at base exteriorly with a black spot extending more or less towards tips, hind tibiae sometimes black at tips and rarely with a spot within; abdomen black, often showing greenish, six banded, ventral segments 2–4 broadly yellow at base, fifth, and sometimes the others, variously narrowed or interrupted, third from the last short, widely emarginate, edges thickened, greenish, last not carinate, with a yellow spot at basal angles, extending more or less towards tips and leaving only a dark median stripe. Length 9–11 mm.

107 ♀, 83 ♂ specimens; Can., N. H., Mass., N. Y., N. J.,

Pa., Del., Md., Va., W. Va., N. C., Ga., La., Tex., Mich., Ill., Dak., Neb., Ks.

Agapostemon texanus Cress.

Agapostemon texanus Cresson, Trans. Am. Ent. Soc. IV, 255, ♀, 1872.
Agapostemon texanus Cresson, Synopsis, 293, ♀, 1887.
Agapostemon texanus Robertson, Trans. Am. Ent. Soc. XX, 147, ♂, 1893.
Agapostemon texanus Dalla Torre, Cat. Hym. X, 97, 1896.

♀.— Golden-green, blue or purplish; mesonotum with a distinct double punctuation.

♂.— Wings hyaline; metathorax rather finely reticulated, presenting a more or less evident triangular space, which is sometimes bluish or purplish and usually more rugose; front and middle trochanters varying from entirely yellow to entirely black, usually yellow beneath and in front, posterior yellow beneath; femora yellow, or black at base behind, extending more or less towards tips; middle ones, and sometimes the anterior, with a spot at tips, sometimes connected with basal spot; hind femora incrassate, the black at base and apex sometimes connected; anterior tibiæ with a brown spot within, and sometimes exteriorly; middle tibiæ with an elongated spot above and beneath, sometimes connected; hind tibiæ black at base, with a stripe exteriorly, sometimes wanting, and another within, towards tips, also sometimes reduced or wanting; abdomen black, showing greenish or bluish on sides and apical margins, five fasciate; ventral segments 2–4 with yellow bands, the rest usually black, third from last widely emarginate, gibbous on the sides and usually greenish in the depressed interval. Length 10–12 mm.

59 ♀, 69 ♂ specimens; Mass., R. I., N. Y., Pa., Va., Ga., Ill., Dak., Neb., Colo., Utah, N. Mex., Ariz., Tex., Nev., Van., Or., Wash., Cal.

This species varies greatly in color and in the extent of the black markings of legs. The thorax above has the pubescence varying from white to nearly fulvous and mixed with black or fuscous.

Agapostemon splendens Lep.

Halictus splendens Lepeletier, Hist. Ins. Hym. II, 283, ♀, 1841.
Agapostemon aeruginosus Smith, Brit. Mus. Cat. Hym. I, 86, ♀, 1853.
Halictus splendens Cresson, Synopsis, 292, 1887.

Agapostemon aeruginosus Cresson, Synopsis, 293, 1887.

Agapostemon nigricornis Robertson, Trans. Am. Ent. Soc. XX, 147, ♀♂, 1893.

Halictus splendens Dalla Torre, Cat. Hym. X, 85, 1896.

Agapostemon aeruginosus Dalla Torre, Cat. Hym. X, 97, 1896.

Agapostemon nigricornis Dalla Torre, Cat. Hym. X, 97, 1896.

♀.— Large, golden-green, the abdomen often showing bluish; metathorax with a triangular space on disc which is less coarsely reticulated; mesonotum densely and finely punctured, or more sparsely and coarsely so; scutellum with large scattered punctures, the intervening spaces densely and finely punctured, or shining and almost impunctate; wings uniformly rufo-hyaline, or the apical margins darker.

♂.— Wings and metathorax as in the female; anterior and middle trochanters yellow, sometimes more or less blackish above and behind, posterior green, subcampanulate; femora yellow, usually with a little blackish at base behind, middle sometimes with spot at tip, posterior strongly incrassate, about one-half as wide as long; anterior and middle tibiae with a brownish streak behind, sometimes wanting on first, hind tibiae black at base, streaked beyond and with a spot at tip exteriorly, a streak towards tips within; abdomen black, with a brown spot at base, six fasciate, ventral segments with yellow basal fasciae, usually wanting on last, third from last short, thickened, widely emarginate, hind metatarsi presenting a dentiform angle. Length 11–13 mm.

25 ♀, 17 ♂ specimens; Can., Mass., N. Y., Pa., Va., N. C., Ga., Fla., Ohio, Mich., Ill., Neb., Ks., Tex.

The following are sex names of any one of the four preceding species. It is fairly impossible to determine them without seeing the insects on which they were based. In that case the first two would probably replace names above adopted.

Apis sericea Förster, Nov. Spec. Ins. I, 91, ♂, 1771.

Andrena nigricornis Fabricius, Ent. Syst. II, 313, ♂, 1793.

Centris nigricornis Fabricius, Syst. Piez., 360, ♂, 1804.

Halictus nigricornis Say, Bost. Journ. I, 394, ♂, 1837, Lec. Edit. II, 772.

Halictus sericea Say, Bost. Journ. I, 394, ♂, 1837, Lec. Edit. II, 772.

Agapostemon tricolor Cresson, Trans. Am. Ent. Soc. IV, 255, ♂, 1872.

Agapostemon nigricornis Cresson, Synopsis, 293, ♂, 1889.

Agapostemon sericea Cresson, Synopsis, 293, ♂, 1889.

Agapostemon sericea Robertson, Trans. Am. Ent. Soc. XXII, 118, ♂ 1895.

Apis sericea Dalla Torre, Cat. Hym. X, 612, ♂, 1896.

The *Apis sericea* Först. may be the male of *A. splendens* on account of the wings being described as "fuscae hyalinae,' but that term might be applied to the other species except the clearest winged examples.

I have supposed that *Andrena nigricornis* F. might be the male of *A. splendens*, as perhaps the commonest species in Georgia and the one to which "femoribus posticis incrassatis" might likely be applied. But this description might be used for any except *A. viridulus*.

A. tricolor Cress. is probably *A. texanus* ♂. In the Am. Ent. Soc. collection I find no other Texan males except one of *A. viridulus*.

I am indebted to Mr. Cresson and Dr. Skinner for the opportunity of examining the specimens of *Agapostemon* contained in the collection of the American Entomological Society.

Andrena F.

Andrena nubecula Sm.

Andrena nubecula Smith, Brit. Mus. Cat. Hym. I, 117, ♀, 1853.

Andrena nubecula Provancher, Addit. Faun. Ent. Can. Hym., 312, ♀, 1888.

♂.— Black, clothed with thin whitish pubescence, that on scutellum more yellowish; head wider than thorax; cheeks strongly produced behind the eyes, rounded and subcarinate posteriorly; face and clypeus closely and finely punctured, the latter with long dense whitish pubescence; basal process of labrum strongly emarginate, presenting two dentiform angles; mandibles long, decussate, rufous at tips; third joint of antennae as long as fifth, longer than fourth, flagellum more or less dull testaceous beneath, vertex finely roughened, shining, almost impunctate, front below ocelli striate; mesonotum almost impunctate, minutely roughened anteriorly, disc, as well as the scutellum, shining; inclosure of metathorax finely roughened, more coarsely so at base; wings hyaline, clouded like the female, but less strongly, marginal cell in front, the tip beyond, the apical margin, and tip of hind wing; nervures and tegulae dull testaceous, stigma darker, second submarginal less than half the length of third, receiving first recurrent nervure about the middle; legs blackish or dull ferruginous, tarsi testaceous; abdomen slender, shining, minutely roughened and almost impunctate, segments 2–5 with margins pale testaceous, barely fringed. Length 6 mm.

Carlinville, Illinois; 18 ♀, 6 ♂ specimens; U. S., Nova Scotia (Smith), Cap Rouge (Prov.), New York (Lintner).

Andrena lauracea ♀.

Black, clothed with thin ochraceous pubescence, paler beneath; head as wide as thorax, striate before ocelli, clypeus somewhat shining, minutely roughened, with sparse, rather large shallow punctures; basal process of labrum small, emarginate; mandibles except base rufous; antennae dull ferruginous at apex beneath, third joint nearly as long as fourth and fifth together; mesonotum with rather sparse shallow punctures, the disc and scutellum more shining; inclosure of metathorax bordered by an impressed line, more rugous centrally and at base, but not strongly so; wings hyaline, nervures and stigma testaceous, tegulae more dull; second submarginal cell less than half as long as third, receiving recurrent near tip; legs blackish at base, dull ferruginous towards tips, scopa ochraceous, floccus paler; abdomen shining, especially towards base, minutely roughened, sparsely, but quite evenly punctured, the punctures less deep and distinct towards apex, apical margins slightly depressed, 2–4 with narrow fasciae, interrupted on second, anal fimbria ochraceous, pygidium rufous. Length 8 mm.

Carlinville, Illinois; one ♀ specimen.

Andrena nothoscordi ♀.

Black, clothed with very thin pale pubescence; head broader than thorax, cheeks rounded, rather strongly produced behind eyes, front before ocelli finely striate; clypeus opaque, minutely roughened, with sparse shallow punctures; basal process of labrum short, truncate or rounded; mandibles except base rufous; antennae short, third joint as long as fourth and fifth together, sixth and following joints ferruginous beneath; mesonotum impunctate, with thin pubescence, shining posteriorly, scutellum somewhat shining; inclosure of methathorax bounded by impressed line, finely roughened;

wings hyaline, nervures, stigma and tegulae exteriorly testaceous; second submarginal cell narrowed above, half as long as third, or longer, receiving recurrent nervure at or before the middle; legs blackish, more or less dull ferruginous towards tips, scopa and floccus thin and whitish; abdomen slightly shining at base, finely roughened, almost impunctate, segments with narrow pale testaceous margins, 2–4 with thin fasciae of whitish pubescence, fimbria subfuscous. Length 7 mm.

Carlinville, Illinois; four ♀ specimens.

This species closely resembles the female of *A. bipunctata* Cr. It may be distinguished by its clypeus not shining, shorter antennae, wider second submarginal, inclosure of metathorax less rugose at base, etc.

Andrena platyparia Rob.

Andrena serotina Robertson, Trans. Am. Ent. Soc. XX. 148, ♂ (non. ♀) 1893.

Andrena platyparia Robertson, Trans. Am. Ent. Soc. XXII, 119, ♂♀, 1895.

Andrena platyparia Rob., race *occidentalis* Cockerell, Ann. & Mag. Nat. Hist. 6, XVIII, 87, ♂ 1896.

The male was described from three specimens, which were not sufficient for indicating the local variations and so formed a poor basis for the foundation of a geographical race. I now have eleven males. It is quite variable. Some specimens show the legs quite black. Even the tarsi and antennae are sometimes quite dark in Illinois and Long Island specimens.

It may prove to be the same as *A. fragilis* Sm., but the description of that species applies even better to *A. salicis* ♂, and nearly as well to *A. mandibularis* ♂.

Carlinville, Illinois, N. Ill. (Nason), New Mexico (Cockerell), Long Island (Mrs. Slosson).

Andrena robertsonii, D. T.

Andrena serotina Robertson, Trans. Am. Ent. Soc. XX, 148, ♀ (non. ♂), 1893 (nec Destefani).

Andrena robertsonii Dalla Torre, Cat. Hym. X, 149, 1896.

Andrena mandibularis Rob.

Andrena mandibularis Robertson, Am. Nat. XXVI, 272, ♂, 1892.

♀.— Black, clothed quite evenly with thin ochraceous pubescence, which is a little paler beneath; head wider than thorax, cheeks produced behind, but not to a salient angle as in the male, face in front of ocelli striate; clypeus finely roughened at base and on the sides, more shining elsewhere, punctures sparse, becoming coarser towards a median impunctate space which widens towards the apex; basal process of labrum nearly semicircular; mandibles rufous at tips; antennae black, third joint as long as fourth and fifth together, or nearly so; mesonotum quite opaque, finely roughened, with obscure shallow punctures; inclosure of metathorax bordered by impressed line, more rugose within; wings fulvo-hyaline, nervures and stigma testaceous, tegulae more dull; first submarginal cell longer than next two together, second half as long as third, receiving recurrent nervure beyond the middle; legs blackish, inclining to dull ferruginous apically, slender, scopa thin; abdomen clothed with thin pubescence, which is longer on basal segment and inclines to form obscure fasciae on the narrow dull testaceous edges of following segments, fimbria thin, fuscous; surface of abdomen, finely roughened, impunctate, somewhat shining. Length 10 mm.

Carlinville, Illinois; 20 ♀, 12 ♂ specimens; Algonquin, Ill. (Nason), Franconia, N. H. (Mrs. Slosson).

The usual specimens have the pubescence pale and quite denuded. The male types were faded. One of my male specimens, as well as the one from New Hampshire, has some black hairs behind the summit of the eyes, as in the male of *A. salicis*.

Andrena g. maculati.

♀.— Black, clothed with thin whitish pubescence; head broader than thorax, cheeks broad and rounded, front before ocelli striate; clypeus minutely roughened, with sparse, coarse, shallow punctures, presenting an irregular transverse ridge before apex; basal process of labrum large, triangular, truncate; mandibles rufous at tips; third joint of antennae longer than next two together, flagellum dull, testaceous beneath; mesonotum minutely roughened, with rather sparse, shallow punctures; inclosure of metathorax finely roughened; wings subhyaline, nervures, stigma and tegulae dull testaceous; second submarginal cell about half as long as third, rather strongly narrowed above, receiving recurrent nervure at, or a little before, the middle; legs slender, blackish, inclining to dull ferruginous on hind tibiae and tarsi; scopa thin and whitish; abdomen shining, faintly roughened and punctured, thinly pubescent, segments 2–4 with thin, narrow, whitish fasciae, anal fimbria fuscous. Length 9 mm.

♂.—Closely resembling the female, the mandibles longer, basal process of labrum subquadrate, cheeks broader, presenting a rounded angle at a point opposite and a little below the middle of the eye, third joint of antennae about equaling next two together, abdomen with margins of the segments narrowly pale testaceous, apex with pale pubescence concealing the ventral process. Length 7–8 mm.

Carlinville, Illinois; 13 ♀, 5 ♂ specimens.

The species is named as above because it seems to depend for pollen upon the flowers of *Geranium maculatum*, whose large grains the thin scopa is well suited for holding.

Andrena arabis ♀.

Black, pubescence of head and thorax thin and pale ochraceous; head not broader than thorax, somewhat produced behind the eyes, hardly striate before ocelli; clypeus finely roughened, opaque, sparsely punctured laterally, in the middle more shining, coarsely punctured and irregularly depressed, sometimes presenting two irregular longitudinal grooves separated by a raised portion; basal process of labrum small, triangular, slightly truncate or emarginate; mandibles except base ferruginous; third joint of antennae as long as next two together, sixth and following joints dull testaceous beneath; mesonotum opaque, finely roughened, with sparse shallow punctures, inclosure of metathorax with rather fine wrinkles extending half way towards apex; wings yellowish hyaline, tips slightly clouded, nervures, stigma and tegulae testaceous, second submarginal cell two-thirds the length of third, receiving recurrent nervure about the middle; legs black, tibiae and tarsi with pubescence inclining to blackish, scopa pale; abdomen at base opaque, finely roughened, with shallow punctures, more shining on fourth and fifth segments, 2–4 with apical fasciae of white pubescence, interupted on second, fimbria fuscous. Length 10 mm.

Carlinville, Illinois, 18 ♀ specimens.

ANDRENA SCUTELLATA D. T.

Andrena scutellaris Robertson, Trans. Am. Ent. Soc. XX, 148, 1893 (nec Morawitz).

Andrena scutellata Dalla Torre, Cat. Hym. X, 151, 1896.

ANDRENA BIPUNCTATA Cress.

Andrena bipunctata Cresson, IV, 259, ♂, 1872.

Andrena flavoclypeata Smith, New Spec. Hym. Brit. Mus., 54, ♂ 1879.

Andrena flavoclypeata Robertson, XVIII, 55, 1891.

The female closely resembles the male and may be readily distinguished from allied species by its clypeus being smooth, shining and impunctate except on the sides.

Through the kindness of Mr. Cresson I have had an opportunity to examine the Texan examples. In the place last cited I indicated the synonymy of the two names, but Cresson's name has the priority.

ANDRENA ZIZIAE Rob.

Andrena ziziae Robertson, XVIII, 55, ♂♀, 1891, in part.

♀.—Black, with an obscure greenish reflection, thinly clothed with pale pubescence; head wider than thorax, finely striate before ocelli; clypeus sometimes dull ferruginous, finely roughened, with sparse, rather coarse, shallow punctures, clothed with thin pubescence; basal process of labrum small, narrow, mandibles honey yellow in middle, rufo-picens at tip; third joint of antennae as long as next two together, or nearly so; flagellum testaceous beneath; lateral depressions of face wide; thorax very thinly clothed with pale pubescence, very sparsely and feebly punctured, finely roughened; inclosure of metathorax wide, rather strongly rogose at base; wings long, yellowish hyaline, nervures, stigma and tegulae testaceous, second submarginal cell half as long as third, or a little wider, receiving recurrent nervure beyond middle; legs blackish or dull ferruginous, often inclining to yellowish; abdomen depressed, impunctate, finely roughened, with an obscure greenish reflection, apical margins of segments pale testaceous, 2–4 with apical fasciae of thin pale pubescence, anal fimbria dirty white. Length 6–7 mm.

♂.—Resembles the female, a little less greenish; clypeus whitish, with a blackish spot on each side, with thin whitish pubescence, basal process of labrum emarginate, mandibles rufous at tips; third joint of antennae shorter than next two together, flagellum testaceous beneath, abdomen with pale testaceous margins broader. Length 5–6 mm.

Carlinville, Illinois; 13 ♀, 4 ♂ specimens.

The sexes were taken in copula. In the original description specimens of this were mixed with the following.

ANDRENA PERSONATA.

Andrena ziziae Robertson, XVIII, 55, ♂♀, 1891, in part.

♀.— The female of this species is distinguished from that of *A. ziziae* by the antennae, mandibles and tegulae being darker; the clypeus darker, more convex, bare, reflecting purplish; lateral facial depressions more narrow, inclosure of metathorax more evenly rugose; second submarginal cell longer, nearly equaling third; receiving recurrent nervure at, or a little before, the middle; legs a little darker, abdomen about the same. Length 6–7 mm.

♂.— Resembles the female; otherwise differs from the male of *A. ziziae* by having a whitish spot on each side of face, also sometimes wanting, or nearly so; antennae long, darker above, brownish testaceous beneath, third joint not longer than fourth. Length 5-6 mm.

Carlinville, Illinois; 19 ♀, 34 ♂ specimens.

ANDRENA HERACLEI ♀.

Black, thinly clothed with pale pubescence; face before the ocelli, smooth and shining, finely and sparsely punctured; lateral depressions of face broad above, at a point about half way between anterior ocellus and antennae strongly narrowed by the encroachment upon it of a smooth and shining portion of the eye margin, the narrow portion being directed a little outward; clypeus shining, closely and coarsely punctured, basal process of labrum subquadrate; mandibles at tips rufous; third joint of antennae shorter than next two together, flagellum more or less dull ferruginous beneath; mesonotum finely roughened, rather closely and strongly punctured, the disc behind slightly shining and more sparsely punctured, in front the mesonotum presents a deep impressed line, with two short lines on each side; scutellum shining and more sparsely punctured in front; metathorax sharply truncate, strongly rugose on the disc, especially the inclosed space, which is poorly defined; wings yellowish hyaline, nervures, stigma and tegulae exteriorly testaceous, second submarginal cell half as long as third, receiving recurrent nervure at, or beyond, the middle; legs black, hind tibiae and middle and hind tarsi dull ferruginous, scopa pale; abdomen shining, rather closely and finely punctured, apical margins of segments narrowly dull testaceous, without pubescent fasciae, 2–4 medially depressed nearly two-thirds their width, anal fimbria fulvous. Length 10–11 mm.

Carlinville, Illinois; 9 ♀ specimens.

In its facial grooves this species resembles *A. nuda* and *A. rugosa*. The second segment of abdomen is not so widely depressed as in those species.

Parandrena.

This is proposed as a new genus of *Andrenidae* for the reception of *Panurgus andrenoides* Cress. It has all of the characters of *Andrena* except that the wing has two submarginal cells.

Parandrena andrenoides Cress.

Panurgus andrenoides Cresson, Trans. Am. Ent. Soc. VII, 62, ♂, 1878.
Panurgus nevadensis Cresson, Trans. Am. Ent. Soc. VII, 214, ♂, 1879.
Panurgus ? andrenoides Robertson, Trans. Am. Ent. Soc. XXII, 121, ♂♀, 1895.

Carlinville, Illinois; 28 ♀, 36 ♂ specimens; Col., Nev., Tex. (Cress.).

This is little more than a section of *Andrena*, only showing as a constant character what is an occasional variation in that genus, for some specimens of *Andrena* have the second and third submarginal cells united in one or both wings. *Halictus anomalus* and *Sphecodes antennariae* have only two submarginal cells in the few specimens known. Some individuals of *Sphecodes mandibularis* show the same variation.

Parandrena wellesleyana.

♀.— Differs from female of preceding in its somewhat larger size, tooth of mandibles nearer the apex, basal process of labrum more spinous, clypeus more strongly punctured, median line more elevated, space on metathorax more rugose, wings clearer, second submarginal cell longer, receiving second recurrent farther from apex, abdomen black in three specimens before me. Length 9–10 mm.

♂.— Besides the characters common to both sexes, differs from the male of preceding in its clypeus being more flat, the sixth segment broader above and beneath, the angles of the latter more strongly reflexed and more evident above. Length 9 mm.

Wellesley, Mass. (A. P. Morse); 3 ♀, 2 ♂, specimens.

Macropis Panz.

Macropis morsei.

♂.— Black, shining, clothed with thin pubescence which is pale except on the mesonotum, where it is blackish and on tarsi beneath where it is more or less fulvous; middle of face rather closely punctured, vertex on each side of ocelli smooth, shining and impunctate; the clypeus, a small spot on each side in the lower corner of the face, and sometimes a spot on base of mandibles yellow; apex of mandibles rufous; flagellum dull testaceous beneath, fourth joint of antennae about one-half as long as third, fifth about as long as third and fourth together and a little shorter than following joints; mesonotum shining and rather sparsely punctured; base of metathorax shining and impunctate; wings subhyaline, nervures, stigma and tegulae dull testaceous, second submarginal cell receiving recurrent nervures near base and apex, narrowing about one-half above; legs blackish, joints 2–4 of tarsi ferruginous, hind tibiae simple, quite different from those of *M. ciliata* and *patellata;* abdomen shining and impunctate, apical margins of segments depressed, second and following segments with thin fasciae of whitish pubescence; ventral segments smooth and shining, apical margins narrowly pale testaceous and wholly without ciliae. Length 7 mm.

♀.— Resembles the male, more sparsely punctured; tibiae exteriorly with pale pubescence, less evident on anterior pair, long dense and white on posterior pair; basal joints of tarsi fuscous above, ferruginous beneath, more black on posterior, the latter sometimes mixed with white hairs basally, joints 2–4 ferruginous, paler on hind tarsi; anal fimbria blackish medially. Length 6–7 mm.

Mass., N. Y. (A. P. Morse), Mich. (Nason); 5 ♂, 2 ♀ specimens.

This is quite distinct from *M. ciliata* and *patellata*. The female of *M. patellata* is unknown or mixed with that of *M. ciliata*. It is impossible to describe the female so that it can be distinguished. *M. andrenoides* Sm. and *M. longilingua* Prov. are sex names which can hardly be identified. These five names no doubt belong to three species.

M. steironematis is nearly twice as large and differs from all in having the abdomen closely and strongly punctured.

Panurgus Panz.

Panurgus novae-angliae ♂.

Black, shining, finely punctured; pubescence above black, mixed with paler on clypeus, middle of face and scutellum, beneath paler, mixed with black on cheeks and legs; clypeus produced, transverse, densely pubescent; labrum short, broad, finely roughened; mandibles rufous at tips; antennae submoniliform, black, dull ferruginous beneath, fourth joint longer than following joints and longer than 2 and 3 together; face closely, vertex sparsely punctured; mesonotum sparsely punctured, disc of metathorax rather strongly rugose; wings except base fusco-hyaline, nervures, stigma and tegulae dark; second submarginal cell about as long as first, narrowing about one-third above, receiving recurrent nervures near base and apex; legs dull ferruginous, tarsi somewhat paler; hind trochanters strongly produced behind into a mammiform process, the femora thickened; tibiae arcuate, thickened towards apex and presenting a small tooth on the lower edge; abdomen minutely punctured, apical margins of segments subdepressed, narrowly pale testaceous; last ventral segment shining, presenting a median elevation which terminates in a long spine, and has a shorter tooth on each side. Length 7–8 mm.

Mass., Ct. (A. P. Morse); 2 ♂ specimens.

PANURGUS MARGINATUS Cress.

Panurgus marginatus Cresson, Trans. Am. Ent. Soc. VII, 62, ♀, 1878.
Panurgus halictulus Cresson, Trans. Am. Ent. Soc. VII, 63, ♂, 1878.
Panurgus autumnalis Robertson, Trans. Am. Ent. Soc. XXII, 121, ♀, 1895.

Carlinville, Illinois, 27 ♀, 7 ♂ specimens; Ks., Col., Utah (Cresson).

NOMADA Scop.

NOMADA BELLA Cress.

Nomada bella Cresson, Proc. Ent. Soc. Phil. II, 287, ♂, 1863.
? *Nomada bella* Provancher, Addit. Faun. Ent. Can. Hym., 333, ♂, 1888.

♀. — Mandibles simple; fourth joint of antennae longer than third or fifth; ferruginous, tips of mandibles, antennae above, middle of face, vertex, cheeks behind, three broad bands on mesonotum uniting before scutellum, pleura beneath wings extending in a broad band on each side of metathorax, broad middle of latter, coxae, trochanters, femora at base behind, hind femora largely, hind tibiae behind and their metatarsi, base of abdomen and apical margins of segments 1–3, more or less black; a spot on each side of segments 2–3, four spots on fourth, and two spots, separated or united, on disc of fifth segment, yellow; wings a little more clouded than in the male. Length 9 mm.

Carlinville, Illinois; 2 ♀, 7 ♂ specimens; Mass., Ct. (Cresson).

NOMADA SUPERBA Cress.

Nomada superba Cresson, Proc. Ent. Soc. Phil. II, 281, ♂, 1863.

♂. — The spots on pleura and collar often wanting. Length 10–13 mm.

♀. — Resembles the male, the wings more clouded, spot on pleura larger, sometimes another small one present; orbit entirely bordered, or nearly so; spots on scutellum united, sometimes also in the male a line on post-scutellum; the face and all of the ornaments below largely tinged with rufous, sometimes all of the ornaments are red except the bands of abdomen above; mesonotum black, or with two or four rufous lines. Length 12–13 mm.

Carlinville, Illinois; 14 ♀, 18 ♂ specimens; Col. (Cress).

The metathorax on each side is produced into a dentiform process. The band on first segment is often indented posteriorly.

Nomada integerrima D. T.

Nomada integra Robertson, Trans. Am. Ent. Soc. XX, 276, ♂♀, 1893 (nec Brulle).

Nomada integerrima Dalla Torre, Cat. Hym. X, 353, 1896.

Nomada viburni ♂.

Black, thinly clothed with whitish pubescence; face below antennae, except two black spots in suture on each side of clypeus above, mandibles except tips, scape in front, narrow anterior orbits to summit of eye, posterior orbits two-thirds to the summit, yellow; flagellum fulvo-ferruginous and with the scape blackish above; mandibles simple; a large spot on pleura extending upwards to tubercles and sometimes backwards, tubercles, tegulae, line on collar, two spots on scutellum, sometimes united, line on postscutellum, and a spot on each side of metathorax below, yellow; coxae yellow in front, black behind; front legs yellow in front, ferruginous behind, the tibiae with a black spot; middle legs similar; hind legs ferruginous, the femora blackish behind; wings hyaline, apical margins slightly clouded, nervures and stigma honey yellow; abdomen black at base, first segment with a fulvo-ferruginous band containing a small yellow spot on each extreme side, 2–5 brownish with broad yellow bands, narrowed on the disc, apical segment emarginate, abdomen beneath with four broad yellow bands, the last segment with a yellow spot. Length 8–9 mm.

Carlinville, Illinois; 2 ♂ specimens.

In both specimens the first transverse cubital nervure is wanting.

Nomada erigeronis ♀.

Black, very closely and coarsely punctured; pubescence thin except a line about tubercles and on collar and sides of metathorax; head below antennae, except mandibles at tips, wide anterior and narrow posterior orbits, nearly meeting on vertex, antennae, except flagellum above, legs, except posterior femora and tibiae behind, irregular patch on pleura, collar, tubercles, tegulae, line above, two lines on mesonotum before scutellum, a tubercle on each side before scutellum, the latter and postscutellum, and abdomen beneath rufo- or fulvo-ferruginous; mandibles simple, fourth joint of antennae nearly one-third longer than third or fifth, tegulae strongly punctured, scutellum bilobed; wings fuliginous, nervures fuscous, stigma ferruginous; abdomen very broad, depressed, basal half of first segment black with a yellow or ferruginous band beyond, finely and sparsely punctured at base, the punctures coarse and close at apical margin; second segment densely punctured, except on the sides, where it is more sparsely punctured and gibbous owing to the strongly depressed apical margin, yellow except a narrow line on disc and the apical margin, the latter as well as margins of two following segments somewhat reflexed; segments three and four with a yellow spot on each side, the fifth with a broad cross band, beneath the abdomen is very strongly, coarsely and densely punctured, the second and third segments reflexed. Length 10 mm.

Carlinville, Illinois; one ♀ specimen.

This is a cyanide specimen, which I have kept for nine years in hopes of finding other examples. Some of the yellow ornaments have turned red. The spots on abdomen are yellow, and I think the sides of face and collar were originally so. In the strong punctuation of abdomen it differs remarkably from any *Nomada* I have seen.

Epeolus Latr.

Epeolus lunatus Say.

Epeolus lunatus Say, Long's 2nd Exped. II, 354, ♀ (non ♂), 1824, Lec. Edit. I, 240.

Epeolus lunatus Cresson, Proc. Ent. Soc. Phil. II, 394, ♂♀, 1864.

I have 32 ♀, 28 ♂ specimens. As a rule both sexes have the three basal joints of antennae, labrum, base of mandibles, tegulae and legs black, as in 23 ♂ and 18 ♀ specimens. Less frequently these parts are more or less rufous, as in 5 ♂ and 14 ♀ specimens. Say described the red-legged female and the male of *E. concavus*, which has black legs. Cresson described red-legged females and black-legged males. My collection would not show so large a proportion of red-legged specimens but for the fact that I have given away and thrown away black-legged specimens, selecting the others and even looking out for them in the field.

EPEOLUS CONCAVUS Cress.

Epeolus lunatus Say, Long's 2nd Exped. II, 354, ♂ (non ♀), 1824, Lec. Edit. I, 240.

Epeolus concavus Cresson, Trans. Am. Ent. Soc. VII, 85, ♀, 1878.

Carlinville, Illinois; 26 ♀, 9 ♂ specimens; N. Mex., Cal., Ga., La. (Cress.).

The characters indicated by Say for the ♂ of his *E. lunatus* — "Anterior half of the thorax with much of the pale yellowish color; bands of the tergum larger than those of the female and one more in number" (i. e. five fasciate) — are exactly the characters which distinguish the male of *E. concavus* from the true male of *E. lunatus*. In *E. lunatus* and *E. remigatus* the ♀ has the abdomen with four fasciae, and cinereous spots on the fifth segment, the ♂ six fasciate. In *E. concavus* ♀ the abdomen is four-fasciate, the fifth segment black, and the ♂ is five-fasciate.

EPEOLUS BIFASCIATUS Cress.

Epeolus bifasciatus Cresson, Proc. Ent. Soc. Phil. III, 38, ♂, 1864.

? *Epeolus fumipennis* Say, Bost. Journ. I, 403, 1837, Lec. Edit. II, 779.

In Say's description lines on the thorax are mentioned three times. They are not mentioned in Cresson's description of *E. bifasciatus*. In 19 ♂♀ specimens before me they are entirely wanting, as well as the whitish lateral edges.

EPEOLUS SCUTELLARIS Say.

Epeolus scutellaris Say, Long's 2nd Exped. II, 355, ♀, 1824, Lec. Edit. I, 240.

Epeolus zonatus Smith, Brit. Mus. Cat. Hym. II, 257, ♀♂, 1854.

Epeolus scutellaris Provancher, Addit. Faun. Ent. Can. Hym. 332, ♀, 1888.

Inverness, Florida; 1 ♀, 2 ♂, specimens; Pa., Ark. (Cress.), Can. (Prov.), Fla. (Smith).

Smith says the male differs in having the apex of the clypeus and only the basal segment of abdomen ferruginous. In the above specimens the abdomen has two basal segments ferruginous, as in the female. The males have the clypeus entirely black, while in the female the apex is ferruginous.

The importance of the encroachment of red or ferruginous on the black ground color (as distinguished from red ornaments which occupy the place of yellow ornaments in allied species) is almost universally exaggerated. It is a common thing in Florida insects.

EPEOLUS CRESSONII.

? *Epeolus mercatus* Fabricius, Systema Piezatorum, 389, 1804.
Epeolus mercatus Cresson, Trans. Am. Ent. Soc. VII, 88, ♀♂, 1878.

Common and polymorphous, varying in size and form from that of *E. pusillus* to a slender specimen of *E. donatus*, or a stout example of *E. remigatus*. The ferruginous color extends to second and third joints of antennae, tubercles and lateral spines of scutellum, or is entirely wanting, except on mandibles, and a tinge on tegulae, tibiae and tarsi; wings yellowish, with honey yellow nervures, or clear, with nervures black; fasciae 2–4 apical and continuous, or submarginal, more or less, and interrupted; small examples a little more coarsely punctured. Length ♀, 8–12 mm; ♂, 8–11 mm.

The true *E. mercatus* F. is quite as likely to be *E. pusillus* Cress. or *E. compactus* Cress. both of which were found by Mr. Fox in New Jersey. They are common in Illinois.

EPEOLUS HELIANTHI ♀.

Black, middle of mandibles with a rufous spot, sides of labrum, third joint of antennae and tegulae sometimes dull ferruginous, front legs blackish, their tibiae more or less ferruginous, their tarsi and middle and hind legs, fulvo-ferruginous, spurs black; pubescent marks as in *E. donatus*, but more yellowish, the abdominal fasciae 2–4 broader and more even; pleura with a broad L-shaped mark extending from the tegulae downwards and forwards to the front margin, then backwards horizontally and ending abruptly, not arcuate and pointed as in *E. lunatus*, etc.; scutellum subbilobate, lateral tooth moderate, wings subhyaline, nervures blackish; middle of fifth segment with fuscous pubescence. Length 10 mm.

Carlinville, Illinois; five ♀ specimens.

Distinguished by the pubescent mark on pleura, the front legs being unusually dark for a red-legged species.

Epeolus pectoralis ♀.

This species agrees in most respects with the preceding; the front legs and tegulae more ferruginous, though sometimes quite dark; base of abdomen more pubescent; pleura with the pubescent patch quite thin and irregular, below smooth, shining, coarsely and sparsely punctured; mesothorax above densely and finely punctured. Length 9–10 mm.

Carlinville, Illinois; seven ♀ specimens.

This is a very ordinary looking species, but the pleura is punctured as in *E. lectus* and *E. bifasciatus*.

Coelioxys Latr.

Coelioxys rufitarsis Sm.

Coelioxys rufiitarsus Smith, Brit. Mus. Cat. Hym. II, 271, ♂, 1854.
Coelioxys dubitata Smith, Brit. Mus. Cat. Hym. II, 272, ♀, 1854.
Coelioxys rufitarsus Cresson, Proc. Ent. Soc. Phil. II. 400, ♂, 1864.
Coelioxys dubitata Cresson Proc. Ent. Soc. Phil. II, 400, ♀, 1864.
Coelioxys rufitarsus Provancher, Faun. Ent. Can. Hym., 725, ♂ ♀, 1883.
Coelioxys dubitata Dalla Torre, Cat. Hym. X, 485, 1896.
Coelioxys rufitarsis Dalla Torre, Cat. Hym. X, 493, 1896.

Can., U. S. (Cress.).

My efforts in matching the sexes of the local species convince me that Smith and Cresson were correct in supposing that *C. dubitata* is the female of *C. rufitarsis*.

Coelioxys 8-dentata Say.

Coelioxys 8-dentata Say, Long's 2nd Expedit. II, 353, ♂, (ex. var. *a*), 1824, Lec. Edit. I, 239.
Coelioxys brevis Cresson, Proc. Ent. Soc. Phil. II, 402, ♂♀, 1864 (nec Eversm.).
Coelioxys altilis Cresson, Trans. Am. Soc. VII, 219, 1879.
Coelioxys cressonii Dalla Torre, Cat. Hym. X, 485, 1896.

The characters indicated by Say for his typical form (i. e., excluding var. *a*) — thorax with a dentated band before, interrupted in the middle, feet rufous, segments of abdomen each with a transverse indented line, the fasciae more distinct, tinged with yellow, and the abdomen opaque in the male — are exactly the characters in which the male of this species is to be distinguished from the following. The abdomen of male appears more opaque from being more strongly punctured. But Say was comparing with a female to which it did not belong.

Inverness, Florida; Carlinville, Illinois; 43 ♀, 26 ♂ specimens; U. S. (Cress.).

I have taken the sexes in copula.

Coelioxys sayi.

Coelioxys 8-dentata Say, Long's 2nd Expedit. II, 353, ♂ Var. *a*, 1824, Lec. Edit. I, 239.

Coelioxys 8-dentata Say, Bost. Journ. I, 400, ♀, 1837, Lec. Edit. II, 777.

Coelioxys 8-dentata Cresson, Proc. Ent. Soc. Phil. II, 401, ♂♀, 1864.

Carlinville, Illinois; Inverness, Florida; 11 ♀, 27 ♂ specimens; Can., U. S. (Cress.).

The female is most readily distinguished by its clypeus being subbilobate. The male may be distinguished from that of the preceding by the interrupted fascia on mesonotum being less evident, darker legs, abdomen more shining, more sparsely punctured, segments less indented transversely, fasciae less evident and whiter.

Coelioxys modesta Sm.

Coelioxys modesta Smith, Brit. Mus. Cat. Hym. II, 271, ♀, 1854.

Coelioxys modesta Cresson, Proc. Ent. Soc. Phil. II, 404, ♀, 1864.

♂.— Easily matched with female by the first segment of abdomen being carinate at the edge of the wide concavity and being fasciate on basal and apical margins, last segment narrow, the fossa quite longitudinal, the teeth being unusually approximated, the interval with black or fuscous hairs; mandibles black, or rufous in middle, legs ferruginous, varying to more or less black, especially apical joints of hind tarsi. Length 9–11 mm., ♀ 10–12 mm.

Carlinville, Illinois, 8 ♀, 12 ♂ specimens; Pa., N. Y., Mex., (Cress.).

Coelioxys totonaca Cress.

Coelioxys totonaca Cresson, Trans. Am. Ent. Soc. VII, 102, ♂♀, 1878.

Coelioxys germana Cresson, Trans. Am. Ent. Soc. VII, 102, ♀, 1878.

Carlinville, Illinois; 4 ♀, 4 ♂, specimens; Ill., Mex. (Cress.).

The form of the trochanters, and the color of pubescence, is variable. All of my specimens have the base of the abdomen red on the sides. ♂, 9–11 mm; ♀, 10–12 mm.

Osmia Panz.

Osmia atriventris Cress.

Osmia atriventris Cresson, Proc. Ent. Soc. Phil. III, 29, ♀, 1864.
Osmia proxima Cresson, Proc. Ent. Soc. Phil. III, 32, ♂, 1864.

Brit. Am., U. S. (Cress.).

Osmia conjuncta Cress.

Osmia conjuncta Cresson, Proc. Ent. Soc. Phil. III, 31, ♀, 1864.
Osmia 4-dentata Cresson, Trans, Am. Ent. Soc. VII, 107, ♂, 1878.
Osmia cressonii Dalla Torre, Cat. Hym. X, 392, ♂, 1896.

Carlinville, Illinois; two ♂, forty-one ♀ specimens; Ct., N. Y. (Cress.).

Osmia illinoensis ♂.

Entirely bright green, of the shade of *Augochlora viridula*, including the tegulae and legs, except apical joints of tarsi; with a bluish or purplish reflection; closely and rather finely punctured, most coarsely on the head, most finely and sparsely on abdomen, which is shining; pubescence long and thin, white below, especially on clypeus where it is also dense, above slightly tinged with ochraceous, on the abdomen short and appearing subfuscous; wings hyaline, nervures fuscous, second submarginal cell longer than first, narrowing nearly one-half towards marginal, receiving first recurrent nervure nearly one-third from base, the second near the tip; sixth segment slightly sulcate on the disc longitudinally, the apical margin produced, slightly sinuate on the sides, entire medially, with only the slightest indication of a notch, apical segment strongly bifid. Length 8 mm.

Carlinville, Illinois; one ♂ specimen.

Heriades Spin.

Heriades bucconis Say.

Osmia bucconis Say, Bost. Journ. I, 400, ♀♂, 1837, Lec. Edit. II, 777, 1859.
Osmia bucconis Cresson, Proc. Ent. Soc. Phil. III, ♀♂, 1864.
Megachile osmoides Cresson, Trans. Am. Ent. Soc. IV, 269, ♀♂, 1872.
Heriades ? denticulatum Cresson, Trans. Am. Ent. Soc. VII, 108, ♂, 1878.
? *Osmia bucconis* Provancher, Nat. Can. XIII, 208, ♀♂, 1882.
? *Osmia bucconis* Provancher, Faun. Ent. Can. Hym., 708, ♀♂, 1883.

Heriades denticulata Schletterer, Zool. Jahrb. Syst. IV, 687, ♂, 1889. (Dalla Torre.)

Eriades denticulatus Dalla Torre, Cat. Hym. X, 375, 1896.

Osmia bucconis Dalla Torre, Cat. Hym. X, 388, 1896.

♀.— Black, closely and coarsely punctured, the punctured a little more separated above; pubescence whitish, short and thin above, more dense on last two segments of abdomen, longer and more dense on sides of the face, cheeks, tubercles and mesothorax in front, posterior edge of scutellum and sides of metathorax; head as large as thorax; strongly produced behind eyes so that the ocelli are nearer insertion of antennae than the edge of the vertex; mandibles stout, with a patch of glittering fulvous hairs at tip; clypeus appearing truncate, slightly notched on each side of middle, which is slightly depressed; antennae short, black; middle of vertex with a shining impunctate space which is irregular; tegulae piceus, with a line of white pubescence above; wings hyaline, nervures blackish, second submarginal cell longer than first, receiving first recurrent nervure about one-third from base, the second near the tip; matathorax above with a transverse space which is smooth, shining and impunctate; legs with thin whitish pubescence, except on tarsi beneath where it is yellowish; abdomen with the basal segments more shining and more sparsely and finely punctured on the disc; basal segment rather broadly and deeply excavated, segments 1–4 with fasciae of white pubescence, wider on sides of first, hairs on tergum short and pale though appearing blackish, ventral scopa fulvous. Length 8–9 mm.

Carlinville, Illinois; two ♀ specimens; Ind. (Say), Can. ? (Prov.), Col., Nev., Tex. (Cress.).

Heriades floridanus ♀.

Black, rather coarsely and closely punctured, more shining and more sparsely punctured on vertex, mesonotum and discs of abdominal segments; pubescence white, most evident on middle and sides of face, mesonotum in front, scutellum behind, edges of pleura and metathorax, line over tegulae, legs, and two apical segments of abdomen; head as wide as thorax and nearly as large, clypeus bare in the middle, closely punctured, apex widely emarginate, presenting two dentiform angles; mandibles stout, two toothed below, apex with yellowish hairs; ocelli about one-third of the distance from vertex to insertion of antennae; metathorax above and large oval depression below, smooth, shining and impunctate; wings hyaline, nervures fuscous, tegulae black with dull testaceous spot, second submarginal cell wider than first, receiving first recurrent nervure about one-third from the base and the second near the tip; first segment of abdomen widely concave at base, segments 2–4 depressed basally, 1–4 with narrow fasciae of white pubescence, widening on sides of first, 5–6 more coarsely punctured, the latter depressed at apex, ventral scopa white. Length 7–8 mm.

Inverness, Florida; two ♀ specimens.

Closely resembles *Acidamea producta* ♀, but the basal segment of abdomen is different and the maxillary palpi three jointed, etc.

Andronicus Cress.

Andronicus cylindricus Cress.

Andronicus cylindricus Cresson, Proc. Ent. Soc. Phil. II, 384, ♂, 1864.

♀.— Closely resembles the male, the clypeus closely and finely punctured, emarginate at tip, mandibles quadridentate, antennae black; wings a little irregularly clouded, second submarginal cell receiving first recurrent nervure near the base and the second near the tip; abdomen at base subtruncate, with a median impressed line, segments 1–5 with narrow fasciae of white pubescence, apical margin of sixth segment hardly depressed, scopa white or pale yellowish. Length 9–12 mm.

Carlinville, Illinois; one ♂, five ♀ specimens; Conn. (Cress.), Can. (Prov.).

The female resembles *Alcidamea producta* ♀, but is larger, more finely punctured, the clypeus more closely, second submarginal cell receiving first recurrent nearer the base, apical margin of abdomen not so depressed, etc.

Alcidamea Cress.

Alcidamea truncata Cress.

Alcidamea truncata Cresson, Trans. Am. Ent. Soc. VII, 108, ♂, 1878.

♀.— Black, more shining and more sparsely punctured above; head as wide as thorax, sides of face with thin pale pubescence; clypeus rather short and flat, opaque, closely punctured, with a median raised line, space above shining and sparsely punctured, apical margin slightly emarginate; edge of cheeks beneath with a row of long incurved hairs; head beneath smooth, shining and impunctate, on each side of tongue fossa; vertex swollen, shining, rather sparsely punctured; antennae and mandibles black, the latter tridentate; mesonotum and scutellum shining and rather sparsely punctured on the disc, scutellum swollen; space on metathorax above opaque, impunctate, fossa shining below; wings a little dusky, more so towards tips; submarginal cells subequal, second receiving one recurrent about one-fourth from base and the other about one-fifth from apex; nervures fuscous, tegulae black; legs with pale pubescence, yellowish on tarsi beneath; abdomen rounded at base, with a median impressed line, basal segments sparsely punctured on the disc, 1–5 with apical fasciae of white pubescence, interrupted and wider on sides of 1–2, ventral scopa white. Length 9 mm.

Carlinville, Illinois; one ♂, one ♀ specimen; Georgia (Cress.), N. Y. (Morse).

The female may be separated from that of *A. producta* by its swollen scutellum, etc.

MEGACHILE Latr.

MEGACHILE INIMICA Cress.

Megachile inimica Cresson, Trans. Am. Ent. Soc. IV, 267, ♀, 1872.
Megachile pugnata Cresson, Trans. Am. Ent. Soc. IV, 264, ♂♀, 1872.
Megachile sayi Cresson, Trans. Am. Ent. Soc. VII, 119, ♂♀, 1878.

U. S. (Cress.) I have four ♂ and twelve ♀ specimens. Some specimens have the pubescence quite as yellow as in the description of *M. inimica*, but usually it is more white.

MEGACHILE OPTIVA Cress.

Megachile optiva Cresson, Trans. Am. Ent. Soc. IV, 268, ♀, 1872.
? *Megachile optiva* Provancher, Faun. Ent. Can. Hym. 715, ♀, 1883.
Megachile petulans Cresson, Trans. Am. Ent. Soc. VII, 127, ♂, 1878.

Carlinville, Illinois; five ♀, twenty-eight ♂ specimens; Can., N. C., Ga., Fla., Tex. (Cress.).

The ♂ varies in length from 8-11 mm. and in color of pubescence from yellow to quite white. Provancher distinguishes his *M. optiva* ♀ from *M. mendica* ♀ by its smaller size and absence of grooves on abdomen. *M. mendica* ♀ varies in length from 9–13 mm., some specimens being no larger than small specimens of *M. brevis.*

MEGACHILE RELATIVA Cress.

Megachile relativa Cresson, Trans. Am. Ent. Soc. VII, 126, ♀, 1878.
Megachile infragilis Cresson, Trans. Am. Ent. Soc. VII, 127, ♂, 1878.

Carlinville, Illinois; five ♂, two ♀ specimens; ♀ Can., U. S.; ♂ N. Y. (Cress.).

The ♂ has the anterior coxae unarmed.

MEGACHILE 6-DENTATA Rob.

Megachile 6-dentata Robertson, Trans. Am. Ent. Soc. XXII, 125, ♂, 1895.

♀.— Black, very robust, opaque and densely punctured, the vertex and abdomen a little more shining and more sparsely punctured; sides of face, cheeks, thorax except the disc, femora and basal segment of abdomen with rather long white pubescence, on vertex, mesonotum, more or less, and abdomen above short, thin and black; middle of clypeus shining, with large rather sparse punctures; mandibles stout; flagellum black or dull, testaceous beneath; wings hyaline, a little clouded at tips and in marginal cell, nervures black or fuscous, tegulae dull, testaceous exteriorly; legs black, tarsi inclining to dull ferruginous with yellowish hairs beneath, anterior and middle tibiae at apex with a testaceous deeply notched process, middle tarsi very broad, joints 1–3 with their anterior angles produced nearly the length of following joint; abdomen broad, flat, basal segment widely and very deeply concave, 2–3 transversely sulcate, 2–5 with narrow fasciae of white pubescence, apical segment without erect hairs except on sides of base, the pubescence dense, closely appressed, sericeous, becoming fuscous towards tip; scopa white, apical ventral segment with hairs short, thin, inclining to yellowish or fuscous, the apex broad, reflexed behind the apex of dorsal segment. Length 13–15 mm.

Carlinville, Illinois; six ♀, three ♂ specimens.

The ♂ varies with the pubescence nearly white and the apex of seventh ventral segment entire.

MEGACHILE MENDICA Cress.

Megachile mendica Cresson, Trans. Am. Ent. Soc. VII, 126, ♀, 1878.
? *Megachile mendica* Provancher, Faun. Ent. Can. Hym., 715, ♀, 1883.

♂.— The male of this species closely resembles that of *M. brevis*, but is distinguished as follows: larger, vertex mesonotum and segments 2–5 of abdomen with black hairs, abdomen more sparsely punctured, edge of sixth segment with the two median teeth sloping away rather equally on each side, about as near to each other as to the lateral teeth, or nearer, pubescence above yellowish or even fulvous varying to whitish. Length 9–11 mm.

Carlinville, Illinois; 27 ♀, 23 ♂ specimens; Can., U. S. (Cress.).

MEGACHILE BREVIS Say.

Megachile brevis Say, Bost Journ. N. H. I. 407, ♂♀, 1837.

The male of this varies in length from 7 to 11 mm. and in color of the pubescence from quite fulvous to white. The edge of the sixth segment has two median teeth like those of a circular saw, convex exteriorly, or nearly so, falling away suddenly within, nearer the lateral teeth than to each other.

I have 47 ♀, 43 ♂ specimens taken in Illinois and 5 ♀, 28 ♂ specimens from Florida.

The females from Florida (*M. lanuginosa* Sm.) have the abdomen more shining, more sparsely punctured and with the black pubescence more evident. With but two exceptions, the male specimens differ from Illinois ones by showing black hairs on vertex, mesonotum and especially on abdomen, which is also more sparsely punctured. They agree, however, in the teeth of sixth segment, but of course are more difficult to separate from *M. mendica* ♂. Besides the teeth referred to they are smaller and have the abdomen more closely punctured than in *M. mendica* ♂.

AMMOBATES Latr.

AMMOBATES HELIOPSIS ♂.

Black, opaque, rather coarsely, densely and confluently punctured; face about antennae, cheeks, edges of pleura, sides of methathorax, sides of prothorax extending upon mesonotum, median impressed line of mesonotum ; borders of scutellar lobes and coxae with whitish scale-like pubescence ; abdomen as long as head and thorax, the latter wider than head, scutellum bilobate ; mandibles, labrum, apex of clypeus, flagellum, tubercles, tegulae, anterior tibiae and tarsi, knees, tips of middle and hind tibiae, narrow edges of ventral segments and the apical segment of abdomen ferruginous; wings subhyaline, apex clouded, nervures and stigma black ; marginal cell about equaling submarginals together, rounded and appendiculate at apex ; second submarginal cell about one-third shorter than first, narrowing nearly two-thirds towards marginal, the recurrent nervures uniting with the transverse cubitals; abdomen black, apical margins of segments with narrow fasciae, rufous passing into golden, first segment with a lunate white patch on each side, 2–5 with four equidistant subbasal white patches. Length 6 mm.

Carlinville, Illinois ; 1 ♂ specimen.

SYNHALONIA Pttn.

SYNHALONIA ATRIVENTRIS Sm.

Melissodes atriventris Smith, Brit. Mus. Cat. Hym. II, 310, ♂, 1854.
Melissodes nigripes Smith, Brit. Mus. Cat. Hym. II, 311, ♀ (non ♂), 1854.
Melissodes dubitata Cresson, Proc. Acad. Sci. Phil. 1878, 194, ♀ (non ♂).
Synhalonia atriventris Cresson, Synopsis, 305, ♂♀ (third line from top), 1887.

Carlinville, Illinois; 33 ♀, 8 ♂ specimens; Algonquin, Ill. (Nason), U. S. (Smith), Ga. (Cress.).

The pubescence of legs, especially the scopa, varies from fulvous through fuscous to black. I have examined the types of *M. dubitata* in Coll. Am. Ent. Soc.

MELISSODES Latr.

MELISSODES DENTIVENTRIS Sm.

Melissodes dentiventris Smith, Brit. Mus. Cat. Hym. II, 312, ♂, 1854.

♀. — Black, pubescence on head, thorax and basal segment of abdomen above long and fulvous ; on the clypeus, labrum, head beneath, some hairs on vertex and a few short ones on disc of mesothorax and scutellum, thorax beneath, legs and abdomen the pubescence is black; some hairs on bases of anterior and middle tibiae at base, pale ochraceous; hind tibiae and exterior base of their tarsi with pale yellowish hair; on the second segment of abdomen a narrow basal line and an oblique one on each side of middle, sometimes also on third, of appressed pale pubescence; mandibles with a yellow stripe at apex, flagellum beneath, except three basal joints, dull testaceous. Length ♂, 10–13 mm.; ♀, 12–14 mm.

Carlinville, Illinois; 23 ♀, 9 ♂ specimens; Ga. (Smith).

The female closely resembles *M. desponsa*. In *M. desponsa* the pubescence above is short and pale, less abundant on first segment of abdomen, no oblique fasciae on second segment, four anterior legs with pubescence more entirely black, etc.

The males agree so well with the description of *M. americana* Lep., that, but for the hairs of the apex of the abdomen and ventral surface being black, I would say it was the same species. The third and fourth segments have a faint indication of a narrow fusco-ferruginous curved fascia. This may become a synonym.

The *M. desponsa* var., which Smith supposed to be the female of *M. americana*, also indicates a close relationship here.

Melissodes agilis Cress.

Melissodes agilis Cresson, Proc. Acad. Sci. Phil. 1878, 204, ♂.
Melissodes aurigenia Cresson, Proc. Acad. Sci. Phil. 1878, 212, ♂♀.

Professor Cockerell has independently arrived at the conclusion that *M. aurigenia* is a synonym of *M. agilis* and writes that Mr. Fox has compared the types and confirmed that opinion.

The female in fresh specimens often has the thorax quite fulvous red. The male seldom approaches this, being usually quite pale. I have 40 ♀, 41 ♂ specimens.

Melissodes nivea Rob.

Melissodes nivea Robertson, Trans. Am. Ent. Soc. XXII, 127, ♀, 1895.

♂.— This sex reproduces all of the ornaments of *M. agilis* ♂, but the wings are whiter, the second submarginal cell longer, the apical margins of abdominal segments white, the pubescence entirely pure white, so that even in the field it may be easily distinguished from the palest males of *M. agilis.*

Carlinville, Illinois; 13 ♀, 15 ♂ specimens.

MELISSODES PENNSYLVANICA Lep.

Macrocera pennsylvanica Lepeletier, Hist. Ins. Hym. II, 97, ♂, 1841.

Melissodes dentiventris Provancher, Addit. Faun. Ent. Can. Hym., 299, ♂♀, 1888.

Carlinville, Illinois; 37 ♀, 26 ♂ specimens; Pa. (Lep.), Can. (Prov.).

In size and color the female very closely resembles that of *M. agilis.* The wings not whitish, the nervures darker, the front and middle legs and ventral surface of abdomen with the pubescence largely black. The male may be distinguished from that of *M. agilis* by the pubescence more fulvous, nervures darker, no spot on mandibles, margins of abdominal segments not pale testaceous.

MELISSODES CONFUSA Cress.

Melissodes confusa Cresson, Proc. Acad. Sci. Phil. 1878, 205, ♀♂.

Melissodes ruidosensis Cockerell, The Entomologist, 1896, 305, ♂.

I have compared the description of the latter with a type specimen of *M. confusa* sent for examination, by Mr. Fox. There is no difference whatever except that the New Mexican insect has black hairs on base of dorsal segments. The type shows a slight indication of black hairs here, while on the scutellum and posterior disc of mesonotum black hairs are present. The female shows black hairs on the thorax above and base of abdominal segments. The presence of similar hairs in the male only increases the probability that they belong together. Cockerell's description of the sixth segment of abdomen is exact for the male type specimen of *M. confusa* before me.

MELISSODES SIMILLIMA.

♀.— Differs from the female of the preceding by its somewhat smaller size and the more abundant admixture of black pubescence, the abdominal fasciae narrower, less white, that of the fourth segments often strongly mixed with fuscous; flagellum dull ferruginous beneath. Length 10–11 mm.

♂.— Also closely resembles male of *M. confusa*, but smaller, flagellum testaceous beneath; clypeus except a notch on each side of base yellowish, sometimes with only a band before apex, apex yellowish or with a black edge; labrum black or with more or less yellow, mandibles rarely with a yellow spot at base and usually with a yellow streak before apex; mesonotum and scutellum more or less mixed with blackish hairs, or sometimes with dark hairs entirely wanting; abdomen black, the apical margins of segments sometimes slightly dull rufous; fasciae ochraceous, narrow, subdiscal, fuscous on sixth segment. Length 9 mm.

Carlinville, Illinois; 16 ♀, 29 ♂ specimens.

I have females of this species which were identified as *M. confusa* by Mr. Cresson for me and for Professor Trelease. It may turn out to be only a form of that species.

Bombus Latr.

Specimens of the sexes of *B. borealis* and *B. fervidus*, each set from its own nest, were received from Professor Comstock. These, as well as the observations of Coville, in Proc. Ent. Soc. Washington I, 201, 1890, convince me that the species are quite distinct. The *Apis elata* F. is the male of *B. fervidus*. *Apathus elatus* Cress. includes males of *B. fervidus* and *B. americanorum*, those of the latter always with a black band between the wings. I have taken the males of *B. americanorum* and *B. nidulans* from the same nest, and Cresson records a similar case in Proc. Ent. Soc. Phil. II, 165, the names used there being synonyms of *B. americanorum*.

Carlinville, Illinois, March 25, 1897.

Issued May 7, 1897.

RELATIONS OF THE DEVONIAN AND CARBONIFEROUS IN THE UPPER MISSISSIPPI VALLEY.*

CHARLES R. KEYES.

Notwithstanding the fact that the Devonian and Carboniferous rocks of the Upper Mississippi Valley were brought prominently into public notice more than half a century ago, the exact line of demarcation between them has remained one of the mooted points in the stratigraphy of the region. To most of the formations which go to make up the two systems a definite geological age has been, without much doubt, correctly assigned. That regarding any portion of the succession there should arise any material differences of opinion is perhaps somewhat surprising, especially when it is remembered that the general stratigraphical arrangement is not particularly complicated. Nevertheless, it is a fact that there is a zone the exact geological age of which has long been in doubt and concerning which little has been done towards the final settlement of its real position.

The fact that the correlations have been various, and, as late work has clearly shown, in large part erroneous, must be ascribed mainly to insufficient data, since nowhere have investigations been detailed enough to enable the critical evidence to be formulated. The beds of the uncertain zone have been placed first in one system and then in the other, sometimes with a loss of some of its layers in the process of shifting, sometimes with a gain of others. These strata of indeterminate age may be regarded as including all those lying between the base of the Burlington limestone, and those which are commonly put down as the western representatives of the New York Hamilton. Although originally placed in the Carboniferous, these beds

* Presented in abstract, April 19, 1897.

were soon assigned altogether to the Devonian, then all were again transferred back to the Carboniferous, where, by common consent, and in the absence of further direct inquiry, they long remained. But accumulated evidence now indicates that their proper place lies partly in the older of the two systems and partly in the younger. However, the grounds for this return in large part to the earliest definitely expressed view are very different from those which were adopted in the beginning. Curiously enough, while the reasons for their early reference to the Devonian were found of late years to be entirely erroneous, the first conclusions were in fact practically correct for the particular district under consideration along the Mississippi river; the premises were totally wrong, and the decisions were founded upon faulty correlations. Herein lies the confusion which has so long existed regarding the proper position of the beds.

The history of the various changes and correlations of the beds under consideration would be a long and perhaps somewhat tedious account, but there is no need of entering into its complications in the present connection, as the main features have been so lately* summarized.

Since the appearance of these summaries special work † in the region has led to considerable modification of some of the views there expressed. At the localities from which the leading fossil forms had been described it was found that the horizon from which they had come was beneath the Louisiana or the "Lithographic" limestone, the commonly recognized basal member of the Kinderhook.

Still more recently a careful examination of the Lithographic beds has been made with the special object in view of discovering fossils in the seemingly unfossiliferous layers above the base, and of determining the vertical distribution of the organic remains. The locality selected was Louisiana, in Pike County, Missouri, where the exposures were unusually favorable, where the vertical section was complete from the

* U. S. Geol. Sur., Bull. 80, pp. 146–170, 1891; also Bull. Geol. Soc. America, vol. III. pp. 283–300, 1894.

† Missouri Geol. Sur., vol. IV. pp. 54–55, 1894.

Silurian to the upper Burlington, and where there occurred an abundance of fossils. In order that the accompanying tabular lists may be understood in their full significance the section of the rocks exposed at Louisiana is given below, essentially as when first published several years ago,* except that for present purposes smaller zones are recognized and some modifications in thickness are made in order to have the section more expressive of the conditions at the town itself.

SECTION AT LOUISIANA, MISSOURI.

			Feet
Recent	21.	Soil and red residuary clay, with chert fragments	4
Upper Burlington	20.	Limestone, brown, with thinly bedded and nodular chert	28
	19.	Limestone, compact, thin-bedded, encrinital, with much gray chert in bands and nodules	18
	18.	Limestone, yellowish brown, rather soft, encrinital	4
Lower Burlington	17.	Limestone, bluish, fine-grained, siliceous	4
	16.	Limestone, massive, white, encrinital, coarse-grained (upper white ledge)	12
	15.	Limestone, brown, encrinital, with irregular chert bands and nodules, and occasional thin clay partings	20
	14.	Limestone, white, very heavily bedded, encrinital, chief quarry stone (lower white ledge)	9
	13.	Limestone, brown, encrinital, heavily bedded	6
Chouteau	12.	Limestone, yellow, massive or heavily bedded, rather soft, fine-grained	9
Hannibal	11.	Shale, brown, sandy, passing into soft sandstone locally	12
	10.	Shale, green, sandy above	60
Louisiana	9.	Limestone, buff to gray, compact, very fine-grained, in layers 4 to 6 inches thick, similar to lithograph stone in texture	34
	8.	Limestone, similar to above	8
	7.	Limestone, similar to above, layers thicker and separated by buff sandy partings	6
	6.	Shale, buff, sandy, 2 to 6 inches	½
Western-Hamilton	5.	Shale, green	2
	4.	Shale, black, fissile	4
Niagara	3.	Limestone, magnesian, buff, massive	4
	2.	Oolite, white, massive	7
Hudson	1.	Shale, blue, with thin bands of limestone	40

* Am. Jour. Sci., (3), vol. XLIV. p. 448, 1892.

The basal member of the section is the Hudson shale. In the neighborhood it attains its full thickness of about 70 feet. It rests on a heavy magnesian limestone carrying characteristic Trenton fossils.

The next two higher members, Nos. 2 and 3, are provisionally referred to the Niagara. The oolite appears to be a somewhat local phase. The organic remains contained are rather abundant. The formation appears to be represented elsewhere in the vicinity by fossiliferous limestones which are not oolitic. The buff massive layer is very thin at Louisiana, being only four feet in thickness in the river bluff in front of the town. Two miles southward, at the mouth of Buffalo creek, it increases to 9 feet, and farther southward on both sides of the Mississippi river, and southwestward towards Bowling Green, it attains a measurement of 25 to 30 feet in a distance of 15 to 20 miles. It is almost destitute of fossils.

The succeeding two, Nos. 4 and 5, belong to the Devonian. The lower black shale contains a characteristic fish fauna. Numbers 6 to 9 form the Louisiana division of the "Kinderhook." It is the Lithographic limestone of the older State reports. The Hannibal shales, Nos. 10 and 11, contain comparatively few fossils, but farther north at Burlington, where the beds have always been regarded as non-fossiliferous, an extensive fauna has been of late disclosed, the general facies of which is very decidedly Devonian.*

The thin, soft, earthy limestone (No. 12), which is nine feet in thickness at Louisiana, is believed to be the attenuated portion of the Chouteau limestone, though it is closely associated with the lower beds of the Burlington. Towards the southwest the Chouteau limestone, before leaving Pike County, has a thickness of thirty feet, and still farther in the same direction in central Missouri the thickness increases to over one hundred feet. The lower Burlington limestone is separated upon lithological and faunal grounds, into five zones; and the upper Burlington, as represented in this locality, into three zones.

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* Iowa Geol. Sur., vol. III. p. 80, 1893.

Nearly all of the strata are highly fossiliferous. The vertical section and the exposures are so extensive for a single locality that the facilities for determining the exact range of the various faunas stand unrivaled in the whole region. Moreover, a key to the stratigraphy of the entire province is furnished. Owing to unusually favorable opportunities for forming extensive collections of the fossils which are representative of the different horizons, the results are very complete. The determination of the faunal zones and their most important relationships as bearing upon the stratigraphy of the region is therefore of great interest.

In considering the faunal features of the succession the chief interest centers in the nature of the fauna of the Kinderhook as a whole, and of each of its several parts. The three most prominent considerations are: (1) the general facies of the fauna in its entirety, and the elements giving it its predominant features, (2) the character and genetic relations of the basal fauna, and (3) the upper limit, if any can be clearly made out, of the fauna most characteristic of the formation.

1. Heretofore the custom has always been to treat the organic remains contained in the "Kinderhook," "Chouteau," or "Chemung" as belonging to a single fauna. Owing to the heterogeneous beds that have been placed together, it has been the chief mission of later work to take out from time to time the various incongruous parts which were originally correlated with this formation. Thus, gradually, at its typical localities the terrane has finally come to be more clearly understood.

The fauna contained in the threefold "Kinderhook" when deprived of those elements which are in reality wholly foreign, presents a very different facies from that generally ascribed to it. In the light of definite zonal distribution of the organic forms there appear to be, instead of a single compact and characteristic group of forms, two very distinct faunas. This is nowhere more clearly shown than at the locality which may be regarded as typical and in which the faunal zones have been determined with considerable accuracy and corroborated by evidence from other districts. It is owing to the indefinite knowledge which has long existed regarding the exact horizons at which the various genera and species occur that the general faunal facies of the "Kinderhook" has therefore borne a composite and not a pure physiognomy.

A tabular arrangement of all the species of fossils that are recognized at a typical locality for the Kinderhook, and that range from the Silurian to the upper Burlington, has brought out very clearly some important facts which heretofore have been overlooked. The first of these is the close affinity of the faunas from the lower two members of the Kinderhook with the underlying Devonian, and the second is the sharpness with which the lower fauna stops at the base of the Chouteau, and the abruptness with which an entirely new fauna begins at the same level.

2. The components of the lower fauna comprise those forms which, as will be seen hereafter, occur in the Louisiana limestone and the Hannibal shales. For the present only the species from the former need occupy attention. The distribution of the forms so far as known is shown in the accompanying table, the figures at the top corresponding with the numbers of the beds in the geological section at Louisiana* :—

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* In the preparation of the tables due acknowledgment should be made to Mr. R. R. Rowley. His large collection and long residence in Louisiana enables a degree of completeness to be given them that would otherwise not have been possible.

DISTRIBUTION OF THE LOWER KINDERHOOK FAUNA AT LOUISIANA, MO.

SPECIES.	Hudson.	Niagara.		Hamilton.		Louisiana.				Hannibal.		Ch.	Lower Burlington.					Upper Burlington.		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Plumulina gracilis (Shumard)								x												
Taonurus crassus? (Hall)											x									
Palæacis enormis (Meek & Worthen)					x	x	x													
Conopterium effusnm (Winchell)					x	x	x													
Zaphrentis acuta, White & Whitfield					x	x	x	x												
Allagecrinus americanus, Rowley							x													
Cyathocrinus sp?							x													
Leioclema sp?						x	x													
Ambocœlia minuta, White						x	x	x												
Athyris hannibalensis, Swallow					x	x	x				x									
Chonetes geniculatus, White						x	x													
" ornatus, Shumard					x	x	x				x									
" rowleyi, Gurley						x	x													
" sp?						x														
" sp?						x														
Cyrtina acutirostris, Shumard					x	x	x	x												
Discina sp?					x	x														
Nucleospira barrisi, White							x	x												
Rhipidomella missouriensis (Swallow)					x	x	x													
Productella pyxidata (Hall)					x	x	x	x	x		x									
Retzia sp?						x	x													
Rhynchonella missouriensis, Shumard					x	x	x													
Spirifer marionensis, Shumard					x	x	x				x									
Spiriferina clarksvillensis, Winchell						x	x	x												
" aciculifera, Rowley						x	x													
Orthotetes lens (White)					x	x	x													
Strophalosia scintilla, Beecher						x	x													
Syringothyris carteri (Hall)					x	x	x	x			x									
Terebratula sp?						x	x													
Dexiobia sp?											x									
Grammysia hannibalensis (Shumard)						x					x									
Pernopecten cooperensis (Shumard)											x									
Conularia sp?						x														
Callonema sp?					x	x														
Murchisonia pygmæa, Rowley							x	x												
Capulus sp?							x	x												
Pleurotomaria minima, Rowley							x	x												
Goniatites louisianensis, Rowley							x													
" sp?							x	x			x									
Cornulites carbonarius, Gurley						x	x													
Spirorbis kinderhookensis, Gurley						x	x													
Phillipsia swallovi, Shumard						x														

As a whole the fauna is closely related to that occurring in the Western Hamilton. Some of the species, though bearing different names, are in reality identical with typical forms from that formation. Heretofore, as already stated, the fossils have been found, with few exceptions, perhaps, only in the basal portion of what is called the Louisiana limestone, in number 6, a thin sandy layer which is lithologically similar to the partings in the limestone itself. The results of the latest investigations show that many of the forms actually extend upwards, some of them passing practically unchanged through the whole Louisiana to the top of the Hannibal. Thus far not a single species of this fauna appears to occur in the overlying Chouteau. Many of the forms also range downwards into the dark-colored shale below, which is regarded as of Devonian age, and which a short distance away becomes very much thicker.

The general impression derived from the table is that the zones 5 to 8 inclusive are faunally very closely related, and that higher ones 9 to 11 also have close affinities with the lower zones. It may be noted in this connection that no special effort was made to determine the full faunas of the higher beds, as the critical evidence that was needed was in regard to the fauna of the Louisiana (Lithographic) limestone. The shales have, heretofore, proved to be very barren in organic remains. Towards the top where they become sandy a number of the lower species are found. That the shales do not appear to be fossiliferous is not remarkable. Since they manifestly do not contain abundant remains in a good state of preservation, they have not been searched so carefully by fossil collectors as have the other beds. At Burlington, Iowa, where there are excellent exposures and numerous active local collectors, besides a host of transient ones, the same shales remained for half a century without a fauna to be ascribed to them. But of late they have been shown to be abundantly supplied with fossils. Without exception the latter appear to be characteristic Devonian forms. As yet, however, the fauna has not been studied sufficiently to be specifically listed, but the brachiopods are for the most part very similar to, if not identical with, the species found in undoubted Devonian shales farther northward in the same state. The cephalopods are represented by large forms of Cyrtoceras, Gomphoceras and Phragmoceras. One belonging to the latter genus may prove to be Winchell's *P. expansum*. Another very characteristic phase of the fauna is the non-trilobitic crustaceans, of which a very considerable number have been found. They have very close affinities to Tropidocaris and Amphipeltis.

It appears, then, that the Devonian fauna characteristic of the region extends up to the top of the Hannibal shales in Northeastern Missouri, at Louisiana especially, and that the argillaceous "Kinderhook" shales of southeastern Iowa, as typically developed at Burlington and corresponding in great part to the Hannibal shales, appear to carry no other remains than those of pronounced Devonian types. The upper part of the section usually regarded as Kinderhook at Burlington, in fact all the thin limestone and sandstone bands down to the main body of shale, may be now more properly regarded as the equivalent of the Chouteau limestone, that is the uppermost member of the so-called Kinderhook in Missouri.

3. One reason why the fauna of the Chouteau (original) limestone has not been better understood in its relation to the faunas occurring lower in the so-called Kinderhook, and higher in the Burlington limestone, has been that in the localities where the lower Carboniferous has been most thoroughly and widely studied, that is, along the Mississippi river, the Chouteau, as commonly recognized, nowhere crops out along the great stream, except perhaps in the vicinity of the town of Louisiana, where, under the typical Burlington, there is an earthy limestone 6 to 12 feet thick, which has been considered a part of the latter but which is now believed to be the attenuated edge of the Chouteau or its equivalent. At any rate, in the same vicinity the undoubted Chouteau attains a thickness of 15 to 30 feet.

Below is a table showing (1) that none of the species come up from below to the base of the Chouteau, (2) those starting in the Chouteau, and ranging upward, (3) the fauna starting in the basal member of the Burlington limestone, and (4) the species which comprise a lower fauna in the midst of a higher.

DISTRIBUTION OF UPPER FAUNAS AT LOUISIANA.

SPECIES.	Hudson.	Niagara.		Hamilton.		Louisiana.				Hannibal.		Chouteau.	Lower Burlington.					Upper Burlington.		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Amplexus blairi, Miller														x	x					
Amplexus sp?														x	x	x	x			
Amplexus fragilis, White and St. John																	x	x	x	x
Clistopora typa? (Winchell)												x								
Michelinia sp?													x	x	x			x		
Zaphrentis calceola, White and Whitfield												x	x	x	x	x	x			
Zaphrentis elliptica, White													x	x	x	x	x			
Zaphrentis tantilla, Miller												x								
Zaphrentis sp?												x	x							
Archæocidaris agassizi, Hall														x	x	x				
Actinocrinus cœlatus, Hall													x	x						
Actinocrinus clarus, Hall													x	x						
Actinocrinus proboscidialis, Hall														x	x					
Actinocrinus puteatus, Rowley												x	x							
Actinocrinus tenuisculptus (McChesney)													x							
Actinocrinus sp?												x								
Actinocrinus sp?												x	x							
Agaricocrinus sp?												x	x							
Agaricocrinus brevis (Hall)														x	x					
Agaricocrinus sp?														x						
Agaricocrinus pyramidatus, Hall														x	x					
Amphoracrinus divergens (Hall)														x	x					
Amphoracrinus spino-brachiatus (Hall)														x	x					
Batocrinus æqualis (Hall)														x						
Batocrinus calvini, Rowley												x								
Batocrinus clypeatus (Hall)														x	x					
Batocrinus discoideus (Hall)													x	x	x					
Batocrinus lepidus (Hall)														x	x					
Batocrinus longirostris (Hall)												x	x	x	x					
Batocrinus quasillus, Meek and Worthen													x	x	x					
Batocrinus subæqualis (Hall)													x	x	x					
Batocrinus turbinatus (Hall)														x						
Batocrinus inflatus, Rowley												x	x							
Batocrinus rodentatus, Rowley														x	x					
Batocrinus sp?												x	x							
Batocrinus sp?												x								
Calceocrinus ventricosus (Hall)														x	x	x		x	x	
Codaster gracillimus, Rowley														x	x					
Codaster sp?												x	x							
Orophocrinus stelliformis (Shumard)															x					
Orophocrinus? inopinatus, Rowley												x	x	x						
Dichocrinus sp?														x	x					
Dichocrinus sp?														x	x					
Dorycrinus subaculeatus (Hall)														x						
Dorycrinus unicornis (Owen and Shumard)												x	x	x	x	x				
Dorycrinus inflatus, Rowley												x								
Eretmocrinus coronatus (Hall)														x	x					
Eretmocrinus leucosia (Hall)														x	x					
Eretmocrinus sp?														x						
Eretmocrinus sp?												x	x	x	x					
Eretmocrinus corbulis (Hall)													x							
Cryptoblastus melo (Owen and Shumard)												x	x	x	x	x				
Granatocrinus projectus (Meek and Worthen)														x	x					
Granatocrinus pisum (Meek and Worthen)														x	x					
Granatocrinus concinulus, Rowley														x	x					
Graphiocrinus sp?														x						
Icythyocrinus sp?												x								
Megistocrinus evansi (Owen and Shumard)													x	x	x					
Physetocrinus ornatus (Hall)														x						
Platycrinus americanus (Owen and Shumard)														x	x					
Platycrinus burlingtonensis (Owen and Shumard)														x						
Platycrinus discoideus, Owen and Shumard														x	x					
Platycrinus pileiformis, Hall														x	x					
Platycrinus planus, Owen and Shumard												x	x	x	x					
Platycrinus pocilliformis, Hall														x	x					
Platycrinus subspinosus, Hall													x	x						
Platycrinus corbuliformis, Rowley												x								

DISTRIBUTION OF UPPER FAUNAS AT LOUISIANA.— Continued.

SPECIES.	Hudson.	Niagara.		Hamilton.		Louisiana.				Hannibal.		Chouteau.	Lower Burlington.					Upper Burlington.		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Platycrinus pisum, Rowley														x	x					
Platycrinus lautus, Miller												x								
Platycrinus sp?												x								
Platycrinus sp?												x								
Poteriocrinus waltersi, Rowley												x	x							
Rhodocrinus wortheni, Hall														x	x					
Symbathocrinus brevis, Meek and Worthen														x						
Taxocrinus themii (Hall)														x						
Metablastus lineatus (Shumard)														x	x					
Coscinium latum, Ulrich														x						
Evactinopora grandis, Meek and Worthen														x	x					
Fenestella filistriata, Ulrich														x	x					
Polypora burlingtonensis, Ulrich														x	x					
Athyris lamellosa, Hall												x	x	x	x	x	x			
Athyris sp?														x	x					
Athyris sp?														x	x					
Centronella rowleyi, Worthen														x	x					
Centronella sp?														x	x					
Chonetes logani, Norwood and Pratten														x	x					
Crania sp?														x						
Cyrtina burlingtonensis, Rowley														x	x					
Discina melie? Hall														x						
Eumetria prima? White														x	x					
Lingula halli? White														x						
Nucleospira sp?														x	x					
Orthis swallovi, Hall												x	x	x	x	x	x	x	x	
Orthis sp?														x	x					
Orthis burlingtonensis, Hall													x	x	x				x	x
Productella shumardiana (Hall)														x						
Productus arcuatus, Hall														x	x					
Productus sp?														x	x	x	x			
Productus burlingtonensis, Hall														x	x	x	x			
Productus punctatus, Martin														x	x					
Productus viminalis, White														x	x					
Productus sp?														x	x	x				
Productus sp?												x	x	x						
Productus sp?														x	x					
Rhynchonella sp?														x	x					
Rhynchonella sp?														x	x					
Spirifera forbesi, Norwood and Pratten													x	x	x					
Spirifera hirtus, White and Whitfield														x	x					
Spirifera incerta, Hall														x	x					
Spirifera lineatoides, Swallow														x	x					
Spirifera peculiaris, Shumard														x	x	x				
Spirifera solidirostris, White														x	x					
Spirifera striatiformis, Meek													x	x	x	x				
Spirifera grimesi, Hall												x	x	x	x	x	x	x	x	x
Spirifera temeraria, Miller														x	x					
Spirifera mundula, Rowley														x	x					
Spirifera sp?														x	x					
Strophomena rhomboidalis, Wilkens (var.)														x	x	x	x	x		
Syringothyris typus, Hall													x	x	x	x	x			
Terebratula burlingtonensis, White														x	x	x				
Terebratula sp?														x	x					
Bellerophon bilabiatus, White and Whitfield														x	x					
Phanerotinus paradoxus, Winchell														x						
Omphalotrochus springvallensis (White)														x	x					
Straparollus latus (Hall)												x	x	x	x	x	x			
Straparollus ammon (White and Whitfield)														x	x					
Straparollus obtusus, White														x						
Loxonema prolixa, White and Whitfield														x	x					
Sphærodoma penguis (Winchell)														x						
Murchisonia sp?														x						
Igoceras capulus (Hall)															x	x				
Igoceras quincensis (McChesney)												x	x							
Capulus latus (Keyes)													x	x						

DISTRIBUTION OF UPPER FAUNAS AT LOUISIANA.—Continued.

SPECIES.	Hudson.	Niagara.		Hamilton.		Louisiana.				Hannibal.		Chouteau.	Lower Burlington.					Upper Burlington.		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Capulus paralius (Keyes)														x						
Capulus obliquus (Keyes)													x	x						
Capulus tribulosus (White)														x						
Orothonychia formosus (Keyes)														x						
Pleurotomaria subcarbonaria, Keyes														x	x					
Pleurotomaria sp?														x	x					
Pleurotomaria sp?														x	x					
Holopea conica, Winchell														x						
Porcellia nodosa, Hall														x						
Crytoceras sp?														x						
Goniatites sp?														x	x					
Goniatites osagensis, Swallow														x						
Nautilus sp?														x						
Orthoceras sp?														x						
Aviculopecten burlingtonensis, Meek & Worthen														x	x					
Aviculopecten circulus, Shumard														x						
Cardiopsis sp														x						
Conocardium sp?														x						
Crenipecten sp?														x	x					
Cypricardella sp?														x						
Edmondia burlingtonensis, White and Whitfield														x						
Edmondia nuptialis, Winchell														x						
Nuculites sp?														x						
Sanguinolites burlingtonensis, Worthen														x	x					
Sphenotus sp?														x						
Lithophaga occidentalis (White and Whitfield)														x						
Phillipsia insignis, Winchell														x	x					
Phillipsia tuberculata, Meek and Worthen														x	x	x	x	x		
Phillipsia sp?														x						

The most striking features in the vertical distribution of the fossils shown in the tables given are: (1) The upper fauna nowhere extends beneath the base of the Chouteau (No. 12), and the lower fauna nowhere rises above the same line; (2) the species belonging to the fauna beginning in the Chouteau extend upward into the Burlington; (3) while in the Burlington many new forms appear, there is not an immediate replacement of the older forms; and (4) the many new species which appear in the second bed of the Burlington (No. 14) are largely so-called Kinderhook forms, not altogether from the Chouteau of the immediate neighborhood but from the limestones which occur just beneath the Burlington limestones in other localities, as at the city of Burlington.

From a consideration of both tabular arrangements the following general conclusions are deduced :—

1. The most marked change in the succession of faunas in the entire sequence of rocks commonly know as the lower Carboniferous or "Subcarboniferous," as represented along the Mississippi river, is at the base of the Chouteau limestone (limited). At this horizon there is so great a faunal hiatus that there is scarcely a species that is common to the beds on either side.

2. That instead of the so-called Kinderhook containing in its fauna a mingling of Devonian and Carboniferous types, there are really two faunas that are perfectly distinct, well defined, and do not merge into each other. The one is characteristically Devonian in character, and the other as strikingly Carboniferous in its general aspect.

3. The basal line of the lower Carboniferous or Mississippian series is the base of the Chouteau limestone, and the lowest member of the fourfold series contains only one formation, instead of the three heretofore commonly ascribed to it.

4. The early reference of a part of the so-called Kinderhook or "Chemung" to the Devonian was correct in fact, though done entirely through erroneous correlations and a misconception of the real facts.

5. That the evidence afforded by the faunas of the region is in close accord with the facts obtained regarding discordant sedimentation and the stratigraphical and lithological characters of formations themselves.

Issued June 1, 1897.

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CRITICAL NOTES ON THE MURICIDAE.*

FRANK COLLINS BAKER.

During the past three years a large number of specimens of this family have passed through the writer's hands, and he has had the opportunity of examining a number of large collections of shells which included a goodly number of this most interesting family. From the trouble and labor in identifying these collections, the following critical remarks concerning the synonymy and classification have seemed necessary.

Family MURICIDAE.

Subfamily MURICINAE.

Genus **Murex** Linné.

Subgenus MUREX (sensu stricto).

The following sections have been proposed † but cannot stand, since the characters are not constant and fade imperceptibly into each other. The shells of the different subgenera of Murices cannot be used as characters upon which to found stable sectional characters. It is barely possible that a study of the animals might bring to light some definite diagnoses: *Acupurpura*, Bayle, 1880 (type M. *tenuispina* Lam.); *Tubicauda*, Jouss, 1880 (type M. *brevispina* Lam.).

MUREX OCCA Sowb.

Murex occa Sowb., Zool. Proc., p. 137, 1840. Conch. Ill., fig. 45.

Various authors have considered this species a synonym of *Murex scolopax*, Dillwyn. I have seen several undoubtedly

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* Presented in abstract, May 17, 1897.

† See Fischer, Manuel de Conchyliologie, pp. 638-649.

authentic specimens of *occa* and hundreds of *scolopax*, and I am sure that they are quite distinct. *Occa* possesses two intervarical tubercles, while *scolopax* is quite smooth even in the very young specimens. The brown bands are wanting in *occa* and the spines are strongly curved upwards, while in the former species they are almost straight. The sizes are also quite different, *scolopax* being six or seven inches in length, while *occa* seldom exceeds three inches. The outer lip of the latter species is toothed (*scolopax* is not), and the canal is almost destitute of spines. All of the specimens I have seen were from China.

MUREX MACGILLIVRAYI Dohrn.

Murex Macgillivrayi Dohrn, Zool. Proc., p. 203, 1862.

It is doubtful if this species will prove synonymous with *Murex scolopax*, as some authors have contended. Mr. E. A. Smith says of it: "It is a yellowish shell, exhibiting three purplish-brown bands on the body-whorl, of which the uppermost is the broadest, being situated around the broadest part of the volution. The spiral lirae are fine, reddish, in some examples more deeply colored than in others, and terminating at the margin of the labrum in red dots, which fall between lobe-like prolongations." (Zoology, Voyage of the Alert, p. 44.)

This is a stumpy little species with but a single well-developed intervarical node and short, slightly curved spines. From *scolopax* it is distinguished by its shorter spines and more nodulous surface, and from *occa* by the greater proportionate width of the body-whorl, the fewer, straighter spines, and the three purplish bands on the body-whorl. The original specimens were dredged off Lizard Island, Torres Strait, Australia, in 29 fathoms.

MUREX TRIBULUS var. NIGROSPINOSUS Reeve.

Murex nigrospinosus Reeve, Zool. Proc., p. 88, 1845. Conch. Icon. sp. 79.

This species seems to be but little understood by most conchologists, for I have received it under at least half a dozen different names and have seen it wrongly named in almost every collection I have examined. It is most frequently confounded with *tribulus*, *ternispina* and *rarispina*. It may be considered a variety of the first-named species, characterized by dark colored spines shading from black into blue. This is the *only* species of the subgenus which has these peculiarly colored spines. This fact will at once distinguish it from the nearly related species.

MUREX TRIBULUS var. ADUNCOSPINOSUS Beck.

Murex aduncospinosus Beck., Reeve, Conch. Icon., fig. 93.

I recently had the pleasure of examining a specimen of this species, and am led thereby to make the above disposition of it. The spines are quite curved and the whole shell is of a much darker color than in the typical *tribulus*. Sowerby in Conchological Illustrations gives a very good figure (fig. 68). The species is from the Red Sea.

MUREX TRIBULUS var. CARBONNIERI, Jousseaume.

Murex carbonnieri Jouss., Le Naturaliste, No. 44, p. 349. Nouvelles Archives du Museum, plate x, fig. 1.

This form will stand as a variety of *tribulus* characterized by chestnut spotted spiral bands. I have seen a large number of specimens of this variety, and when perfect it is a very handsome shell. The largest specimen seen by me measured a little over three inches in length.

MUREX ACANTHODES, Watson.

Murex acanthodes, Watson, Jour. Linn. Soc. London, p. 599, 1883. Challenger Report, Gastropoda, p. 151, pl. x, fig. 1.

The specimen from which this was described is a juvenile form, and I am strongly inclined to consider it the young of *Murex tribulus* or some of its varieties. I have seen juvenile specimens of *tribulus* which would answer to the description of *acanthodes*. That it is a young shell is evident from its size (alt. 1.8 in., diam. 0.6 in., aperture alt. 1.5 in. [excluding the canal 0.38 in.], diam. 0.27 in.), which is about that of some small specimens of *tribulus* that I have seen. It was dredged off Cape York, Australia, and Albany Island, in 3 to 12 fathoms. It is said by its describer to resemble *Macgillivrayi*, *aduncospinosus* and *Cabritii*.

MUREX COPPINGERI, E. A. Smith.

Murex coppingeri, E. A. Smith, Zool. Voyage of H. M. S. Alert, p. 42, pl. 5, fig. 9.

It seems to me very doubtful if this species will prove to be more than a variety of *Murex tribulus*. I have seen many specimens of var. *nigrospinosus* which would answer very well to the description and figure of this species. Mr. Smith says of it, "This may prove eventually a remarkable variety of *M. nigrospinosa* of Reeve, the only species it is likely to be confounded with. That species, although attaining a larger size, consists of only eight whorls, whilst in *M. Coppingeri* I count nine and a half. The nucleus of the latter consists of two and a half whorls, which are a little convex, together forming a blunt-topped cone. In the former species there are two nuclear volutions very convex, forming a globose apex. * * * in the interstices in *M. nigrospinosus* three or even more nodose costae are met with, whilst in the present species there are but two, and these are not nodulous. * * * *M. tribulus* has a different apex, more convex whorls, different coloration, and much coarser and nodose spiral ridging. The number and position of the spines is seen to be very similar in all three species when closely and carefully compared." From the above remarks, and from the fact that specimens of *tribulus* which have passed through my hands are so nearly like the species in question, I should be strongly inclined to place *Coppingeri*, either as a synonym, or at most as a variety of *M. tribulus*. The species was found in the Arafura Sea, Dundas Straits, in 17 fathoms.

MUREX SERRATOSPINOSUS, Dunker.

Murex serratospinosus, Dunker, Malakozoologischer Blätter, p. 35, pl. 1, fig. 4, 5, 1883.

This is a distinct little shell, and the description of it is not in the reach of the average conchologist. I believe, therefore, that a translation of the original description will not be out of place here. "Shell solid, with three varices, whitish encircled by wide yellowish bands, on the varices pale ferruginous, and nearly equal lirae, longitudinally plicate-costate. Varices thick, rounded, serrate-spinose in front, posteriorly hollowed-subcanaliculate; intervarical folds two or three. Whorls 8 to 9, separated by profound sutures, the last, including canal, more than double the length of spire; lip crenate, sulcate within; columella rugose-plicate; throat milky white, entirely smooth; canal elongated, nearly straight, a little ascending, the channel narrowly open. Alt. 95 mm." It is from the Island of Flores. The species is related to the *tribulus* group.

MUREX ACANTHOSTREPHES Watson.

Murex acanthostrephes, Watson, Journ. Linn. Soc., London, p. 596, 1883; Challenger Report, Gastropoda, p. 149, pl. x, fig. 2. E. A. Smith, Zool. Voy. H. M. S. Alert, p. 143, pl. v, fig. B.

This appears to be a very distinct species, and I am not able to refer it to any described form. It differs from *adunco-spinosus*, Beck, in the spines standing out much more from the axis, and the earlier whorls being ornamented with a double row of hollow squamous spines; from *ternispina*, Lam., it differs in possessing a double row of hollow spines; from *tribulus*, Linné, it differs in having longer, more numerous spines, and in the general form of the apex; and from *Cabritii*, Bernardi, it differs in being longer, thinner, and with longer, weaker spines. It is a species which will at once be recognized when seen. The original specimens were from west of Cape York, off S. W. point of Papua, in 28 fathoms, in green mud.

MUREX MARTINIANUS Reeve.

Murex Martinianus, Reeve, Proc. Zool. Soc., p. 88, 1845; Conch. Icon., *Murex*, sp. 72.

This species has no affinity with *ternispina*, Lam., as many authors have supposed. Many hundred specimens of both of these species have passed through my hands, and I have thus far failed to notice a specimen connecting them. The present species has a longer shell with shorter and more numerous spines. In *ternispina* there are eight well-developed spiral ribs and no longitudinal costae, while in the present species there are three, sometimes four, heavy longitudinal costae, and about fourteen light spiral lines. In *Martinianus* there is a strong tooth at the base of the outer lip, which is absent in *ternispina*. The apices are quite different, the present species having nearly two glossy, horn-colored whorls with a carnia running about their base, while *ternispina* has an apex with two and a half conical, glossy, smooth whorls. The species is found in China and Japan.

MUREX TROSCHELI Lischke.

Murex Troscheli Lischke, Mal. Blätt., p. 219, 1868; Jap. Moll., I, p. 41, pl. 1, figs. 1, 2; suppl., p. 164.

This is a species which is rare in collections, and therefore but little understood. I have received it under various names but it is more often confounded with *ternispina*. I recently had the pleasure of examining over a dozen specimens fresh from Japan. It is a perfect giant, being the largest of the subgenus. The spines are short and blunt, and almost straight, resembling in this respect *Martinianus*. There are no intervarical nodes on the last three whorls, but on the first three, after the nuclear whorls, there are four well-developed costae; there are on the body-whorl five to seven strong spiral lines of a rich red color, and between these larger lines several finer lines. The operculum differs also, being nearly round, and having its surface raised in strong lines of growth. That of *ternispina* is long-ovate and the lines of growth are not nearly so prominent. The nuclear whorls are widely different, those of *Troscheli* having a very strong, sharp carina encircling two and a half whorls, while in *ternispina* there are but one and one-half rounded whorls destitute of a carina. The largest specimen examined measured as follows: Alt., 6.8 in.; diam., 2.10 in.; aperture alt., 1.25 in.; diam., 0.75 in. It has been reported from Japanese waters only.

MUREX CABRITII Bernardi.

Murex Cabritii Bernardi, Journ. Conch., VII, p. 301, pl. 10, fig. 3 1858.

This is a rare species in collections and I was quite surprised to find two very perfect examples in a lot of shells recently examined. Its principal distinguishing point is the row (4) of long spines on the canal; all the other spines are very short. The color is pink or pinkish-white. There are three distinct longitudinal costae, and numerous distinct spiral lines encircling the body whorl. The species is not likely to be confounded with any other form. The localities for this species, so far as known, are as follows: Off Sombrero, 50–72 fms.; Gulf of Mexico, in 84 fms.; Santa Cruz, in 115 fms., on a rocky bottom; Saba Bank, in 150 fms.; Montserrat, in 88 fms.; Grenada, in 92–164 fms., coral; Barbados, in 76 fms.; 20-40 miles east and south of Cape Hatteras, North Carolina, in 34-62 fms., sand. Dr. Wm. H. Dall suggests (Blake Gastropoda, Bull. Mus. Comp. Zool. Harvard College, XVIII, no. XXIX) that *Murex Tryoni* Hidalgo may be a young specimen of this species. From a study of the limited material at my disposal I should be inclined to agree with him. Neither figure nor description give any distinctive characters which are not possessed by *Cabritii*.

MUREX RECURVIROSTRIS Brod.

Murex recurvirostris Brod., Proc. Zool. Soc., p. 174, 1832; Reeve, Conch. Icon., *Murex*, fig. 75. *Murex messorius*, Menke, Zeitsch., 1850.

This group is badly mixed in Tryon's Manual, and seems to be but little understood. Many of the species have very close relationships, but they may, for the most part, be easily recognized, and possess tangible specific characters. The typical *recurvirostris* is a species almost wholly destitute of spines, the varices are thick, and the canal nearly closed and curved at the end. The color is a dark slaty-brown. The species is confined to Panama.

MUREX MESSORIUS (Sowb.) Reeve.

Murex messorius Sowb., Conch. Ill., fig. 93. Reeve, Conch. Icon., *Murex*, fig. 90, 1845. *Murex Gundlachi* Dunker, Malak. Blätt., p. 35, pl. 1, fig. 1, 2, 1883.

The present species is one which is seldom named correctly; it is most frequently called *recurvirostris* and *rectirostris*. The shell is quite stout, almost destitute of spines, with two strong and a single faint intervarical rib, and is devoid of any color markings, like dots or lines. The few spines are thick and curved. Dr. W. H. Dall has characterized a variety *rubidum*, from Cedar Keys, Florida, the shell being of a deep pink color. The species is found from Cedar Keys, Florida, to Aspinwall, Panama.

Murex nigrescens Sowb.

Murex nigrescens Sowb., Conch. Ill., fig. 113.

From a careful study of numerous material I am led to conclude that this species is specifically distinct from *messorius*. The canal is considerably curved, the spire is long and conical, and the shell is almost destitute of spines, some specimens possessing but a single spine on the canal just below the aperture. The varices are thick and strong, and the spiral lines well developed. The general color of the shell is ashy with a dark brown band above the periphery of the body-whorl. The species is confined to the Panamic province.

Murex rectirostris Sowb.

Murex rectirostris Sowb. Proc. Zool. Soc., 1840. Conch. Ill., fig. 111.

I know of no good description of this beautiful species, and the one which follows, and which was drawn from over a dozen fine specimens, seems quite necessary.

Shell fusiform, whitish, with two broad brown spiral bands; sutures deeply impressed; whorls 8½, the two apical smooth and glossy, the second provided with a well-marked carnia near the suture of the third whorl; the rest of the whorls rounded, somewhat shouldered at the suture, trivaricose, with three nodules between the varices; the latter are provided with one strong spine at the suture of the whorls; whorls ornamented by fine spiral lines, which rise into ridges on the varices and nodules; spire high, about twice the length of the aperture; canal long, straight and about three times the length of the aperture and crossed by from 16 to 20 coarse lirae; a short spine is frequently developed to the left of the inner lip; aperture ovate, white; outer lip thin at the edge and denticulated; inner lip erect, thin and raised over the columella, at the lower end of which it runs into the long, closed canal. Alt., 70; diam., 25; aperture alt., 13; diam., 9 mill. Canal 40 mill. long.

Habitat. Xipixapi, West Columbia, in 11 fathoms (Cuming); China (Sowerby).

This species is separated from *recurvirostris*, Sowb., by the greater elevation of the spire, comparatively longer canal and the entire absence of any indication of an old snout end; and it is separated from *similis*, Sowb., by the greater elevation of the spire, straight canal, which in *similis* is recurved, and by having but three intervarical nodes whilst *similis* generally has four. The canal in *similis* is only twice the length of the aperture, while that of *rectirostris* is three times the length. The spiral striation in *similis* is much finer than in *rectirostris*. The character which will at once separate it from all related forms is the presence of the carina on the second apical whorl.

MUREX MINDANENSIS Sowb.

Murex Mindanensis Sowb., Conch. Ill., fig. 92.

In the more elongated spire and fusoid form this species differs specifically from *Murex rarispina* Lam.; the spines in the latter species are longer and the general character of the shell more robust than in the present species. The most noticeable character of *rarispina* is the great development of the superior spines of the body-whorl, they being eight times the length of the other spines. It is from the Island of Mindanao, Philippines.

MUREX BEAUI Fischer and Bernardi.

Murex Beaui Fischer and Bernardi, Journ. de Conch., V., p. 295, pl. viii, fig. 1, 1856.

This distinct species has recently been found in considerable quantity in and about the Gulf of Mexico. The additional localities are as follows: Florida Reefs, 119 fms.; Barbados, 82 fms.; off Frederickstadt, Santa Cruz, in 115 fms., on a rocky bottom; Saba Bank, 254 fms., sand; off Guadalupe, 183 fms.; south of Cuba, 254 fms., sand; between the delta of the Mississippi river and Cedar Keys, Florida, in 111 fms., mud.

MUREX PLICIFERUS Sowb.

Murex pliciferus, Proc. Zool. Soc., p. 138, 1840. Conch. Ill., fig. 101.

After a careful study of more than fifty specimens of this species I am convinced that its proper place is in the typical Murices rather than in *Chicoreus*. The shell has the same general characteristics as *similis*, *motacilla*, *antillarum*, etc., and is the most fusiform *Murex* yet described. It is not a synonym or even a variety of *calcar* Kiener, as has been thought by some authors. It is a Japanese species.

MUREX SUPERBUS Sowb.

Murex superbus Sowb., Proc. Zool. Soc. London, p. 565, pl. 28, figs. 10, 11, 1888.

This species is closely related to *Murex pliciferus* of the same author and may eventually prove to be but a variety of the same. The shell is said to be browner in color, the nuclear whorls are round and smooth and the spiral lirae are granular in texture; the varices are somewhat scaly. The dimensions given are, alt., 70; diam., 32; aperture alt., 18; diam., 15 mill. Only a single specimen is known, the type, from Hong Kong, China, and it is reasonable to suppose that when more material is collected it will be found but a variety, at most, of the preceding species.

MUREX CALCAR Kiener.

Murex calcar Kiener, Coq. Viv., pl. 36, fig. 2.

This species should be classed with the typical Murices, instead of with *Chicoreus*, and is of the same general type as *Murex rarispina* and *M. nodatus*.

MUREX NODATUS Reeve.

Murex nodatus Reeve, Conch. Icon., Murex, fig. 107, 1845.

This species is not a synonym of *messorius* Reeve. They may always be separated by the following characters: *nodatus* is a lighter, more spinose species, the intervarical plicae are more numerous, and the inter-nodular brown spiral lines give the shell a granular appearance. In *messorius* the nodules are large and coarse, and the varices much shorter, less numerous or wanting. *Nodatus* has been found at the following localities: Off Santa Cruz, in 115 fms., rocky bottom; Flannegan Passage, in 27 fms., sand; off Montserrat, living in 88 fms.; off Barbados, in 76 fms., sand (Dall). It is a species which may be looked for in collections from the West Indies.

Subgenus CHICOREUS Montfort, 1810.

Considerable revision is necessary to bring order out of chaos in this group. In my judgment the following sections have no distinctive characters which can be regarded as higher than specific: *Siratus*, Jouss., 1880 (type *M. Senegalensis*

Gmel.); *Euphyllon*, Jouss., 1880 (type *M. monodon*, Sowb.; *Inermicosta*, Jouss., 1880 (type *M. fasciatus* Sowb.). So far as my material goes, I am able to trace a gradual transition from very spinose to a condition entirely destitute of spines. Some character other than the shell must be chosen upon which to base the subdivisions of this group, if, indeed, such division is necessary.

Murex microphyllus Lam.

Murex microphyllus Lam., An. sans Vert., IX, p. 576.

Murex Poirieri, Jousseaume (Le Naturaliste, No. 44, p. 349; Nouvelles Archives du Museum, p. 58, pl. iv, fig. 2, a, b, 1882) is a synonym of *microphyllus*. I can find no distinctive characters in the description, and I have seen typical specimens of *microphyllus* which cannot be distinguished from the figure. *Murex Jousseaumei* Poirier, described in the same paper, is also a synonym.

Murex Banksii Sowb.

Murex Banksii Sowb., Conch. Ill., fig. 82.

Murex Bourguignati, Poirier (Nouvelles Archives du Museum, p. 57, pl. v, fig. 2, a, b), is a synonym of this species.

Murex torrefactus Sowb.

Murex torrefactus Sowb., Proc. Zool. Soc., p. 141, 1840; Conch., Ill., fig. 120.

Murex Rochebruni Poirier (Nouvelles Archives du Museum, p. 57, pl.v, fig. 1, a, b), is a slim, elongated form of this species. In the last three species the authors have been unfortunate in fixing upon the frondosity as a specific character, really one of the most mutable characters of the whole family. Particularly in this subgenus is this variation most perplexing, and instead of new species being found, old ones will be seen to merge with others, and a reduction of species will be the result.

Murex rufus Lamarck.

Murex rufus Lam., Anim. sans Vert., IX, p. 574.

This species is not a synonym of *Murex adustus* Lam., as quoted by Mr. Tryon. Dr. W. H. Dall quotes it from the

West Indies, and on the Atlantic coast of the United States from Cape Fear to West Florida. I have found it on the northern coast of Yucatan. Its extreme southern range is Carthagena. *Murex salleanus*, A. Adams, which was made a synonym of *Murex pomum*, Gmel. by Mr. Tryon (Man. Conch. II, p. 98) is a synonym, instead, of *rufus*. *Murex florifer* Reeve is a variety found at Nassau, N. P.

MUREX RECTICORNIS Martens.

Murex recticornis Martens, Jahrb. Deutsch. Malak. Gesell., VII, p. 81, pl. iv, fig. 3.

This species is very closely related to *Murex cervicornis* Lam., from the same faunal region, and may prove eventually to be but a variety of that species. It is described as follows:—

"Shell fusiform, solid, canal slim, rather long, slightly curved, spire subturreted; whorls 7 with three varices; varices rounded, spire very narrow, the last whorl armed with two long, acute spines; distinctly spirally lirate, provided with two equal folds between the varices; aperture round, small, the canal nearly closed, double the length of aperture, columella arcuate, callous quite thick, suberect, slightly tuberculate above; outer lip erect, crenulated, armed with a scale at the foot of the last varix; canal provided with a series of spines; unicolored dull brown. Alt., 42; diam., 17 mill. Aperture alt. (including canal), 29 mill."

Collected at East Australia, in 76 fathoms.

The species is also very closely related to *Murex longicornis* Dunker, and is perhaps more nearly related to this species than to *cervicornis*, since Von Martens does not mention that the spines are bifurcated in any way.

MUREX CAPUCINUS Lam.

Murex capucinus Lam., Anim. sans Vert., IX, p. 576.

In a letter to Mr. Tryon, Mr. R. E. C. Stearns says: "This species is certainly found at the Philippines, where I have received it from reliable collectors." The species has a wide distribution, being found in Valparaiso, Porto Rico and the Philippines.

Subgenus Phyllonotus Swainson.

The following sections may be considered synonyms: *Bassia*, Bayle, 1880 (type *M. Stainforthii* Reeve); *Poirieria*, Jouss., 1880 (type *M. Zelandicus* Quoy and Gaim.); *Paziella*, Jouss., 1880 (type *M. Pazi* Crosse). No one has yet been able to find characters of enough stability to form sections of this extremely variable group.

Murex Stainforthii Reeve.

Murex Stainforthii Reeve, Proc. Zool. Soc., p. 104, 1842; Conch. Icon., sp. 68.

Murex hirsutus Poirier, described and figured in Nouvelles Archives du Museum, 1882, p. 83, pl. vi, figs. 2[a], 2[b], is simply a very perfect specimen of this species.

Subgenus Homalocantha Mörch.

Murex scorpio Linné.

Murex scorpio Linné, Syst. Nat., XII, p. 1215.

Murex Lamberti Poirier (Arch. du Museum, p. 86, pl. vi, figs. 3[a], 3[b]) is a synonym. The specimen figured is simply a very fine individual.

Subgenus Pteronotus Swainson.

The following sections have no distinctive value: *Morchia* Jouss., 1880 (type *M. clavus* Kiener); *Naquetia*, Jouss., 1880 (type *M. triqueter* Born.); *Triremis* Bayle, 1880 (*M. Gambiensis* Lam.); *Poropteron* Jouss., 1880 (*M. uncinarius* Lam.); *Pteropurpura* Jouss., 1880 (*M. macropteron* Desh.); *Alipurpura* Bayle, 1884 (*M. acanthopterus* Lam.). It is difficult to conceive of what use these sections are to the scientific world.

Murex macropterus Desh.

Murex macropterus Desh., Mag. de Zool. pl. xxxviii, 1841.

Several living specimens of this species were obtained by the United States Fish Commission Steamer Albatross. The operculum is as figured by Deshayes. The specimens were collected off Cape Hatteras in 63 fathoms.

MUREX BEDNALLI Angas.

Murex Bednalli Angas, Proc. Zool. Soc., 1880, p. 418, pl. xl, fig. 2.

This species strongly resembles *Murex triformis* Reeve, from the same region. Specimens before me agree quite well with the description given by Angas. It may prove to be but a well-developed form of this species or, perhaps, a variety. *Murex bipunctatus* Reeve may eventually prove to be a variety of *triformis*.

Genus **Trophon** Montfort.

Section TROPHON (sensu stricto).

TROPHON ACANTHODES Watson.

Trophon acanthodes Watson, Journ. Linn. Soc. London, XVI, p. 386; Challenger Report, Gastropoda, p. 166, pl. x, fig. 6.

I am strongly inclined to consider this species a variety of *Trophon vaginatus* Jan. It is said to differ from that species in being more tumid on the base, more constricted at the anterior canal, has a straighter canal, a less contracted suture, and a more depressed spire. The figure given by Watson is excellent. It was collected off Patagonia in 175–245 fms., blue mud.

TROPHON BAILEYANA Tenison-Woods.

Trophon Baileyana Tenison-Woods, Trans. Royal Soc. Victoria, XVII, p. 80, fig. 1, 2.

I have seen specimens of *Trophon Flindersi* Adams & Angas, which strongly resembled this species, although there are some points in which *Baileyana* differs considerably, as in the sculpture and form of the spire. It is an Australian species.

Section BOREOTROPHON Fischer.

TROPHON CLATHRATUS Linné.

Trophon clathratus Linn., Syst. Nat., XII, p. 1223, 176.

Trophon declinans Watson (Journ. Linn. Soc. London, XVI, p. 388; Challenger Report, Gastropoda, p. 168, pl. x, fig. 10) can be considered nothing but a large, thin variety of this species. *Trophon cepula* Sowb. (Thes. Conch., IV, p. 61, pl. 404, fig. 14; pl. 405, fig. 27) is also a synonym.

TROPHON CRATICULATUS Fabricius.

Trophon craticulatus Fab., Faun Grönl., p. 400.

Trophon Stuarti E. A. Smith (Proc. Zool. Soc., p. 481, pl. 48, fig. 6, 1880), seems to me to be simply a well developed form of this species. I can see no distinctive characters by which the two species may be separated.

Genus **Ocinebra** Leach.

The following sections are probably synonymous with *Ocinebra: Heteropurpura* Bayle 1880 (type *O. polymorpha* Broc.) and *Hadriana* Buc. et Dantz. 1882 (type *O. craticulata* Broc.).

Subgenus FAVARTIA Fischer.

OCINEBRA CELLULOSA Conrad.

Murex cellulosa Conrad, Proc. Phil. Acad. Sci., III, p. 25, 1846.

Besides *Murex nuceus* Mörch, the following species are undoubtedly synonymous with *cellulosa: casta* A. Adams, *Jamaicensis* Sowb., *tetragonus* Brod., and *cyclostoma* Sowb. Dr. Wm. H. Dall has characterized a variety distinguished by being somewhat smaller and more slender, with one varex less and the varices thinner and branched, each branch having a sharp edge. The species is found plentifully throughout the West Indies and southeastern part of the United States.

Subgenus PTEROHYTIS Conrad, 1862.*

OCINEBRA CALIFORNICA Hinds.

Murex Californicus Hinds, Zool. Proc., London, p. 128, 1843; Voyage Sulphur, pl. iii, fig. 9, 10.

I have seen no good description of this species, and as it is very frequently mixed with other species, a description

* For the reasons for changing the name of this subgenus from *Cerostoma* see the author's paper in Bull. Chi. Acad. Sci., II, No. 2, 1895.

drawn from a fine series of specimens will not be out of place.

Shell fusiform, yellowish, with three varices; varices subspinose; spirally lirate, the lirae coarse, equidistant; one node between the varices; spire elongated, scalar; apex consisting of two roundish, nearly smooth whorls; whorls 7, shouldered and considerably angulated below the sutures; sutures hardly impressed; aperture oblong-oval, smooth inside, produced anteriorly into a moderate, closed canal; outer lip provided with short digitations; columella arcuate, white, smooth, continuous above with the outer lip; below, and near the old canal-end, it is raised in a thin lamina; color yellowish, with a greenish tinge; the tip of the canal inside and the throat marked with purple. Operculum with the nucleus at the lower, outer edge.

Alt. 60, diam. 30 mill., aperture alt. 17, diam. 10 mill. California and Lower California.

This species is quite distinct from *Ocinebra trialata* Sowb., a synonym of which many authors have considered it.

Genus **Muricidea** (Swainson) Mörch.

Muricopsis Bucquoy and Dautzenberg (Moll. Marins du Roussilon, p. 19, pl. i, figs. 5, 6, 1882) is a synonym.

MURICIDEA CRISTATA Brocchi.

Murex cristatus Brocchi, Conch. Foss. sub-app., p. 394, pl. vii, fig. 15.

Murex porrectus Locard (Ann. Soc. Linn. Lyons, XXXII, p. 221, 1885) is a synonym of variety *Blainvillei* Payr. *Murex inermis* Monter., described on same page, is also a synonym. In 1840 Sowerby described a *Murex inermis* in Zool. Proc.

Genus **Urosalpinx** Stimpson.

This genus differs from *Muricidea* (with which some authors have confounded it) in its operculum, which combines the characters of both *Murex* and *Purpura*. Externally it is like *Murex* and internally it is like *Purpura*, showing the peculiar gyratory scars so characteristic of that genus. The nucleus is situated within the edge of the operculum, midway between the ends. *Hanetia* Jouss., 1880 (type *Urosalpinx Haneti* Petit) is a synonym.

It may not be out of place here to mention the American species of the genus, since they are pretty badly mixed in most cabinets.

U. CINEREUS Say. Massachusetts to Florida.

U. TAMPAENSIS Conrad. West Coast of Florida. (This species is usually classed as a *Eupleura*.)

U. PERRUGATUS Conrad. Cedar Keys, Key West to West Florida. (See Proc. Phil. Acad. Sci., pp. 46–47, 1890.)

U. CAROLINENSIS Verrill,
U. MACRA Verrill, } off Cape Hatteras, 120–938 fms.

(See A. E. Verrill, Trans. Conn. Acad., VI, pp. 237–239.)

Genus **Lachesis** Risso.

This genus, formerly included in Pleurotomidae, is now placed by Fischer in the Muricidae (vide Man. de Conch.). The characters are said to be entirely muricoid, thus the change. The type species, *Lachesis minima* Mont., is from European seas. Its relationships are somewhat doubtful.

Subfamily PURPURINAE.

Genus **Purpura** Brug.

Subgenus THALESSA H. & A. Adams.

PURPURA ARMIGERA Chemn.

Purpura armigera Chemn., Conch. Cab., XI, pl. 187, fig. 1798.

Purpura affinis Reeve (Conch. Icon., sp. 77, 1846) may be considered a good variety of *armigera;* it is always a much slenderer form, with the spines less numerous; it is also a smaller species, ranging from 37 to 65 mill. in length.

Subgenus STRAMONITA Schum.

PURPURA HAEMASTOMA Linné.

Purpura hæmastoma Linn., Syst. Nat., XII, p. 1202.

Purpura Trinidadensis Guppy (Proc. Sci. Ass. Trinidad, 1869) is said by Dr. W. H. Dall to be a variety of *haemastoma*. *Purpura oceanica* Locard (Ann. Soc. Linn. Lyon., XXXII, p. 216, 1885) is a synonym of typical *haemastoma*.

Subgenus POLYTROPA Swainson.

PURPURA LAPILLUS Linné.

Purpura lapillus Linn., Syst. Nat., XII., p. 1202.

Purpura celtica Locard (Agric. Soc. Lyons, p. 558, 1886) is a synonym of *lapillus*. This prolific form probably has as numerous a synonymy as any existing species.

PURPURA SCOBINA Quoy.

Purpura scobina Quoy, Voy. Astrol., II., pl. XXXVIII., figs. 12, 13.

Purpura biconica Hutton is said by its authors to = *tristis* Dunker (= *scobina*). Vide letter to Mr. G. W. Tryon, Jr. (1882).

PURPURA EXILIS Dunker.

Purpura exilis Dunker, Mal. Blätt., XVIII., p. 154, 1871.

This species was said by Mr. Garrett, in a letter to Mr. Tryon, to = *Daphnella tricarinata* Val.

PURPURA CHEESEMANI Hutton.

Polytropa cheesemani Hutton, Trans. New Zealand Institute, p. 131, 1882.

The writer recently had the pleasure of examining a dozen fine specimens of this species, and there is no question concerning its validity. It is a small species (about half an inch in length) and may at once be known by its white shell encircled by five spiral ribs, with the ribs broad and smooth and the grooves narrow and transversely lirated. The interior of the aperture is bright purple. It is allied to *Purpura propinqua* Tenison-Woods, but the grooves in that species are much narrower. The species was originally collected at Port Waikato, New Zealand.

Genus **Sistrum** Montfort, 1810.

< *Sistrum* Montfort, Conch. Syst., II, p. 594, 1810.
= *Ricinula*, Lamarck, Extr. d'un Cours, 1812.

The name *Sistrum* has two years' priority over *Ricinula*. *Pentadactylus* Klein (Ostracol., p. 17, 1753) has been used for this group, but Klein's work antedates the tenth edition of the Systema of Linnaeus and cannot therefore be used.

Subgenus MORULA Schumacher, 1817.

< *Morula*, Schumacher, Nouv. Syst., p. 227, 1817.

This name should be used in the same sense that *Sistrum* has heretofore been used for the smaller forms of the genus.

SISTRUM MARGINATUM Blainv.

Sistrum marginata Blainv., Nouv. Ann. du Mus., I, p. 218, pl. x, fig. v, 1832.

In a letter to Mr. Geo. W. Tryon, Mr. Garrett said (some ten years ago): "*Sistrum affinis* Pease is a synonym of *marginatum* (=*fusconigra* Dunker); the latter is not a synonym of *muricina* as supposed by Schmeltz. *Marginatum* is common at the Marquesas, but is not found in any other part of Eastern Polynesia; but is found commonly in the Western Group.

"*Sistrum squamosum* Pease (= *marginatum*) is not found east of Samoa, but is common in the Western Group and Australia."

Subfamily CORALLIOPHILINAE.

Genus **Latiaxis** Swainson.

Some time ago (Bull. Soc. Zool. de France, 1883, p. 187), M. Jousseaume proposed the name *Latiaxiena* for a number of species belonging to various genera; his diagnosis was as follows: "Shell largely umbilicated, fusiform and ventricose, longitudinally costate and encircled with squamose lirae or with denticulate striae, aperture oval, crenate on the outer edge and lirate within, uniting posteriorly in a curve with the inner lip, this margin is interrupted at the level of the suture by a deep sinus; canal more or less elongated, open, and with straight margins; the general aspect of the shell is constant in all the species; the form of the canal and posterior sinus of the outer edge permit us to distinguish at the first sight the *Latiaxiena* from the allied genera.'' The following species are included in the genus: —

MUREX LUCULENTUS Reeve (= *Trophon fimbriatus* Hinds).

FUSUS MURICOIDES Desh. (fossil).

AFER BLOSVILLEI Desh. (= Buccinidæ).

LATIAXIS RHODOSTOMA A. Adams (= *Coralliophila* + *Latiaxis*).

LATIAXIENA LATIAXIENA Jouss. (Bull. Soc. Zool. de France, 1883, p. 189, pl. x, fig. 1).

LATIAXIENA ELEGANS Jouss. (Bull. Soc. Zool. de France, 1883, p. 190).

All the species, save the last two, are referable to other genera or families. The last two species appear to me to be some form of *Coralliophila* (= *Latiaxis*) near *Jeffreysii* E. A. Smith or *pachyraphe* E. A. Smith. The genus is certainly not a valid one, and in its construction the author has followed closely in the footsteps of Humphreys.

Subgenus CORALLIOBIA A. Adams.

< *Coralliobia* A. Adams, Zool. Proc., p. 93, 1852.

Magilus Tryon, Man. of Conch., II, p. 217, 1880 (non Montf.).

Coralliobia Fischer, Man. de Conch., p. 647, 1884.

This subgenus has been merged with *Magilus* by various authors, but its affinities seem to be rather with *Latiaxis* (*Coralliophila*). The shell is irregular in outline, the spire is very short, lateral and partly concealed by the last whorl; surface lamellose; aperture oval, subsinuous; border of the columella very much reflected and covered by the spire. It inhabits the Pacific ocean. The species included are: —

C. FIMBRIATA A. Adams,	C. ROBILLARDI, Lienard.
C. CANCELLATA Pease,	C. SCULPTILIS Pease.

The last two are unfigured and may possibly be synonymous with either of the first two species.

Genus **Melapium** H. & A. Adams.

Dr. Paul Fischer refers this genus to the family Turbinellidae. This disposition is probably correct, as the columella has a very distinct plait.

Issued June 12, 1897.


Map of the District of Cienfuegos.
..... Route of Collector
—— Railroad
Scale in Kilometers
0
5
10
20
30
40
50
Santa Clara
Esperanza
Ranchucho
S. Juan de los Yeras
Cartagena
Cruces
Palmira
R. Caunao
Leguellio
Aguada de Pajeros
San Lino
Congojas.
Rodas
Sabanas
Abreus
Cieneguita
Constancia
Santa Rosalia
Caunao
Yaguaramas
San Nicholas
Jucaro Quemado
La Seiba
Romonelia
Encrucijada
Cabeza de Toro
Ciego
Alejandro
Caleto del Ingles
Caleta Cocodrilos
Punta Mangles
Faro Villa
Punta Colorada
Caya Piedras del Sur
Cienfuegos
Lagunillas
San Anton
San Mateo
Arimao
R. Arimas
Montes de Siguanea
Guinia de Soto
R. Manati
Trinidad
Punta del Grandes
3° West
22° North

PLANTS COLLECTED IN THE DISTRICT OF CIENFUEGOS, PROVINCE OF SANTA CLARA, CUBA, IN 1895–1896.

ROBERT COMBS.*

INTRODUCTION.

The collection of the plants listed here was begun at the commencement of the rainy season in May, 1895, and extended through the remainder of the year until April in 1896, except the months of October and November, 1895, during which months I was absent from the island. The plants therefore represent the flora of both the rainy and the dry seasons.

The territory covered during this time extends from the entrance to the bay of Cienfuegos (Jagua Bay), on the south coast, up to the bay on both sides — excepting the northeast coast from "Pasa Caballos" opposite Castillo de Jagua around to Cienfuegos — and thence up Rio Damuji to Rodas; west from the river at Abreus to Yaguaramos and south almost to the Cienega de Zapato. (See map). The territory includes nearly all kinds of soils and conditions that are found upon the island (except in the mountainous region and the "cienegas," or mud swamps). The plants collected at Cieneguita N. and at Faro Villa Nueva E., border on the mountainous flora; and some from Cieneguita S. W. and Cieneguita R. R., S. W. Branch, are allied to the cienega flora.

In making the collection, I made my headquarters on the estate of Cieneguita, to the owner of which, Sr. Dn. Fermin de Sola, I wish to express my sincerest thanks for the many courtesies and conveniences extended to me. And to Prof.

* Presented in abstract to the Academy of Science, St. Louis, June 7, 1897.

L. H. Pammel, of the Iowa Agricultural College, Ames, Iowa, under whose advice and direction the whole work has been done, my most heartfelt thanks and gratitude are due.

The full credit of the determinations, except the *Loranthaceae* which were determined by Dr. I. Urban of Berlin, is due to Mr. J. M. Greenman of the Gray Herbarium, Harvard University, whose notes and descriptions are placed in quotation marks, and to whom I am deeply grateful for manuscript and suggestions as well as for his arduous labor in determining these plants for me. The drawings for the plates illustrating the new and interesting plants were made under my direction by Miss Charlotte M. King, artist for the Iowa Agricultural Experiment Station, to whom much credit is due.

RELATIONS OF THE FLORA.

The flora of Cuba is interesting, not only for its great number of endemic types, but also for the striking characters of those types, their occurrence, distribution and economic uses. The flora belongs to the neotropic region, which is noted for being rich in strange and characteristic animals peculiar to this part of the world; therefore one might expect to find its plants also striking and peculiar, which to a certain degree is true. Cuba, being in the northeast corner of the neotropic realm, besides having the general important characters of the region as a whole, has striking endemic peculiarities.

A comparison of its flora with that of its near neighbor, Florida, shows a greater difference than a comparison of the floras of Florida and Canada, while a comparison with far off Central and South Americas shows it to be almost identical with them in general character. This fact, from a superficial point of view, is strange indeed, but considering the geological and geographical relations that Cuba has to those countries, it is what one would expect.

Cuba, with the whole of the Greater Antilles, was at one time probably connected with the continent, South and Central American, and the land has since subsided, leaving only the islands above water, or, as Belt suggests,* "the land may never have subsided, but the connection with the continent was made by the water having been withdrawn to form the polar ice cap during the glacial epoch, leaving the islands connected with one another and with the continent by what are now submarine banks." This explanation seems hardly probable, since during the glacial epoch the polar regions were greatly elevated, and the southern part of the United States region was greatly depressed. This would touch the West Indies, and it is hardly probable that they would be above water when the southern part of the United States was under water. Marine charts of this region show Cuba connected with Yucatan, except for a short distance of 15 miles, by a marine bank, covered by a depth of from 600 to over 1,000 fathoms of water.

Cuba and Haiti are connected by a submarine ridge lying a little north of the shortest distance between them, which does not exceed the depth of 900 fathoms; Haiti with Jamaica by one, the extreme depth of which is something near 1,000 fathoms, and Jamaica in turn with Honduras at a depth of 1,000 fathoms. On the north, Cuba is connected with the Bahamas at 300 fathoms by the Great Bahama Bank, and the Bahamas are in turn connected with Florida at 500 fathoms. Then, as Hitchcock † says, "if from any cause the depth of the water of the ocean should be lessened by 100 fathoms there would be exposed the Little Bahama and Great Bahama banks and several of the smaller banks to the southeast. The Bahamas would be separated from the surrounding islands and from Florida, and the important channels would still occupy the same places. If reduced by 300 fathoms, the Great Bahama bank would be united with Cuba. If the water were 500 fathoms shallower than at present, the Little and Great Bahama banks would be united with Florida and some of the Windward Islands would be connected. It is not, however, till a layer of water 1,000 fathoms deep is removed that important changes would occur. Jamaica would be

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* The Naturalist in Nicaragua, p. 266.

† Plants collected in the Bahamas, etc., p. 160.

united with Honduras, Cuba with Florida and also with South America, through the Windward Islands. There would be a narrow channel between Cuba and Yucatan, between Jamaica and Haiti, and a wide and deep channel between Jamaica and Cuba."

Florida and the Bahamas, with their submarine banks, are all of recent formation from the calcareous deposit of the warm waters of the Gulf Stream, and are still growing. From this we may deduce that at one time the United States and Cuba were not connected through Florida and the Bahamas, because these connections did not exist. Then we would have Cuba connected with Yucatan and Honduras only, and thereby account for the neotropic origin of the Cuban flora.

The Greater Antilles are all of an old formation, and the presence of such a great number of endemic species of phaenogams would indicate that they were separated from the mainland at an early date, thus giving isolation and the time necessary for the evolution of the plants peculiar to them. Cuba, being the greatest, would have a natural right to the greatest number of these peculiar forms.

The geographical means of distribution are important factors in tracing the origin of the Cuban flora. The Gulf Stream, washing the coast of northern South America, is deflected from the coast of Central America into the Caribbean Sea, carrying all tropical seeds that it may have gathered from the shores of South and Central America, over into the West Indies. Cuba's great coast line and its proximity to the stream, a part of which flows down along the south coast, losing itself in the Lesser Antilles, while the main part flows north, making a circuit of the Gulf of Mexico, and back toward the south, striking the north coast of Cuba, would greatly favor the reception of such seeds. The Gulf Stream in this way not only establishes neotropic plants in Cuba, but materially prevents the entrance of plants from Florida.

All the prevailing winds in this region are from the south except an occasional norther, whose distributing influence is more than counteracted by the Gulf Stream. Even should these northers succeed in driving seeds across from Florida, as these winds occur in winter, Cuba's dry season, the seeds could hardly establish themselves for want of favorable conditions, and when the rainy season comes, in May, they could not contend with the luxuriant tropical plants already established there.

But, if the migration is so decidedly from south to north in this region, the question might well be asked: Why does not the neotropical flora become established in Florida? That it does not, is due partly to the fact that the Gulf Stream flows rapidly in the straits of Florida, and, when it leaves the straits it quickly diverges from the coast, thus throwing all its influence on the Bahamas instead of on Florida, as might at first be supposed. It is also due in part to the inability of the tropical plants to contend with temperate ones on their own "native heath."

The great difference between the Cuban and Floridan floras is beautifully accounted for by considering the original birthplace of plants to have been somewhere in the northern hemisphere, and that they then by migration came south, part going to Florida, where they stopped, part going down the continent through Mexico into Central and South America, and thence turning north, along the lines of the now submarine banks, into Cuba. This would make the Floridan flora much the oldest and most general, while the Cuban would be an extreme.

The distribution of the flora over the island is very interesting. The many different kinds of soil, the altitude, the proximity to the sea, all combine to make a constantly varying or changing flora, which might be likened by an enthusiast to a great panorama.

We have, 1st, the maritime region, the plants of which vary with its character, according to whether it is rocky cliffs, rocky reefs, long sandy beaches, sand hills, salt marshes, or mangrove swamps; 2d, the river bottoms, gradually differentiating from the maritime as they ramify in the island; 3d, the inland swamps, or "cienegas," derived from the maritime; 4th, the upland woods, varying with the soil and moisture; 5th, the mountain region, the plants varying with altitude, proximity to sea, etc.; 6th, the savannahs or wooded grass lands, grading into upland woods on the one hand, and into what are called "maniguas," and prairies with scattered clumps of bushes, on the other, and varying with the soil as to whether red, gravelly, or black; and 7th, a kind of arid, desert-like region, which may be classed as a savannah, but of an extremely gravelly, red, dry soil, and usually covering a comparatively small area. All seven of these divisions grade into one another, from the maritime at one extreme to the arid regions at the other, each one having plants common to some of the others, but possessing some plants peculiar to itself alone.

CATALOGUE.

RANUNCULACEAE. I.

CLEMATIS DIOICA L. "Cabello de angel."
Common to savannahs in good soil, both black and red. Cieneguita, Dec. to Jan., fruits in March. (674.)

DILLENIACEAE. II.

DAVILLA RUGOSA Poir. "Bejuco colorado."
In gravelly, red soil, savannahs, not frequent. Cieneguita S. W., Feb. 26, '96. (713.)

ANONACEAE. V.

ANONA PALUSTRIS L. "Bagá," "Palo bobo de Cuba."
Not uncommon, in river marshes and along small marshy streams. Abreus, May 23, '95. (79.)

A. RETICULATA L. "Mamón."
A good fruit, cultivated and spontaneous in good soil. Cieneguita, June 8, '95. (144.)

OXANDRA VIRGATA Rich.
Rich soil along the sea, uncommon. Loma de Pajeros at Calicita, Aug. 26, '95. (537.)

MENISPERMACEAE. VI.

CISSAMPELOS PAREIRA L. "Pareira brava" and "Bejuco de mona."

Open woods, fertile soil; a low climber, not frequent. Cieneguita, July 3 and 6, '95. (278.)

NYMPHAEACEAE. VIII.

NYMPHAEA AMPLA DC. var. PULCHELLA Casp. "Nelumbio blanco" and "Flor de agua."

Not common; open mangrove swamps along Rio Damuji. Constancia, Aug. 2, '96. (380.)

PAPAVERACEAE. X.

ARGEMONE MEXICANA L. "Cardo santo."

A not uncommon weed in fertile waste places, Dec.-April. Rare in summer. Rodas, Aug. 17, '95. (485.)

CRUCIFERAE. XII.

NASTURTIUM OFFICINALE R. Br. "Berro."

In small streams, running water. Not common, June-Nov. Common, Dec.-April. Cieneguita, June 17, '95. (156.)

CAPPARIDEAE. XIII.

CLEOME SPINOSA L. "Volantín."

Not frequent or not common, rocky fertile soil. Calicita, May 31, '95. (98.)

C. HOUSTONI R. Br. "Volantín."

Along Rio Damuji, fertile soil, uncommon. Abreus, Aug. 20, '95. (632.)

C. POLYGAMA L. "Volantín."

Uncommon, in fertile soil along small streams. Cieneguita E., May 21, '95. (64.)

POLANISIA VISCOSA DC.

Not uncommon in waste places, dry sandy soil. Juragua, Sept. 14, '95. (582.)

GYNANDROPSIS PENTAPHYLLA DC. "Volantín."

A common weed in waste places. Cieneguita, June 10, '95. (188.)

CAPPARIS JAMAICENSIS Jacq. "Carbonero."

Along the coast, rather poor soil. Loma de Pajero, Calicita, Aug. 26, '95. (536.)

C. CYNOPHALLOPHORA L. "P — de perro," "Palo diablo."

Low sandy coast woods, uncommon. Calicita, Aug. 26, '95. (649.)

C. GRISEBACHII Eichl. "Alcaparro."

Rocky and sandy coast woods, uncommon. Faro Villa Nueva, Sept. 18, '95. (574.)

VIOLARIEAE. XVI.

IONIDIUM JACQUINIANUM Roem. and Schultes.

Rough, rocky hillsides and sea banks, common. Castillo de Jagua, Sept, 17, '95. (550.)

SAUVAGESIA ERECTA L. "Yerba de San Martín."

Marshy grass land, shaded places, not uncommon. Cieneguita S. W., Aug. 8, '95. (435.)

S. TENELLA St. Hil.

Poor, gravelly, wet soil along small streams, common or frequent. Cieneguita S. W., Aug. 8, '95. (439.)

CANELLACEAE. XVII.

CANELLA ALBA Murr.

Rare along Rio Damuji, fertile soil. Abreus, June 20 and 29, '95. (227.)

Polygaleae. XXI.

Polygala longicaulis Kth. "Poligala."

Gravelly wet soil near source of stream. Cieneguita R. R., S. W. Branch, Aug. 8, '95. (442.)

P. angustifolia Kth.

Common in grass lands of savannahs, dry black and red soil. Cieneguita, June 18, '95. (213.)

Securidaca Lamarckii Griseb. "Enredadera del hacha" or "Flor de la cruz."

Low climber, not uncommon in open woods and savannahs. Cieneguita, May 20, '95. (71.)

Guttiferae. XXIX.

Clusia rosea L. "Copey," "Cupey."

Low coast woods, open rich soil. Calicita, Aug. 27, '95. (501.)

Malvaceae. XXXIII.

Malvastrum tricuspidatum Gray. "Malvavisco."

Common in pastures, waste places and savannahs. Cieneguita, May–July. (89 and 323.)

Anoda hastata Cav.

Common in waste places. Cieneguita, July 10, '95. (298.)

Sida acuta Burm. var. carpinifolia K. Sch. "Malva de caballo."

Common in waste places, etc. Cieneguita, May 27 and 29, '95. (91 and 117.)

S. urens, L. "Malva peluda."

Not uncommon in savannahs. Cieneguita S., Dec. 6, '95. (664.)

S. pyramidata Cav.

Not common, in low rough woods or thickets. Cieneguita N., Feb. 3, '96. (699.)

S. CORDIFOLIA L.

Common in dry sandy soil, along the coast at Castillo de Jagua, Sept. 16, '95. (561.)

S. LINIFOLIA Juss.

Common in dry savannahs, sandy poor soil. Cieneguita S., Sept. 10, '95. (595.)

BASTARDIA VISCOSA Kth. "Escoba de bruja."

Sandy river banks of Rio Damuji, uncommon. Santa Rosalia, Aug. 2, '95. (387.)

WISSADULA PERIPLOCIFOLIA Griseb. "Pichana."

In dry savannahs, red soil, rare. Cieneguita N., Aug. 22, '95. (634.)

ABUTILON INDICUM G. Don. var. HIRTUM Griseb. "Boton de oro."

Sandy waste places along suburban streets of Cienfuegos, common, Aug. 13, '95. (462.)

A. LEIOSPERMUM Griseb. "Pichana macha."

Sandy waste places, suburbs of Cienfuegos, not common, Aug. 13, '95. (464.)

MALACHRA RUDERALIS Gürcke.

A weed; very common in waste places, fertile soil. Cieneguita, May 15, '95. (48.)

M. ALCEAEFOLIA Jacq. "Malva mulata."

Black fertile soil, not uncommon. Cieneguita and Santa Rosalia, July and Aug., '95. (63 and 391.)

M. RADIATA L. "Malva mulata."

Fertile waste places, a common weed. Cieneguita, May 15, '95. (47.)

URENA SINUATA L. "Escoba."

Rich damp savannahs, common. Cieneguita, May 15, '95. (46.)

PAVONIA SPINIFEX Cav. "Majagüilla de costa, espinosa."

In low rocky woods or thickets. Not infrequent. Cieneguita N., June 3, '95. (124.)

P. RACEMOSA Sw. "Majagüilla."

Common along river banks, Rio Damuji. Abreus, June 20, '95. (222.)

KOSTELETZKYA PENTASPERMA Griseb.

Wet river woods, mangrove swamps, etc. Infrequent along Rio Damuji. Abreus, June 20 and 29, '95. (267.)

HIBISCUS ROSA-SINENSIS L. "Mar-Pacífico."

A white-flowered variety is called "Leche de Venus." Commonly cultivated in gardens, sometimes escaped. Cieneguita, July 22 and 29, '95. (359.)

H. ELATUM Sw. "Majagua comun."

Paritium elatum G. Don.

Infrequent along small streams and Rio Damuji. Cieneguita, Dec. 7, 95. (672.)

THESPESIA POPULNEA Corr. "Majagua de Florida."

Common along the water's edge of the bay at Calicita, Aug. 24, '95. (522.)

GOSSYPIUM BARBADENSE L.

Not uncommon. Cultivated in fertile soil, as a garden plant. Cieneguita S. W., Sept. 13, '95. (609.)

ERIODENDRON ANFRACTUOSUM DC. "Seiba."

Common in fertile savannahs. One of the largest trees of Cuba. Cieneguita, Jan. 25, '96. (696.)

STERCULIACEAE. XXXIV.

MELOCHIA HIRSUTA Cav. var. SERRATA Schaur. "Bretonica peluda."

Common in fertile waste places and pastures. Cieneguita, June 11 and 22, '95. (217.)

M. NODIFLORA Sw. ("Bretonica prieta"), "Malva colorada."

Not uncommon in open woods and savannahs, black, fertile soil. Cieneguita, Dec. 3, '95. (653.)

WALTHERIA AMERICANA L. "Malva blanca."

Common in old fields and pastures, red soil. Cieneguita, June and July, '95. (189 and 274.)

GUAZUMA ULMIFOLIA Lam.

A very common low tree (10–30 ft.) in savannahs, red and black soil. Cieneguita, May 18, '95. (51.)

G. ULMIFOLIA Lam.

G. tomentosa HBK.

A large tree (20–40 feet), black fertile soil. Common along the sea. Calicita, Aug. 26, '95. (533.)

AYENIA PUSILLA L.

Common on rocky hillsides near the sea at Castillo de Jagua, Sept. 17, '95. (549.)

TILIACEAE. XXXV.

TRIUMFETTA SEMITRILOBA L.

Common in savannahs, fertile black soil, sometimes red soil. Cieneguita, May 29, '95. (115.)

CORCHORUS SILIQUOSUS L. "Malva té," also "Té de la tierra."

In fertile savannahs, black soil. Cieneguita, May 29, '95. (118.)

C. HIRSUTUS L.

In rich sandy soil near the shore, common at Castillo de Jagua, Sept. 16, '95. (572.)

LUHEA SPECIOSA Willd.

L. platypetala Rich.

Not uncommon in savannahs, both black and red soil. Cieneguita, Dec. 4, '95. (651.)

PROCKIA CRUCIS L.
Trilex crucis Griseb.
Rare. In fertile open woodlands along small streams at Cieneguita N., June 4, '95. (125.)

LINEAE. XXXVI.

ERYTHROXYLON BREVIPES DC.
Rare along rocky coast hills at Calicita, June 12, '95. (178.)

E. OBTUSUM DC. "Jibá."
Not uncommon in rocky fertile woods and thickets. Cieneguita N., May 14, '95. (30.)

MALPIGHIACEAE. XXXVIII.

BYRSONIMA CRASSIFOLIA HBK. "Peralejo."
Very common in dry savannahs and in gravelly arid black and red soil. Cieneguita S. W., May 9, '95. (16.)

MALPIGHIA URENS L. "Palo bronco."
Infrequent in savannahs, black fertile soil. Cieneguita, May 13, '95. (27.)

M. URENS L. var. LANCEOLATA Griseb.
3–5 feet high, in gravelly poor soil, savannahs, uncommon. Cieneguita S., June 22, '95. (218.)

M. URENS L. var. LANCEOLATA Griseb.
4–6 feet high, along rocky sea banks. Calicita, Aug. 24, '95. (517.)

M. COCCIGERA L. "Palo bronco del pinar."
4–6 inches high, in dry, arid, sandy and gravelly soil. Rare. Cieneguita R. R., S. W. Branch, Aug. 19, '95. (493.)

BUNCHOSIA MEDIA DC.
Uncommon in rocky woods. Cieneguita N., Aug. 1, '95. (362.)

HETEROPTERIS LAURIFOLIA Juss. "Vergajo de toro."
Not uncommon in open fertile woods or savannahs, black soil. Cieneguita, May 29, '95. (113.)

STIGMAPHYLLON PERIPLOCAEFOLIUM A. Juss.
A high climber, uncommon, savannahs and woods. Cieneguita S., Jan. 1, '96. (678.)

S. SAGRAEANUM Juss.
Mostly trailing, common in savannahs throughout the year. Cieneguita, May 4 and 6, '95. (14.)

BANISTERIA PAUCIFLORA Kth.
Low climbing, in savannahs, uncommon. Cieneguita, Aug. 1, '95. (628.)

TRIOPTERIS RIGIDA Sw. "Bejuco de paralejo," "San Pedro de flor azul."
Common, climbing and trailing (?) in savannahs and open woods. Cieneguita, May 6, '95. (15.)

ZYGOPHYLLEAE. XXXIX.

TRIBULUS MAXIMUS L. "Abrojo."
Common weed in fertile waste places, as fields, roadsides, etc., black soil. Cieneguita, May 15, '95. (33.)

RUTACEAE. XLI.

ZANTHOXYLUM PTEROTA HBK. "Espino," "Limoncilla."
8–10 ft. high, in savannahs or open woods, rather dry red soil, not uncommon. Cieneguita S. W., July 9, '95. (301.)

Z. JUGLANDIFOLIUM Willd. "Ayuda blanca."
15–20 ft. high, in rough woods, fertile soil, infrequent. Cieneguita N., Aug. 6, '95. (Fruits.) (376.)

MURRAYA EXOTICA L. "Murraya" and "Boj de Persia."
4–10 feet high, cultivated. (Cienfuegos; Cieneguita S. W.) Calicita, July 17, '95. (309.)

Citrus aurantium L. var. spinosissimum Mey.
In savannahs and open woods, apparently indigenous. Frequently cultivated. Cieneguita, June 5, '95. (137.)

Simarubaceae. XLII.

Suriana maritima L.
Along the sea shore, not uncommon. Calicita, Aug. 14, '95. (467.)

Picramnia pentandra Sw. "Quina del pais" and "Aguedita."
In rocky or rough woods, not frequent. Cieneguita N., July 13, '95. (316.)

Picrodendron arboreum Planch. "Yanilla."
P. juglans Griseb.
In dry woods and rocks along coast. Faro Villa Nueva, Sept. 18, '95. (646.)

Ochnaceae. XLIII.

Gomphia (Ouratea Aubl.) acuminata DC.
In savannahs and woods, gravelly poor soil, infrequent. Cieneguita, June 14, '95. (171.)

G. ilicifolia DC. "Guanabanilla de sabana."
Open woods and savannahs, gravelly poor soil, infrequent. Calicita R. R. 11K., June 27, '95. (249.)

Burseracea. XLIV.

Bursera gummifera L. "Almacigo colorado."
Common in savannahs. Cieneguita, Aug. 16, '95. (486.)

B. angustata Wright. "Almacigo de costa."
Along rocky sea-shore, uncommon. Calicita, Aug. 14, '95. (454.)

Meliaceae. XLV.

Melia Azedarach L. "Paraiso" and "Prusiana."
Cultivated and escaped (?). (Cieneguita), Rodas, Aug. 17, '95. (479.)

Guarea trichilioides L. "Yamao."
On small streams, rare. Cieneguita E., May 17, '95. (49.)

Trichilia spondioides Sw. "Cabo de hacha."
Common in fertile open woods and rich savannahs. Cieneguita, June 10, '95. (187 and 700.)

T. havensis Jacq. "Ciguaraya."
Fertile open woods along small streams, not frequent. Cieneguita E. and N., July 26, '95. (346.)

Olacineae. XLVII.

Ximenia Americana L.
On low sandy hills near sea-shore, rare. Castillo de Jagua, Sept. 16, '95. (642.)

Celastrineae. L.

Maytenus buxifolius Griseb. "Boje."
On sandy shore at Calicita, rare. Aug. 14, '95. (457.)

Myginda Rhacoma Sw. "Maravedí."
Fertile sandy soil along sea, not frequent. Cienfuegos and Calicita, Aug. 13 and 14, '95. (452 and 456.)

M. ilicifolia Poir.
Along sandy shore, common at Cienfuegos. Aug. 13, '95. (451.)

Rhamneae. LIII.

Colubrina ferruginea Brongn. "Bijáguara."

Not uncommon in savannahs, gravelly red soil. Cieneguita S. W., Feb. 28, '96. (733.)

C. reclinata Brongn. "Jayajabico."

Along rocky coast hills, Calicita, not uncommon. Aug. 24, '95. (520.)

Colubrina sp.?

Coast hills at Calicita, not frequent. Aug. 24, '95. (528.)

Gouania tomentosa Jacq. "Bejuco de Cuba."

Climbing in fertile open woods or savannahs, not common. Cieneguita, May 28, '95. (93.)

Ampelidaceae. LIV.

Vitis aestivalis Michx.?

Climbing in rough rocky woods, infrequent. Cieneguita N., Aug. 1, '95. (365.)

Cissus sicyoides L. "Ubí."

Common in savannahs, along fences, etc. Cieneguita, May 11, '95. (21.)

C. trifoliata L. "Ubí macho."

Along small stream in savannahs, not uncommon. Cieneguita S., June 14, '95. (170.)

Cissus sp.

Low climber in low, open woods and wet savannahs along small streams. Cieneguita S. W., July 26, '95. (355.)

Sapindaceae. LV.

Serjania diversifolia Radl.

Low climber in savannahs, common, usually in fertile soil. Cieneguita R. R., S. W. Branch, Aug. 19, '95. (490.)

HYPELATE TRIFOLIATA Sw. "Yaicuage de costa."
On coast hills, rather poor soil, rare. Loma de Ciego, Calicita, Aug. 28, '95. (506.)

ANACARDIACEAE. LXI.

MANGIFERA INDICA L. "Mango."
Culivated in fertile soil, black and red. Common. Abreus, Jan. 17, '96. (695.)

ANACARDIUM OCCIDENTALE L. "Acajú" and "Marañón."
Cultivated and escaped, not frequent. Calicita R. R., 13K., July 17, '95. (310.)

SPONDIAS LUTEA L. "Jobo."
Not uncommon in open fertile woods and fertile savannahs. Cieneguita, May 13, '95. (24.)

S. PURPUREA L. "Ciruela campechana," "Ciruela colorada."
In fertile soil, savannahs, not frequent. (Cultivated.) Cieneguita S. W., Feb. 28, '96. (722.)

COMOCLADIA DENTATA Jacq. "Guao."
Common in red gravelly soil, savannahs and open woods. Cieneguita S., Feb. 26, '96. (712.)

MORINGEAE. LXIII.

MORINGA PTERYGOSPERMA Gaertn. "Ben" and "Palo blanco."
Cultivated and escaped. A common ornamental shrub. Calicita, June 6–12, '95. (177.)

LEGUMINOSEAE. LXV.

CROTALARIA RETUSA L. "Maromera."
Common in savannahs, fertile soil. Cieneguita, May 13, '95. (25.)

C. PUMILA Ort.

Uncommon in savannahs, red soil. Cieneguita S., June 22, '95. (219.)

C. INCANA L. "Canario."

Not uncommon in fertile soil. Abreus, May 31, '95. (122.)

INDIGOFERA TINCTORIA L. "Añil."

Not uncommon in fertile savannahs, roadsides and pastures. Cieneguita, July 9, '95. (308.)

TEPHROSIA CINEREA Pers.

Sandy coast hills, common. Suburbs of Cienfuegos, Aug. 13, '95. (459.)

GLIRICIDIA PLATYCARPA Griseb. "Jurabaina" or "Cucharillo."

On rocky sea banks, uncommon. Faro Villa Nueva E., Sept. 18, '95. (600.)

G. MACULATA HBK.

In rich soil, open woods. (Cultivated.) Cieneguita S. W., Feb. 28, '96. (736.)

SESBANIA GRANDIFLORA Poir.

Agati grandiflora Desv.

In fertile black soil. (Cultivated.) Cieneguita S. W., Feb. 21, '96. (719.)

PICTETIA SESSILIFOLIA Wright, in herb.

Pictetia ternata, Griseb. Cat. Pl. Cub., p. 73, not DC.

"Shrub, 1 to 2 meters high: leaves sessile, trifoliolate; stipules obsoletely spinose; leaflets oblanceolate, shortly mucronate-acuminate, 8 to 30 millimeters long, 2 to 5½ millimeters broad, glabrous on either surface, margins entire, revolute, midrib prominent beneath: pedicels fascicled in the axils, smooth, slender, bibracteate above the middle, 8 to 16 millimeters long: flowers yellow: calyx glabrous, veiny, unequally divided; anterior lobe acuminate, the other lobes of the calyx obtusish.— Collected by Charles Wright, 1860–1864, no. 2320; also by Robert Combs in dry, sandy or gravelly barrens and savannahs at Cieneguita, Cuba, February 28 and March 4, 1896, no. 735. This species was distributed in Wright's collection under the name *Pictetia ternata* DC., from which, however, it is readily distinguished by its sessile leaves and by its narrower and less distinctly veined leaflets."— Plate xxx.

BRYA EBENUS DC. "Granadillo."

Common in dry gravelly red soil, savannahs. Cieneguita S., May 17, '95. (54.)

AESCHYNOMENE SENSITIVA Sw.

In grassy marshes along small streams, not uncommon. Cieneguita S. W., Aug. 10, '95. (409.)

A. AMERICANA L.

Common in pastures and waste grass land. Cieneguita, Sept. 26, '95. (620.)

A. BRASILIANA DC.

Not uncommon in barren, sandy or gravelly red soil, savannahs. Cieneguita R. R., S. W., Aug. 10, '95. (408.)

STYLOSANTHES VISCOSA Sw.

Not uncommon, barren, sandy or gravelly, red soil, savannahs. Cieneguita R. R., S. W., Aug. 10, '95. (407.)

ARACHIS HYPOGEA L. "Maní."

Cultivated and escaped in fertile, black soil. Cieneguita, July 8, '95. (306.)

ZORNIA DIPHYLLA Pers. var. LATIFOLIA Benth.

In dry, gravelly, red soil, rare. Cieneguita R. R., S., June 14, '95. (166.)

Z. SLOANEI Griseb.

Not uncommon in dry, gravelly or sandy red soil. Cieneguita R. R., S. W. Branch, Aug. 10, '95. (404.)

Desmodium triflorum DC.

Not frequent; creeping in old pasture land, fertile soil. Cieneguita E., Dec. 3, '95. (661.)

D. incanum DC. "Amor seco."

This plant has white flowers, a form probably due to locality. In shaded, fertile places along small streams, rare. Cieneguita E., Oct. 1, '95. (616.)

Desmodium incanum DC. var. angustifolium Griseb.

"A very interesting specimen clearly referable to this variety, although a still more reduced form, was collected by Robert Combs in dry, poor soil at Cieneguita, Cuba, June 22, 1895, no. 215. In Mr. Combs' plant the stems (about 25 centimeters high) are tufted from the base, and the leaves nearly all unifoliolate, sparingly pubescent on either surface; the lower oblong-elliptic, 7 to 13 millimeters long, 3 to 6 millimeters broad; the upper linear, 2 to 4½ centimeters long, 1 to 3 millimeters broad."— Plate xxxi.

D. axillare DC. "Amor seco."

Common in fertile shady woods, along small streams. Cieneguita E., May 21, '95. (70.)

Alysicarpus vaginalis DC.

Not uncommon in fertile soil in old pasture lands. Cieneguita E., Dec. 3, '95. (662.)

Centrosema Plumieri Benth. "Conchita de Plumier."

Common in fertile open waste lands and fertile savannahs. Cieneguita, Sept. 9, '95. (622.)

C. Virginianum Benth. "Conchita Virginia."

Not uncommon in rich savannahs. Cieneguita, May 23, '95. (76.)

Clitoria glycinoides DC. "Conchita blanca."

In open, fertile savannahs, not frequent. Cieneguita, Sept. 10, '95. (103.)

ERYTHRINA CARNEA Ait.
Not uncommon, escaped (?) and cultivated. Cieneguita, Feb. 28, '96. (721.)

CALOPOGONIUM CAERULEUM Hemsl. "Jícama cimarrona."
Not frequent in fertile woods and savannahs. Cieneguita, Aug. 31, '95. (542.)

GALACTIA ANGUSTIFOLIA Kth. "Soplillo."
Climbing in savannahs, gravelly red soil. Cieneguita S., June 22, '95. (216.)

CANAVALIA OBTUSIFOLIA DC. "Mate de costa" or "Cayajabo."
Along the rocky beach at Calicita, June 22, '95 (also Cieneguita). (235.)

PHASEOLUS LUNATUS L. "Frijolito."
Cultivated as a flower. Cieneguita, Dec. 4, '95. (652.)

P. SEMIERECTUS L.
In fertile waste places, fields, etc., not uncommon. Cieneguita, May 21, '95. (65.)

VIGNA VEXILLATA Rich. "Marrullero."
Common in fields and waste places, fertile soil. Cieneguita, May 15, '95. (32 and 102.)

CAJANUS INDICUS Spreng. "Gandú."
Cultivated and escaped in fertile waste places, not common. Calicita, Aug. 28, '95. (511.)

RHYNCHOSIA MINIMA DC. "Peonía chica."
Common in waste places. Cieneguita, May 21, '95. (69.)

ERIOSEMA CRINITUM E. Mey.
Common in dry, sandy, arid soil. Cieneguita R. R., S. W. Branch, Aug. 10, '95. (395.)

Ecastaphyllum Brownii Pers. "Péndola."
Along Rio Damuji in fertile soil, infrequent. (Abreus), Santa Rosalia, Aug. 2, '95. (386).

Lonchocarpus sericeus HBK. "Guamá bobo."
In savannahs and along small streams, fertile soil, not frequent. Cieneguita, June 17, '95. (150.)

Sophora tomentosa L. "Tambalisa."
Along rocky sea banks, not common. Calicita, May 31, '95. (121.)

Belairia mucronata Griseb. "Jamaguey."
Common in savannahs, usually in poor, red soil. Cieneguita S., June 18, '95. (200.)

Ateleia apetala Griseb. "Yerba de la sangre."
On rocky and sandy coast hills, not frequent. Castillo de Jagua, Sept. 16, '95. (562.)

Poeppigia procera Presl. "Tengue."
A tree, 20 feet high, in savannahs, red soil, rare. Cieneguita, S., July 16, '95. (322.)

Caesalpinia Bonduc Roxb. "Guacalote amarillo" "Jayabo."
Spiny, shrubby, climber, in open woods and savannahs, not frequent. Cieneguita, May 29, '95. (116.)

C. Bonducella Fleming. "Guacalote prieto."
Spiny climbing shrub in rich sandy woods along the coast at Castillo de Jagua, Sept. 16, '95. (564.)

C. bijuga Sw. "Guacamaya de costa," "Campeche."
A stout, thorny shrub, 10 feet high, common along the coast, sandy fertile soil. Calicita, Aug. 14, '95. (455.)

C. pulcherrima Sw. "Guacamaya" or "Guacamaya nacional."
Cultivated and escaped, common garden flower. Calicita, Aug. 26, '95. (629.)

C. CRISTA L. "Brasilete colorado."

A thorny shrub, 4 to 7 feet high, common in savannahs and woods. Poor, dry, sandy or gravelly soil. Calicita R. R., 11K., July 17, '95. (313.)

C. PAUCIFLORA Benth. and Hook. f.

A slender, spiny shrub, 4 to 6 feet high, along rocky shores, uncommon. Calicita, May 31, '95. (97.)

CAESALPINIA CUBENSIS Greenman, n. sp.

"A low spreading shrub or tree, 3 to 4 meters high: leaves alternate, petiolate, bipinnate, unarmed; pinnae 2 to 4 pairs; leaflets 6 to 8 pairs, oblique-oblong, obtuse or rounded at the apex, obtuse at the unequal base, entire, puberulent on both surfaces, at length glabrate, finely but not prominently reticulate-veined beneath, 2 to 5 centimeters long, nearly two-thirds as broad; the upper opposite, the lower subalternate; petiolules 2 to 4 millimeters long, sparingly pubescent: racemes terminal, short pedunculate, 16 to 32 centimeters long, puberulent: flowers solitary or subfascicled, pedicellate; pedicels about 5 millimeters long, jointed above the middle: calyx turbinate, ferruginous-pubescent, 5-parted; the four inner divisions oblong, rounded at the apex, irregularly glandular-ciliate, glandular-punctate, 4½ millimeters long, 2 to 3 millimeters broad; the fifth and lower division of the calyx elliptic-oblong, slightly narrowed at the base, concave, about 7 millimeters long, glandular-punctate, and with a glandular-pectinate margin: petals broadly spatulate, entire, 6½ millimeters long: 2½ millimeters broad, flabellate-nerved, glandular-punctate, rounded at the apex, narrowed below into a short retrorsely pubescent claw, inserted on the tube of the calyx; the fifth and upper petal somewhat narrowed, thickened, recurved, and with more dense retrorse pubescence.— Collected by Robert Combs in sandy soil along the coast at Castillo de Jagua, Cuba, Oct. 16, 1895, no. 571. The plant is nearly related to *Caesalpinia tinctoria*, Dombey, from which it is readily distinguished by the distinct petiolules, the venation of the leaflets, the more slender inflorescence, and the character of the calyx." — Plate XXXII.

POINCIANA REGIA Boj. "Flamboyant."

A cultivated tree, very ornamental, common. Cieneguita, May 20, '95. (84.)

PARKINSONIA ACULEATA L. "Espinillo," "Palo de rayo."

Commonly cultivated for ornamental purposes. Cieneguita S. W., Feb. 28, '96. (726.)

CASSIA CHRYSOCARPA Desv.

A climbing shrub. Along the coast and in savannahs, gravelly or red soil. Caemonera, Aug. 28, '95. (504.)

C. LIGUSTRINA L.

A shrub about ten feet high in marshy open woods, fertile soil, rare. Cieneguita S., Sept. 24, '95. (617.)

C. ALATA L. "Guacamaya francesa," "Guajaba."

Cultivated, an ornamental shrub, not uncommon. Cieneguita, Dec. 19, '95. (673.)

C. OCCIDENTALIS L. "Brusca" and "Yerba hedionda."

A common shrub, 3 to 4 feet high, in waste places and savannahs. Cieneguita, May 27, '95. (92.)

C. OBTUSIFOLIA L. "Guanina" and "Yerba hedionda."

A common weed in waste places, red soil. Cieneguita, June 26, '95. (243.)

C. SERICEA Sw. "Guanina" and "Yerba hedionda."

A weed in waste places, red soil, not frequent. Cieneguita, June 26, '95. (244.)

C. HISPIDULA Vahl.

A spreading shrub, prostrate on red gravelly dry soil, branches about 1 foot long, not uncommon. Cieneguita S. W., Mar. 4, '96. (732.)

C. ROTUNDIFOLIA Pers.

A spreading prostrate herb, on gravelly red soil, not frequent. Cieneguita R. R., S., June 14, '95. (167.)

C. LINEATA Sw.

A common shrub (4 feet high) along the sea on sand hills at Castillo de Jagua and Calicita, Aug. 28, '95. (505.)

C. GLANDULOSA L.

Not uncommon in savannahs. Cieneguita, Aug. 1, '95. (368.)

BAUHINIA KRUGII Urban.

Not frequent in sandy grass land along the Bay at Cienfuegos, Aug. 13, '95. (449.)

TAMARINDUS INDICA L. "Tamarindo."

Cultivated and escaped (?) not uncommon, in rich open woods, Cieneguita, June 17, '95. (199.)

MIMOSA VIVA L. "Dormidera" "Dormilona."

A creeping herb, forming a very sensitive mat on fertile soil, savannahs. Cieneguita, Sept. 10, '95. (594.)

M. PUDICA L. "Vergonzosa" and "Sensitiva."

In fertile red soil, savannahs, not frequent. Cieneguita R. R., S., Aug. 6, '95. (375.)

ACACIA PANICULATA Willd. "Tocino."

Common in savannahs and open woods, climbing and trailing, fertile soil, black or red. Cieneguita, May 11, '95. (22.)

A. MASCHALOCEPHALA Griseb.

Not uncommon, climbing or trailing, in coast woods, fertile soil. Calicita, Aug. 26, '95. (526.)

A. SARMENTOSA Desv. (?)

A tree 15–20 feet high, not frequent, in fertile savannahs. Cieneguita N. W., June 24, '95. (237.)

A. FARNESIANA Willd. "Aromo amarillo."

A low spreading tree, 10 feet high, not frequent, sand and fertile grass land along the coast. Cienfuegos, Aug. 13, '95. (448.)

ACACIA POLYPYRIGENES Greenman, n. sp.

"A spreading shrub or low tree, 3 to 5 meters high: branches with red or grayish bark, dotted with numerous small lenticels: leaves alternate, bipinnate, on short (3 to 4 millimeters long) petioles; pinnae 1 to 5 pairs; leaflets 8 to 14 pairs, small, 1 to 2 millimeters long, scarcely 1 millimeter broad, oblong, rounded at the apex, a little oblique at the base, entire, glabrous, sessile or nearly so; stipules of short straight or slightly recurved spines, 3 to 6 millimeters long: flowers in heads on single axillary slender peduncles; the heads about 6 millimeters in diameter; peduncles 8 millimeters long; the young pod smooth except on the outer surface of either valve, where there is a narrow glandular area extending two-thirds its entire length; mature fruit not seen.— Collected by Robert Combs at Faro Villa Nueva, near the entrance to the Bay of Cienfuegos, Cuba, October 18, 1895, no. 602.

"A species apparently belonging to Bentham's series *Gummiferae*, subseries *Semibracteateae*, and most nearly related to *A. Farnesiana*, and *A. tortuosa* Willd., being distinguished from the former by the smaller leaflets and different habit, from the latter by the shorter stipular spines, the smaller leaflets, and the character of the pod."— Plate XXXIII.

LYSILOMA LATISILIQUA Benth.

A tree, 15 to 20 feet high, in fertile red soil, savannahs, uncommon. Cieneguita S., Aug. 1, '96. (367.)

L. SABICU Benth. "Sabicú."

A tree, 10 to 15 feet high, on fertile coast hills, not frequent. Castillo de Jagua, Sept. 17, '95. (553.)

CALLIANDRA PAUCIFLORA Griseb.

A hardy shrub, 6 inches to 4 feet high, decumbent or upright, and spreading. Common along small streams in hard, sandy, gravelly, barren savannahs. Cieneguita S. W. (Yaguaramos), Feb. 28, '96. (724.)

PITHECOLOBIUM TORTUM Mart.
Acacia Vincentis Griseb.
A spreading tree, 10 to 15 feet high, not uncommon in fertile open woods and savannahs. Cieneguita N., May 20, '95. (74.)

P. SAMAN Benth.
Calliandra Saman Griseb.
A large tree (30 to 40 feet high) not uncommon in fertile soil along streams. Cieneguita, May 14, '95. (31.)

ROSACEAE. LXVI.

CHRYSOBALANUS ICACO L. "Hicaco."
A shrub, 4 to 10 feet high, not uncommon in marshy, fertile soil along small streams. Cieneguita R. R., S. W. Branch, Aug. 8, '95. (436.)

DROSERACEAE. LXIX.

DROSERA COMMUNIS St. Hil.
In marshy grass land, fertile soil, at source of small stream, common. Cieneguita R. R., S. W. Branch, Jan. 9, '96. (689.)

RHIZOPHORACEAE. LXXIII.

RHIZOPHORA MANGLE L. "Mangle colorado." "Mangle de uña."
Common along marshy and swampy river and sea banks in the edge of the water. Rio Damuji and bay of Cienfuegos. Abreus and Calicita, June 20, '95. (231.)

COMBRETACEAE. LXXIV.

TERMINALIA CATAPPA L. "Almendro de la India."
Cultivated and escaped in fertile soil, uncommon at Abreus. June 20, '95. (232.)

T. BUCERAS L. "Júcaro de playa."

A large tree, 30 to 40 feet high, in swampy, marshy, fertile soil, along coast rivers and in upland swamps, common. Calicita, May 31, '95. (109.)

CONOCARPUS ERECTUS L. "Yana" and "Mangle botón."

Common in mangrove swamps along Rio Damuji. Abreus, June 20, '95. (229 and 230.)

C. ERECTUS L. var. SERICEUS DC.

Uncommon on coast along salt marshes. Calicita, August 26, '95. (534.)

LAGUNCULARIA RACEMOSA Gaertn. "Patabán" or "Mangle bobo."

Common in mangrove swamps and along swampy river banks, Rio Damuji. Abreus, June 20, '95. (221.)

MYRTACEAE. LXXV.

PSIDIUM GUAVA Radd. "Guayabo" and "Guayabo coterrero."

Common in savannahs, fertile soil. Cieneguita, May 3, '95. (Fruits in July.) (1.)

EUGENIA AXILLARIS Willd.

A low tree, 10 feet high, not uncommon in savannahs, fertile soil. Cieneguita S., June 7, '95. (129.)

E. LATERIFLORA Willd.

A slender shrub, 6 to 10 feet high. In fertile woods, not frequent. Calicita R. R., 14K., July 20, '95. (331.)

E. FARAMIOIDES Rich.

A shrub 5 to 7 feet high, not uncommon in low, thick upland woods, fertile soil. Cieneguita N., July 16, '95. (320.)

CALYCORECTES PROTRACTUS Griseb.

Shrub, 4 to 6 feet high, not frequent, red soil (and black), savannahs and open upland woods. Cieneguita S., June 18, '95. (201.)

Melastomaceae. LXXVI.

Acisanthera quadrata Juss.

Common in marshy grass land, fertile soil, at the source of small streams. Cieneguita R. R., S. W. Branch, Aug. 10, '95. (410.)

A. pellucida Wright.

Not frequent, in grassy marshes, fertile soil, at the source of small streams. Cieneguita R. R., S. W. Branch, Sept. 13, '95. (650.)

Tetrazygia bicolor Cogn.

In savannahs, fertile red soil, not common. Cieneguita S., June 7, '95. (128.)

Miconia albicans Triana.

A shrub, 4 to 8 feet high, in barren savannahs, dry, red and gravelly soil, not common. Cieneguita W., Feb. 26, '96. (711.)

Lythrarieae. LXXVII.

Ammannia latifolia L. "Yerba de cáncer."

An herb, not common along boggy small streams. Cieneguita, Aug. 20, '95. (645.)

Cuphea Parsonsia R. Br. "Chiagari."

Common in savannahs, red gravelly soil. Cieneguita S., June 22, '95. (212.)

Ginora Americana Jacq. "Rosa del rio."

Not uncommon along the banks of small streams in rocky places. Cieneguita E., May 13, '95. (26.)

Lawsonia inermis L. "Resedá francesa."

A shrub, cultivated. Cieneguita, May 16, '95. (45.)

Onagrarieae. LXXVII.

Jussiaea repens L. "Clavellina," "Yerba del clavo."

Common in the water of small streams. Cieneguita, June 17, '95. (158.)

J. erecta L.

In marshy places along brooks, fertile soil, not uncommon. Cieneguita, June 18, '95. (205.)

J. suffruticosa L.

J. salicifolia HBK.

Not uncommon along brooks in wet fertile soil. Cieneguita, June 17, '95. (157.)

J. Peruviana L.

Not uncommon along brooks in wet fertile soil. Cieneguita, June 18, '95. (204.)

Ludwigia palustris Ell.

Jussiaea palustris Mey.

Common aquatic in mangrove swamps along Rio Damuji. Abreus, Aug. 17, '95. (475.)

Samydaceae. LXXIX.

Casearia sylvestris Sw. "Rompe-hueso," "Llorón."

A tree, 15 to 20 feet high (or a shrub) in savannahs, rich soil. Cieneguita, July 30, '95. (168 and 341.)

C. hirta Sw. "Jía peluda."

A shrub, 5 to 8 feet high, not frequent, in fertile savannahs and upland woods. Cieneguita, July 30, '95. (75 and 342.)

C. praecox Griseb.

A shrub, 6 to 10 feet high, in rocky woods, fertile soil, (flowers precocious), rare. Cieneguita, Feb. 12, '96. (704.)

C. SPINESCENS Griseb.

A slender spreading shrub, 6 feet high, in savannahs, poor, red, gravelly soil. Cieneguita W., Mar. 4, '96. (730.)

BANARA RETICULATA Griseb.

A shrub, 5 feet high, on rocky coast hills, not uncommon. Castillo de Jagua, Sept. 17, '95. (551.)

TURNERACEAE. LXXXI.

PIRIQUETA CISTOIDES Mey. "Piriqueta."

Common in savannahs, red (gravelly) soil. Cieneguita S., June 18, '95. (214.)

P. CISTOIDES Mey.

Common in wet gravelly soil. Cieneguita R. R., S. W. Branch, Aug. 19, '95. (491.)

P. VISCOSA Griseb.

Uncommon on gravelly red soil in savannahs. Cieneguita R. R., S. W. Branch, Aug. 10, '95. (416.)

TURNERA ULMIFOLIA L. "Mari-Lope."

Not uncommon in rich soil along coast. Calicita, June 5, '95. (133.)

T. PUMILEA L.

Common in red gravelly soil, savannahs. Cieneguita S., June 14, '97. (165.)

PASSIFLORACEAE. LXXXII.

PASSIFLORA SUBEROSA L. "Huevo de gallo."
P. pallida L.

Not uncommon in savannahs, fertile soil. Cieneguita, N. E., May 17, '95. (50.)

P. SUBEROSA L. (forma). "Huevo de gallo."

A form with entire leaves and quite hirsute. In savannahs, rare. Cieneguita S., July 10, '95. (304.)

P. RUBRA L. "Pasionaria de cerca."

In open fertile upland woods, rare. Cieneguita N., July 3, '95. (279.)

P. CILIATA Ait. "Pasionaria de Candelaria."

P. foetida Cav. var. *ciliata* Mast.

Common in savannahs, grass lands, fertile red soil. Cieneguita S., May 16, '95. (44.)

P. OBLONGATA Sw. "Pasionaria vejigosa." "Tagua-tagua."

In fertile open woods, climbing high (10 ft.), not frequent. Calicita R. R., 10K., July 13, '95. (318.)

CARICA PAPAYA L. "Papaya" and "Fruta bomba."

Not uncommon, in fertile soil along small streams, etc. (Often cultivated.) Cieneguita, May 29, '95. (110.)

CUCURBITACEAE. LXXXIII.

LAGENARIA VULGARIS Sw. "Güiro cimarron."

Cultivated and escaped in fertile waste places. Cieneguita, July 8, '95. (324.)

MOMORDICA CHARANTIA L. "Cundeamor."

Common in fertile waste places (often cultivated). Cieneguita, May 20, '95. (72.)

LUFFA ACUTANGULA Roxb. "Jaboncillo."

Not uncommon in fertile, waste places (often cultivated). Cieneguita, May 20, '95. (68.)

L. ACUTANGULA Roxb. (forma). "Jaboncillo," "Estropajo," or "Cayote frances."

Same as above but fruit more angulated and flowers lemon yellow. Cieneguita, Sept. 2, '95. (543.)

CUCUMIS ANGURIA L. "Pepino cimarrón."

Not infrequent in fertile, waste places, fields, etc. Cieneguita, May 15, '95. (38.)

Cucurbita radicans Naud.
In waste places, fertile soil, not common. Cieneguita, May 27, '95. (627.)

Melothria pervaga Griseb.
Frequent in fields and waste places, fertile black soil. Cieneguita, May 15, '95. (37.)

Anguria Ottoniana Schlecht.
In fertile wood lands, not common. Abreus, May 23, '95. (83.)

Cayaponia Americana var. vulgaris Cogn. "Coloquintilla."
In fertile fields and waste places, rare. Cieneguita S. W., Aug. 10, '95. (415.)

Elaterium Carthagenense L.
In fertile river woodlands along Rio Damuji. Abreus and Santa Rosalia, Aug. 2 and 17, '95. (388.)

Cacteae. LXXXVI.

Cereus eriophorus Link. "Patana."
Common (climbing) creeping over rocks, etc. (sometimes in palmetto trees). Cieneguita, May 15, '95. (66.)

Rhipsalis Cassytha Gaertn. "Disciplinaria."
Not uncommon in savannahs, hanging from trees, usually palmettos. Cieneguita R. R., S., 7K., July 17, '95. (470.)

Opuntia Tuna Mill. "Tuna."
Common along rocky coast hills at Castillo de Jagua. Sept. 19, '95. (648.)

Ficoideae. LXXXVII.

Sesuvium Portulacastrum L. "Verdolaga de costa."
Common on the sandy, marshy beach at Calicita, May 31, '95. (208.)

Umbelliferae. LXXXVIII.

Hydrocotyle prolifera Kell. (?)

Along rocky shoals of Rio Damuji, not uncommon at Rodas, Aug. 17, '95. (625.)

Araliaceae. LXXXIX.

Dendropanax (Gilibertia) arboreum Decsne. and Planch. "Víbona."

Schradophyllum Jacquinii Griseb.

A tree, 10 to 20 feet high, infrequent. Along small streams, fertile soil. Cieneguita, June 15, '95. (196 and 197.)

Rubiaceae. XCII.

Exostemma Caribaeum Roem. and Schultes. "Macaguá de costa."

A shrub or low tree, 10 to 15 feet high. Along banks of Rio Damuji, not common. Santa Rosalia, Aug. 2, '95. (383.)

E. longiflorum Roem. and Schultes.

A shrub, 3 to 5 feet high, along small streams, not common. Cieneguita E., May 21, '95. (62.)

Rondeletia trifolia Jacq.

Not uncommon in savannahs, fertile red soil. Cieneguita S., July 6, 95. (290.)

Rondeletia Combsii Greenman. n. sp.

"Shrub or low tree, 3 to 5 meters in height: branches terete, covered with a grayish verrucose bark; branchlets somewhat compressed: leaves elliptic-lanceolate, acute or obtusish at the apex, often short-mucronate, entire, revolute, 2 to 5 centimeters long, one-third to one-half as broad, narrowed below to a short pubescent petiole, and covered on both surfaces with a short spreading pubescence; stipules ovate, acuminate, entire, 3 to 4 millimeters long, densely pubescent; inflorescence axillary, usually near the ends of the branchlets; peduncles about 3 to 5 millimeters long, equaling the petioles, often terminated by the three short-pedicelled flowers: calyx 4-merous, united above the ovary for about one-third its length; lobes linear, acute, 2 millimeters long: corolla tubular, 7 millimeters long, retrorsely strigillose-pubescent; lobes rotund: young capsule ovoid-globose and (as well as the calyx) densely pubescent; mature capsule 7 millimeters long.— Collected by Robert Combs at Calicita, Cuba, August 24, 1895, no. 527. Although this plant is stated by Mr. Combs to be common on sea banks and coast hills at the above named station, it does not agree with any described species known to the author. The plant is habitally much like *R. Camarioca*, Wright and *R. chamaebuxifolia*, Griseb., but differs from the former in foliage and especially in the characters of the calyx, and from the latter by the pubescent leaves, longer petioles, and less divided calyx."— Plate XXXIV.

RACHICALLIS RUPESTRIS DC.

Along the barren rocks of the sea-shore, common. Castillo de Jagua, Sept. 16, '95. (566.)

HAMELIA PATENS Jacq.

Not uncommon in upland woods, fertile soil. Cieneguita, May 11, '95. (29.)

CATESBAEA SPINOSA L. "Catesbea."

A shrub, 6 to 10 feet high, along river banks in sandy fertile soil. Rio Damuji, Santa Rosalia, Aug. 2, '95. (384.)

CATESBAEA NANA Greenman, n. sp.

"A small, glabrous or slightly puberulent shrub, 10 to 30 centimeters high, branching rather profusely from the base: branches provided with numerous axillary spines, these about 1 centimeter long, slightly exceeding the internodes: leaves elliptic to broadly ovate, 2 to 5 millimeters long, two-thirds as broad, obtuse at the apex, narrowed at the base into a short petiole: flowers solitary in the axils, short-pedicellate: calyx minutely 4-lobed (occasionally 3-lobed): ovary 2-celled; cells several (5-6)-ovuled; ovules pendulous or at least descending from the upper inner angle of the cell: fruit a several-seeded red berry, in the dried state about 7 millimeters long, and equally broad; seeds flattened, concavo-convex with a papillose surface.— Collected by Robert Combs in dry poor soil at Cieneguita, Cuba, August 10, 1895, no. 406. A species nearly related to *C. parviflora* Sw."— Plate xxxv.

Alibertia edulis Rich. "Pitajoni cimarron."
A shrub 5 to 10 feet high, not uncommon in fertile savannahs. Cieneguita S., June 27, '95. (248.)

Genipa Caruto Kth. "Jagüilla."
Common in savannahs, fertile black and red soils. Cieneguita, July 16, '95. (327.)

Guettarda longiflora Griseb. "Cuero."
Common in savannahs, fertile soil. Cieneguita S., July 2, '95. (270.)

G. elliptica Sw. "Cuero de sabana."
In savannahs, a shrub, rather uncommon. Cieneguita S., July 22, '95. (360.)

G. calyptrata Rich. "Cuero de hojas grandes."
A common shrub, 4 to 6 feet high, in upland woods, gravelly red soil. Calicita R. R., 11K., July 17, '95. (312.)

Stenostomum (Antirrhoea Comm.) lucidum Gaertn.
A shrub or low tree along the rocky shore, not frequent at Calicita, Aug. 24, '95. (518.)

Erithalis fruticosa L. var. odorifera Jacq.
A shrub, 3 to 6 feet high, along the shore, not uncommon. Loma de Pajeros, Calicita, Aug. 26, '95. (538.)

CHIOCOCCA RACEMOSA Jacq. "Cainca."

A low trailing shrub, savannahs and woods, not uncommon. Abreus, May 21, '95. (57.)

C. RACEMOSA Jacq. "Cainca."

A form with dark leaves and purplish flowers. In marshy woods, fertile soil. Cieneguita S. W., July 9, '95. (302.)

MORINDA ROYOC L. "Piña raton, arbusto."

A low trailing or erect shrub, 2 to 4 feet high, in savannahs, red soil, common. Cieneguita S., July 6, '95. (289.)

PSYCHOTRIA TENUIFOLIA Sw.

A slender shrub, 3 to 5 feet high, in upland woods, fertile soil, common. Cieneguita S., July 6, '95. (291.)

P. RUFESCENS Kth.

A slender shrub 2 to 4 feet high, in upland woods, fertile red (?) soil, common. Cieneguita S., July 6, '95. (288.)

P. PUBESCENS Sw.

A shrub, 4 to 6 feet high, in rich woods, not frequent. Cieneguita N., May 29, '95. (119.)

P. NUTANS Sw. var. PUBERULA Wright.

A shrub, 5 to 8 feet high, not frequent on coast hills near sea. Castillo de Jagua, Sept. 17, '95. (552.)

P. HORIZONTALIS Sw.

A much spreading shrub, 10 feet high, infrequent in savannahs. Cieneguita W., July 8, '95. (307.)

P. MYRTIPHYLLUM Sw.

A low spreading, slender shrub, 4 to 6 feet high, infrequent in fertile woods along small streams. Cieneguita R. R., S. W. Branch, Feb. 26, '96. (720.)

P. CORONATA Griseb. "Lengua de vaca."

Not common, in upland woods, poor soil. Calicita R. R., 11K., July 13, '95. (315.)

P. FOVEOLATA Ruiz and Pavon.

A shrub, 3 to 5 feet high, in fertile, black, shaded soil along small streams. Cieneguita E., May 17, '95. (56.)

PALICOUREA PAVETTA DC.

A slender shrub, 4 to 6 feet high, in fertile upland woods, rare. Cieneguita, May 13, '95. (181.)

DIODIA TERES Walt.

D. prostrata Sw.

Common in waste places, poor red soil. Cieneguita S., June 26, '95. (240.)

D. SIMPLEX Sw.

Borreria simplex Griseb.

Not uncommon in upland, damp, fertile woods, black soil. Cieneguita N., July 30, '95. (339.)

SPERMACOCE TENUIOR L. "Yerba de garro."

In open, upland woods, fertile, damp, black soil. Cieneguita N., July 30, '95. (340.)

S. ASPERA Aubl. (?)

Growing in thin, fertile, damp or wet soil, over rock strata in marshy woods. Cieneguita S. W., Sept. 24, '95. (619.)

S. ASPERA Aubl. var. LATIFOLIA Griseb.

In fields and waste places, not uncommon. Cieneguita S., July 2, '95. (275.)

S. PODOCEPHALA DC. "Boton blanco de arenales" (Puerto Rico).

Common in barren, red, sandy or gravelly soil, flat savannahs. Cieneguita R. R., S. W. Branch, Aug. 10, '95. (396.)

S. LAEVIS Lam.

Borreria laevis Griseb.

Common in waste places, (rather poor) red soil. Cieneguita S., June 26, '95. (241.)

RICHARDSONIA SCABRA L.
Common in waste places, fertile red soil. Cieneguita S., July 2, '95. (272.)

COMPOSITAE. XCVI.

SPARGANOPHORUS VAILLANTII Gaertn.
Not uncommon along small streams, in damp, fertile soil, shaded places. Cieneguita E., Dec. 7, '95. (670.)

VERNONIA MENTHAEFOLIA Less.
Not uncommon in savannahs, fertile soil (usually red). Cieneguita S., Feb. 10, '96. (706.)

ELEPHANTOPUS SPICATUS Juss. "Lengua de vaca," "Yerba de burro."
Not uncommon in savannahs and along brooks. Cieneguita E., Dec. 3, '96. (660.)

AGERATUM CONYZOIDES L.
Not common; fertile waste places, usually damp soil. Abreus, May 21, '95. (59.)

EUPATORIUM CANESCENS Vahl.
A low shrub, 3 to 5 feet high, along coast hills near shore, not common. Castillo de Jagua, Sept. 17, '95. (554.)

E. VILLOSUM Sw. "Albahaca de sabana."
In fertile, open, coastal woods, not common. Calicita, Aug. 24, '95. (525.)

MIKANIA TRINITARIA DC. "Guaco."
An annual or suffruticose climber, not uncommon along brooks. Cieneguita N., Jan. 4, '96. (682.)

M. GONOCLADA DC. "Guaco."
An annual, twining; fertile, rough woods, not common. Cieneguita N., Jan. 4, '96. (683.)

M. ORINOCENSIS Kth. "Guaco."

An annual twiner; in fertile, open savannahs and woods, damp places, not common. Cieneguita, June 10, '95. (184.)

ASTER EXILIS Ell.

Common along water in open, marshy woods, fertile soil. Cieneguita S. W., Dec. 6, '95. (668.)

ERIGERON JAMAICENSIS Sw.

Common in barren places in old pastures. Cieneguita S. W., Aug. 7, '95. (424.)

BACCHARIS HALMIFOLIA L. "Bajaquillo."

A shrub, 6 to 8 feet high, in marshy open woods, common. Cieneguita S. W., Sept. 3, '95. (544 and 545.)

PLUCHEA ODORATA Cass. "Salvia de playa."

In open, marshy woods and upland marshes, common. Cieneguita S. W., Mar. 2, '96. (729.)

GNAPHALIUM PURPUREUM L.

A much reduced form (2 to 4 inches high) common in marshy, open savannahs. Cieneguita W., Feb. 26, '96. (714.)

LAGASCEA MOLLIS Cav. "Romerillo cimarron."

In fertile waste grass lands, common. Cieneguita, June 28, '95. (251.)

ELVIRA BIFLORA DC.

Not uncommon in fertile fields and waste places. Cieneguita, June 18, '95. (206.)

ACANTHOSPERMUM HUMILE DC. "Pinedo."

Spreading on black fertile soil, rare. Cieneguita S., Aug. 16, '95. (487.)

PARTHENIUM HYSTEROPHORUS L. "Escoba amarga."

Very common weed in fields and waste places. Cieneguita, June 28, '95. (250.)

Iva cheiranthifolia Kth. "Artemisa de playa."
Common, creeping and spreading in fields and waste places. Cieneguita, June 28, '95. (453.)

Eclipta alba Hassk.
Common in wet places, fertile soil along brooks. Cieneguita, Aug. 20, '95. (472.)

Isocarpha atriplicifolia R. Br.
In wet marshy places, not uncommon. Cieneguita S. W., Jan. 2–6, '95. (666.)

Borrichia arborescens DC. "Verdolaga de la mar."
B. argentia DC.
Common on sandy beach at Calicita, July 27, '95. (372 and 499.) No. 499, a form from same locality with little or no pubescence.

Wedelia gracilis Rich.
Common, spreading on fertile red or black soil. Cieneguita S., June 11, '95. (193.)

W. reticulata DC. "Careicillo amarillo."
Not frequent in fertile soil. Abreus, June 29, '95. (269.)

Melanthera deltoidea Rich. "Botón de plata."
In fertile, sandy soil along Rio Damuji, common. Santa Rosalia, Aug. 2, 95. (385.)

Verbesina encelioides Benth.
Not uncommon on low sand hills along the sea-shore. Faro Villa Nueva, Sept. 18, '95. (577.)

V. alata L. "Botoncillo."
Not common, fertile soil, waste places. Abreus, May 21, '95. (60.)

Synedrella nodiflora Gaertn.
Not uncommon in fertile river woodland. Rio Damuji, Abreus, Aug. 17, '95. (478.)

Cosmos caudatus HBK. "Margarita."
Not infrequent in fertile waste places. Cieneguita, Sept. 30, '95. (623.)

Bidens leucantha Willd. "Romerillo."
Common weed in fields and waste places, fertile soil. Cieneguita, Aug. 9, '95. (432.)

B. bipinnata L. "Romerillo de loma."
Not uncommon in rocky woods, fertile soil. Cieneguita N., June 17, '95. (152.)

Chrysanthellum procumbens Rich. "Manzanilla del pais."
Common in savannahs, red, fertile soil. Cieneguita S., June 6, '95. (142.)

Tridax procumbens L.
Common in grassy, waste places, fertile soil. Cieneguita, Aug. 31, '95. (541.)

Thymopsis Wrightii Benth.
Not uncommon in wet or marshy grass land along small brooks. Cieneguita R. R., S. W. Branch, Aug. 8, '95. (437.)

Flaveria repanda Lag.
Common weed in waste places. Cieneguita, Aug. 20, '95. (473.)

Pectis ciliaris L. "Romero cimarrón."
In savannahs, fertile red soil, not common. Cieneguita S., Sept. 10, '95. (596.)

P. prostrata Cav. "Romero macho."
Spreading prostrate, in fertile waste places, not uncommon. Cienfuegos, Aug. 13, '95. (460.)

Anastraphia Northropiana Greenman, n. sp.
"Much branched rugged shrub, 1 to 1½ meters in height: stems covered below with a rough grayish bark, closely

pubescent above: leaves alternate, oblong to slightly obovate, 1 to nearly 4 centimeters long, almost or quite half as broad, obtuse or rounded at the apex, entire or spinulose-denticulate, closely pubescent above in the early stages, later becoming glabrous and shining, densely white-tomentose with short felted hairs beneath, obtuse or rounded and often slightly unequal at the base; petioles densely white-tomentose, 5 to 8 millimeters long: heads 2 to 2½ centimeters long (including the exserted stamens and styles), 8–10-flowered; involucre about 13 millimeters long; inner scales linear-attenuate, distinctly one-nerved, 8 millimeters long, nearly 2 millimeters broad; the outer gradually smaller, pubescent on the outer surface, margin ciliate; the involucral scales becoming strongly recurved with age: flowers 2 centimeters long: corolla divided nearly to the base, 6 millimeters long: achenes villous-pubescent, 3 millimeters long; pappus sordid.— Collected by John I. and Alice R. Northrop along Fresh Creek, Andros Island, June 10, 1890, no. 743; and by Robert Combs along rocky sea banks near Calicita, Cuba, Aug. 24, 1895, no. 521. This species is most nearly related to *A. intertexta* Wright, but differs in the foliar characters, the much smaller flowers, and the more pubescent achenes."— Plate XXXVI.

CHAPTALIA ALBICANS Vent.

Not infrequent in fertile waste grass lands, etc. Cieneguita, June 11, '95. (192.)

TRIXIS FRUTESCENS P. Br.

A shrub, 2 to 4 feet high (or suffruticose). In rocky woods, common. Cieneguita N., Feb. 12, '96. (703.)

LOBELIACEAE. XCIX.

ISOTOMA LONGIFLORA Presl. "Revienta caballos."

Common along the banks of small streams, fertile black soil. Cieneguita, May 13, '95. (34.)

LOBELIA CLIFFORTIANA L. "Lobelia."

In damp fertile black soil, open savannahs, or upland woods. Cieneguita S. W., Feb. 10, '96. (58.)

Ericaceae. CII.

Bejaria angustifolia Sw.

A twining annual in rocky woods, not common. Cieneguita N., June 24, '95. (236.)

Plumbagineae. CVII.

Plumbago scandens L. "Mala-cara."

Not frequent. In fertile soil, black or sandy. Castillo de Jagua (and Cieneguita), Sept. 16, '95. (565.)

Primulaceae. CVIII.

Centunculus pentandrus R. Br.

Not uncommon in rich damp shaded upland woods. Cieneguita R. R., S. W. Branch, Sept. 13, '95. (592.)

Myrsineae. CIX.

Wallenia clusiifolia Griseb. "Guacamarí," "Casmagua."

A shrub, 3 to 6 feet high, not uncommon in marshy upland woods, rich soil. Cieneguita N., Jan. 7, '96. (685.)

Conomorpha bumelioides Griseb.

A shrub or low tree, 10 feet high, in savannahs, rare. Cieneguita S., July 31, '95. (336.)

Jacquinia ruscifolia L.

Not uncommon shrub, 3 to 5 feet high, savannahs, fertile sandy soil along river banks, Rio Damuji. Constancia, Aug. 2, '95. (382.)

J. linearis Jacq. "Espuela de cabellero."

In barren savannahs, along brooklets, red sandy or gravelly soil. Infrequent. Cieneguita W., Feb. 28, '96. (723.)

SAPOTACEAE. CX.

CHRYSOPHYLLUM OLIVIFORME Lam. "Caimitillo."

Common, in savannahs, usually in red fertile soil. Cieneguita, June 24, '95. (361 and 234.)

LUCUMA PAUCIFLORA A. DC.

A low tree, 10 to 15 feet high, in fertile savannahs, infrequent. Cieneguita N., July 30, '95. (344.)

L. MAMMOSA Gaertn. "Mamey colorado."

A large tree, in rich savannahs, uncommon. Commonly cultivated. Cieneguita N., Jan. 7, '96. (684.)

ACHRAS SAPOTA L. "Nispero" or "Sapote."

Sapota achras Mill.

Commonly cultivated as a fruit tree. Cieneguita, June 5, '95. (136.)

BUMELIA HORRIDA Griseb. "Sapote espinosa."

A rigid, thorny shrub, 3 to 4 feet high, trailing in hard, sandy or gravelly red soil in savannahs near small brooks. Cieneguita W., Feb. 28, '96. (734.)

EBENACEAE. CXI.

DIOSPYROS HALESIOIDES Griseb.

In fertile rocky woods, uncommon or rare. Cieneguita N., May 28, '95. (94.)

OLEACEAE. CXII.

JASMINUM BAHIENSE DC.

Cultivated climber. Abreus, June 15, '95. (161.)

FORESTIERA PORULOSA Poir.

A shrub or low tree, 8 to 10 feet high, on sea bank above Calicita, rare, Aug. 14, '95. (458.)

F. RHAMNIFOLIA Griseb.

A low tree or shrub (10 to 15 feet high), rare on coast, fertile sandy soil. Calicita, Aug. 26, '95. (530.)

LINOCIERA LIGUSTRINA Sw.

On coast, hillsides, fertile soil, rare. Calicita E., Aug. 27, '95. (508.)

APOCYNACEAE. CXV.

VALLESIA GLABRA Cav.

A shrub, 6 to 10 feet high, in fertile coast woods, not uncommon. Loma de Pajeros, Calicita, Aug. 24, '95. (529.)

RAUWOLFIA NITIDA L. "Huevo de toro."

A tree, 20 to 30 feet high, in fertile upland woods, rare. Cieneguita, July 3, '95. (296.)

R. CANESCENS L. "Palo boniato."

A shrub, 3 to 5 feet high, in fertile soil, open woods, along streams. Cieneguita N., Abreus, May 23, '95. (81.)

R. ALPHONSIANA Müll. Arg.

Not uncommon in savannahs, red soil. Cieneguita W., June, 13, '95. (180.)

R. CUBANA A. DC. "Lirio de costa."

A spreading shrub, 3 to 6 feet high, common in savannahs, dry, poor, gravelly, red soil. Calicita R. R., 11K., June 27, '95. (245.)

CAMERARIA RETUSA Griseb. "Maboa de sabana."

In savannahs, common in fertile, usually red soil, gravelly. Cieneguita S., May 9, '95. (19.)

VINCA ROSEA L. "Vicaria."

Not infrequent in fertile soil. Commonly cultivated. Cieneguita, Aug. 7, '95. (369.)

Plumeria obtusa L. "Lirio amarillo."

A shrub, 5 to 8 feet high, in rough, rocky woods, not uncommon. Cieneguita N., May 15, '96. (36.)

Tabernaemontana citrifolia Jacq. "Huevo de gallo."

A shrub, 4 to 6 feet high, common in fertile savannahs. Cieneguita, May 9, '95. (18.)

Forsteronia corymbosa Mey.

A shrubby climber in fertile coast woods, infrequent. Calicita, Aug. 24, '95. (524.)

Nerium Oleander L. "Adelfa" "Rosa francesa."

Commonly cultivated as a garden shrub. Calicita, June 12, '95. (207.)

Echites rosea A. DC. "Rosa de sabana."

Very slender shrub, climbing in savannahs, usually fertile, red soil, not frequent. Cieneguita, June 5, '95. (138.)

E. umbellata Jacq.

Shrubby climber in fertile savannahs and open coast woods. Not uncommon. Cieneguita (Calicita), May 9, '95. (17.)

E. paludosa Vahl.

Shrubby climber in open mangrove swamps and river marshes, Rio Damuji. Abreus, May 23, '95. (78.)

E. Andrewsii Chapm.

E. neriandra Griseb.

Common shrubby climber in savannahs. Cieneguita S., May 9, '95. (13.)

E. Cubensis Griseb.

Upland woods and savannahs, fertile soil. Uncommon. Cieneguita S., Aug. 1, '95. (635.)

Asclepiadaceae. CXVII.

Cryptostegia grandiflora R. Br.

In fertile waste places, uncommon. Most probably escaped from cultivation. Cienfuegos, Aug. 13, '95. (463.)

PHILIBERTIA VIMINALIS Gray.

Climbing in upland marshy woods, fertile soil. Cieneguita N., July 19, '95. (330.)

CALOTROPIS PROCERA R. Br.

A shrub, 3 to 4 feet high, in sandy soil, coastal hills and savannahs, not common. Castillo de Jagua, Sept. 17, '95. (610.)

ASCLEPIAS CURASSAVICA L. "Flor de calentura."

Common in savannahs. Cieneguita, May 30, '95. (105.)

A. NIVEA L. "Flor de calentura blanca."

Common in savannahs. (Cieneguita) Abreus, May 21, '95. (61.)

METASTELMA PENICILLATUM Griseb.

Slender woody climber in upland woods and savannahs, red soil. Not common. Calicita R. R., 11K., June 27, '95. (247.)

M. FILIFORME Wright.

A slender profuse woody climber, common in rocky, rough woods. Cieneguita N., July 2, '95. (276.)

M. BRACHYSTEPHANUM Griseb.

A low slender woody climber, infrequent, savannahs, dry, sandy or gravelly soil. Cieneguita R. R., S. W. Branch, Aug. 10, '95. (413.)

M. BAHAMENSE Griseb.

A shrubby climber not frequent in coast hills. Castillo de Jagua, Sept. 17, '95. (556.)

MARSDENIA SATUREIAEFOLIA, A. Rich.

A higher climber in low woods on coast hills. Castillo de Jagua, Sept. 17, '95. (558.)

M. FUSCA Wright.

A climber in rough open woods, rare. Cieneguita, June 3, '95. (123.)

M. CAMPANULATA Griseb.

A woody climber on low shrubs, coast hills along the sea. Caemonera, Aug. 28, '95. (503.)

LOGANIACEAE. CXVII.

SPIGELIA ANTHELMIA L. "Yerba lombricera."

A low herb, common in fields and waste places. Cieneguita, June 28, '95. (258.)

MITREOLA PETIOLATA Torrey and Gray.

In wet fertile soil along brooks, common. Cieneguita R. R., S. W. Branch, Aug. 19, '95. (496.)

GENTIANEAE. CXVIII.

SCHULTESIA STENOPHYLLA Mart.

Common low herb, 2 to 4 inches high, in damp sandy (?) soil at marshy source of brook. Cieneguita R. R., S. W. Branch, Aug. 19, '95. (438.)

S. HETEROPHYLLA Miq. "Genciano de Cuba."

Not common in damp or marshy soil along brook. Cieneguita R. R., S. W. Branch, Sept. 13, '95. (587.)

HYDROPHYLLACEAE. CXX.

HYDROLEA SPINOSA L. "Tabaco cimarrón."

Not uncommon in damp fertile black soil (savannahs), upland marshy woods. Cieneguita N., Jan. 7, '96. (686.)

H. NIGRICAULIS Wright.

In marshy black soil along small stream. Uncommon. Cieneguita R. R., S. W. Branch, Jan. 9, '96. (691.)

BORAGINEAE. CXXI.

CORDIA GERASCANTHOIDES Kth. "Varia."

A tree, 20 to 25 feet high, in rough rocky upland woods, fertile soil, infrequent. Cieneguita N., Feb. 25, '96. (717.)

C. Sebastiana L. "Vomitel colorado."

A roughish, spreading low tree or shrub, 8 to 10 feet high, along sand hills near the sea. Castillo de Jagua, Sept. 17, '95. (608.)

C. nitida Vahl. (?) "Ateje."

A large spreading tree (40 feet high) in fertile savannahs, not uncommon. Cieneguita N., Aug. 20, '95. (471.)

C. ulmifolia Juss. "Ateje."

A shrub, 6 to 10 feet high, in fertile damp soil, infrequent. Cieneguita S. W., Aug. 7, '95. (420.)

C. globosa Kth. "Ateje."

A low, spreading shrub (3–6 feet high) common in sandy, fertile soil along the shore. Cienfuegos, Aug. 13, '95. (450.)

Bourreria microphylla Griseb.

A small shrub (1–2 feet high) in dry sandy or gravelly soil, barren savannahs, common. Cieneguita R. R., S. W. Branch, Aug. 10, '95. (393.)

B. montana Wright.

A shrub, 6 to 10 feet high, on rough rocky sea banks. Not frequent. Calicita, Aug. 24, '95. (523.)

Ehretia tinifolia L. "Roble prieto."

A tree, 10 to 15 feet high, in fertile soil, savannahs, infrequent. Cieneguita, June 7, '95. (176.)

Tournefortia gnaphalodes R. Br. "Balsamillo" "Incienso de playa."

A shrub, 4 to 6 feet high along rocky sea shore. Castillo de Jagua, Sept. 16, 95. (611.)

T. hirsutissima L. "Nigua."

A common shrubby climber in rough fertile woods. Cieneguita N., May 25, '95. (86.)

T. BICOLOR Sw.

A woody climber in fertile soil in savannahs, not frequent. Cieneguita, June 13, '95. (183.)

T. LAURIFOLIA Vent. "Nigua de paredón."

A low climbing shrub, much branched. Not frequent, savannahs. Cieneguita, May 23, '95. (77.)

T. VOLUBILIS L. "Nigua."

A profuse low woody climber, coast hills, not uncommon. Calicita, June 5, '95. (134.)

HELIOTROPIUM INDICUM L. "Alacroncillo."

A common herb (weed) in waste places, fields, etc. Frequent in early spring. Jurugua, Sept. 14, '95. (612.)

H. PARVIFLORUM L. "Alacroncillo."

Not uncommon in fertile sandy soil along the coast at Calicita. June 12, '95. (179.)

H. INUNDATUM Sw. "Alacroncillo."

Common in wet fertile soil, waste places. Cieneguita, June 21, '95. (174.)

H. CURASSAVICUM L. "Alacroncillo de playa."

Common on sandy beach at Calicita. May 31, '95. (96.)

H. HUMIFUSUM Kth.

A small spreading decumbent shrub, 3 to 6 inches in diameter, when in natural state; lying flat on the sand, in small sandy places along rocky sea-shore. Castillo de Jagua, Sept. 16, '95. (568.)

CONVOLVULACEAE. CXXII.

IPOMOEA BONA-NOX L. "Flor de la Y."

Common in fertile soil in waste places and along brooks. Cieneguita E., Feb. 24, '96. (716.)

I. BATATAS Lam. "Boniato."
In wet places, fertile soil, not common. Cieneguita, Dec. 3, '95. (656.)

I. SIDAEFOLIA Chois. "Aguinaldo blanco."
Common trailing or climbing, shrubby in savannahs. Cieneguita, Dec. 3, '95. (658.)

I. TENUISSIMA Chois.
Creeping or a low climber in red soil in savannahs, not uncommon. Cieneguita, June 26, '95. (238.)

I. UMBELLATA Mey. "Aguinaldo amarillo."
Common, creeping or low climbing, in fertile savannahs, usually along brooks. Cieneguita, Dec. 30, '95. (675.)

I. PES-CAPRAE Sweet. "Boniato de playa."
Common, creeping on sandy beach. Castillo de Jagua, Sept. 17, '95. (614.)

I. NYMPHAEIFOLIA Griseb. "Boniato de playa."
In marshy upland woods, rare. Cieneguita S. W., Aug. 3, '95. (630.)

I. MARTINICENSIS Mey.
Not uncommon, in fertile, damp soil of open savannahs. Cieneguita S. W., July 26, '95. (358.)

I. HEPTAPHYLLA Griseb. "Bejuco de crïollo."
Common, climbing, low, coast hills, fertile soil. Calicita, Aug. 28, '95. (509.)

I. MICRODACTYLA Griseb. (?)
On fertile hillsides near the sea, rare. Castillo de Jagua, Sept. 19, '95. (643.)

I. FUCHSIOIDES var. GLABRA Griseb. (Ex. char.)
On fertile hillsides near the sea, rare. Castillo de Jagua, Sept. 19, '95. (607.)

I. cissoides Griseb.

Not uncommon in fertile black land, savannahs. Cieneguita S. W., Jan. 1, '96. (680.)

I. cathartica Poir. "Aguinaldo."

Common in savannahs, low climbing. Cieneguita, July 2, '95. (271.)

Convolvulus micranthus Roem. and Schultes.

Not uncommon in fertile soil and coast hills, low climbing. Castillo de Jagua, Sept. 17, '95. (548.)

C. Havanensis Jacq.

A suffruticose climber, common along rocky sea-shore at Castillo de Jagua, Sept. 17, '95. (557.)

Evolvulus sericeus Sw.

Common, low spreading on barren, gravelly, red soil. Cieneguita S., May 17, '95. (41.)

E. nummularius L. "Aguinaldito rastrero."

Creeping and rooting in fertile black soil, not uncommon, in open places, upland woods near coast. Castillo de Jagua, Sept. 19, '95. (606.)

Breweria calophylla Griseb.

In fertile savannahs, not common. Cieneguita N., May 20, '95. (73.)

Cuscuta Americana L. "Bejuco de fideo."

Common in marshy open woods on low shrubs and weeds (Compositae). Cieneguita S. W., Sept. 3, '96. (546.)

Solanaceae. CXXIII.

Lycopersicum Humboldtii Dun.

Along Rio Damuji in fertile black soil, uncommon or rare. Abreus, June 20, '95. (225.)

SOLANUM SEAFORTHIANUM Andr.

A woody climber in fertile soil, commonly cultivated. Cieneguita, May 8, '95. (35.)

S. CALLICARPAEFOLIUM Kth. and Bouch. "Prendedera macha."

In savannahs, red fertile soil, infrequent. (Cieneguita S.) Calicita R. R., 13K., July 17, '95. (311.)

S. VERBASCIFOLIUM L. "Pendejera macho," "Prendedera hedionda" and "Tabaco cimarrón."

In fertile savannahs, not uncommon. Cieneguita, June 18, '95. (202.)

S. HAVANENSE Jacq. "Tomatillo de la Habana."

In rough, rocky woods, fertile soil, infrequent. Cieneguita N., May 29, '95. (114.)

S. LENTUM Cav.

A woody climber in savannahs, uncommon. Cieneguita E., June 15, '95. (164.)

S. BAHAMENSE L.

Along sandy sea-beach, not frequent. Loma de Pajeros, Calicita, Aug. 26, '95. (539.)

S. SCABRUM Vahl. "Ajicón."

Common in river marshes and open mangrove swamps. Rio Damuji. Abreus, June 20, '95. (228.)

S. JAMAICENSE, Sw.

In savannahs, fertile soil, not uncommon. Cieneguita S., June 11, '95. (190.)

S. TORVUM, Sw. "Prendedera" and "Pendejera."

In savannahs, common, Cieneguita, June 10, '95. (185.)

S. MAMMOSUM, L. "Güirito."

In waste places, infrequent. Cieneguita, June 15, '95. (209.)

S. ACULEATISSIMUM Jacq.

In fertile waste places, rare. Cieneguita S., Dec. 6, '95. (665.)

S. MELONGENA L.

Commonly cultivated. Cieneguita S., Jan. 10, '96.

PHYSALIS ANGULATA L. "Tomatillo."

In fertile waste places, not frequent. Cieneguita N., June 8, '95. (163.)

CAPSICUM BACCATUM L.

Common in rough woods, fertile soil. Cieneguita N., June 8, '95. (149 and 151.)

CESTRUM DIURNUM L. "Galán de dia." "Jasmin de dia."

A shrub, 4 to 6 feet high, in fertile sandy soil along the coast. Not common. Cienfuegos, Aug. 13, '95. (461.)

GOETZEA AMOENA Griseb. "Arrayán."

A shrub, 4 to 8 feet high, in savannahs, common. Cieneguita, May 6, '95. (12.)

BRUNFELSIA SINUATA A. Rich. Fl. Cub. Fanerog. ii. p. 151, t. 66.

"Specimens agreeing in every detail with Mueller's description (Walp. Ann. V., p. 596) of this species were collected by Robert Combs on rocky hillsides on the coast at Calicita, June 5, 1895, no. 132. The species is well characterized by the stellate-tomentose pubescence on the younger branches and on the lower surface of the leaves, by the shallowly and ciliately lobed calyx, and finally by the long slender glabrous corolla-tube; the latter being about 12 centimeters long. No. 3021 of Wright's Cuban collection, cited as *B. sinuata*, Rich. in Griseb. Cat. Pl. Cub. 188, from the glabrous character of stem, leaves, and the deeply parted calyx, should doubtless be referred to *B. nitida*, DC."

SCHWENKIA ADSCENDENS, Kth. "Tabaco cimarrón."

In barren savannahs, dry, sandy or gravelly red soil, infrequent. Cieneguita R. R., S. W. Branch, Aug. 10 and 13, '95. (82.)

Scrophularineae. CXXIV.

Angelonia angustifolia Benth. "Fernandina."

In fertile black soil, savannahs, common. Cieneguita S., June 6, 95. (130.)

Stemodia durantifolia, Sw.

In damp or marshy upland woods (maniguas), fertile soil. Cieneguita S. W., Aug. 7, '95. (422.)

Herpestis sessiliflora Benth.

In damp shaded places, fertile soil, not common. Cieneguita R. R., S. W. Branch, Sept. 13, '95. (590.)

H. Monnieria Kth. "Graciola."

A small, creeping or ascending herb, common in the edge of river marshes and mangrove swamps. Constancia, Aug. 2, '95. (381.)

Micranthemum bryoides Benth. and Hook.

Amphiolanthus bryoides Griseb.

On damp, fertile, thin soil over rock strata, common. Cieneguita S. W., July 26, '95. (353.)

Scoparia dulcis L. "Escobilla."

Common in savannahs, usually red soil. Cieneguita, June 11, '95. (191.)

Capraria biflora L. "Escabiosa."

Not uncommon in fertile waste places, along river woods. Rio Damuji, Rodas, Aug. 17, '95. (482.)

Buchnera elongata Sw.

In barren savannahs, damp sandy or gravelly red soil. Not uncommon. Cieneguita R. R., S. W. Branch, Aug. 8, '95 and Sept. 13, '95. (444 and 598.)

Gerardia hispidula Mart.

In damp marshy savannahs, fertile soil, near brook. Cieneguita R. R., S. W. Branch, Sept. 13, '95. (591.)

G. DOMINGENSIS Spreng. "Fernandina blanca."

In wet or marshy fertile soil, along brook. Cieneguita R. R., S. W. Branch, Aug. 8, '95. (443.)

LENTIBULARIEAE. CXXVI.

UTRICULARIA SUBULATA L.

In grassy marsh at source of small stream, common on the mud. Cieneguita R. R., S. W. Branch, Aug. 10, '95. (412.)

U. JUNCEA Vahl.

In grassy marshes at source of small streams, common on mud. Cieneguita R. R., S. W. Branch, Aug. 10, '95. (411.)

U. SPIRANDRA Wright. (?)

On "water weeds" and algae, in brook water, common. Cieneguita R. R., S. W. Branch. Aug. 19, '95. (494.)

POLYPOMPHOLIX LACINIATA Benj.

On mud and damp soil of marshes at source of small streams. Cieneguita R. R., S. W. Branch, Jan. 9, '96. (687.)

BIGNONIACEAE. CXXIX.

BIGNONIA GNAPHALANTHA Rich.

In savannahs and open coast woods, common. Cieneguita, Calicita, May 31, '95. (106.)

B. SAGRAEANA DC.

In open woods and savannahs, high climbing, uncommon. Calicita R. R., 16K., July 20, '95. (332.)

TABEBUIA PENTAPHYLLA Hemsley. "Roble de yugo" or "Roble blanco."

Tecoma pentaphylla Griseb.

A large tree in open upland woods and savannahs, fertile soil, not frequent. Cieneguita S. W., Aug. 7, '95. (421.)

T. LEPIDOPHYLLA Greenman, in litt. "Sabanero" or "Rompe-ropa."

Tecoma lepidophylla Griseb.

Common in savannahs, red soil. Cieneguita S., May 4, '95. (11.)

TABEBUIA PETROPHILA Greenman, n. sp.

"Shrub or small tree, 2½ to 6 meters high, stems much branched, covered with a grayish bark: leaves unfoliolate; leaflets oblong, obtuse or rounded, sometimes slightly retuse at the apex, rounded or obtuse at the base, entire, subrepand, 8 to 18 millimeters long, 4 to 7 millimeters broad, minutely lepidote on both surfaces; petioles short, about 1 millimeter long: flowers on slender, solitary peduncles at the ends of the branchlets; peduncles nearly or quite 1 centimeter in length: calyx unequally lobed, minutely lepidote on the outer surface, 8 millimeters long: corolla somewhat funnel shaped, glabrous, about 3 centimeters in length: fruit not seen.—Collected by Robert Combs in rocky mountainous woods on the seashore at Faro Villa Nueva, Cuba, Sept. 18, 1895, no. 601. This plant is said by Mr. Combs to be very rough and ragged in habit. It resembles certain forms of *Tabebuia lepidophylla* (*Tecoma lepidophylla* Griseb. Mem. Am. Acad. n. ser. viii. p. 524), from which species it is distinguished by its very different habit, smaller and more typically oblong leaflets, and decidedly smaller flowers."—Plate XXXVII.

T. LONGIFLORA Greenman, in litt. "Roble real."

Tecoma longiflora, Griseb.

A high tree in rough, rocky woodlands, rare. "Colonia de Columbia," Juragua, Sept. 14, '95. (581.)

TECOMA STANS Juss. "Sauco amarillo."

Common in fertile open woods, often cultivated. Cieneguita, May 6, '95. (10.)

CRESCENTIA CUJETE L. "Güira cimarrona."

Common in savannahs, fertile soil. Cieneguita, May 6, '95. (9.)

Acanthaceae. CXXXI.

Ruellia paniculata L.

Annual or suffruticose, not uncommon in rocky, fertile upland woods. Cieneguita S. W., Feb. 10, '96. (702.)

R. tuberosa L. "Salta-perico."

Common in fertile savannahs and river woods. (Cieneguita.) Abreus, June 20, '95. (224.)

Barleriola solanifolia Oerst.

Barleria solanifolia L.

A small shrub, flowers not common. Savannah, Aug. 20, '95. (88.)

Anthacanthus spinosus Nees.

A shrub, 4 to 6 feet high (trailing) in rough rocky woods on coast. Faro Villa Nueva, Sept. 18, '95. (576.)

Stenandrium droseroides Nees.

Common in barren savannahs, dry, sandy or gravelly soil. Cieneguita R. R., S. W. Branch, Aug. 19, '95. (492.)

Justicia origanoides Griseb. (Ex. char.)

Not uncommon on sand hills near the sea. Castillo de Jagua, Sept. 16, '95. (570.)

Dianthera pectoralis Murr.

Not infrequent along brooks in the water or in wet places. Cieneguita S. W., Aug. 7, '95. (418; also 481.)

D. reptans Griseb.

In the edge of or near upland marsh, common. Cieneguita N., July 19, '95. (329.)

Dicliptera assurgens Juss.

Not uncommon in fertile rough woodland. Cieneguita N., Dec. 3, '95. (654.)

Myroporineae. CXXXII.

Bontia daphnoides L.

A shrub, 6 to 8 feet high, along the sea banks, rare. Caemonera, Aug. 28, '95. (497.)

Verbenaceae. CXXXIV.

Lantana Camara L. "Filigrana."

Not infrequent in savannahs and open coastal woods. Calicita, May 31, '95. (108.)

L. involucrata L. "Yerba de la sangre."

Common, open woods on coast hills, fertile soil. Calicita, May 31, '95. (107.)

Lippia nodiflora Michx.

Creeping in fertile wet soil in upland woods. Cieneguita S. W., Aug. 7, '95. (423.)

L. dulcis Trev. "Orozúz de la tierra?"

A trailing shrub, 2 to 3 feet high, in fertile open river woods. Rio Damuji, Abreus, Aug. 17, '95. (476.)

L. stoechadifolia HBK.

Suffruticose or shrubby, not uncommon in damp or wet grass land, savannahs near small brooks. Cieneguita N., Aug. 7, '95. (425.)

Bouchea Ehrenbergii Cham.

Common weed in fertile waste places, fields, etc. Cieneguita, June 13, '95. (154.)

Stachytarpheta (Stachytarpha Link) Jamaicensis Vahl. "Verbena azul."

In fertile savannahs, common. Cieneguita, June 11, '95. (194.)

S. angustifolia Vahl. "Verbena de hoja angosta."

Not uncommon in grassy marshes along small brook Cieneguita R. R., S. W. Branch, Sept. 13, '95. (589.)

PRIVA ECHINATA Juss.

In fertile waste places, usually shaded, black soil, not uncommon. Cieneguita, June 24, '95. (220.)

VERBENA URTICIFOLIA L.

In rich sandy soil, Rio Damuji. Santa Rosalia, Aug. 2, '95. (389.)

CITHAREXYLUM VILLOSUM Jacq.

Fertile coast hills, not uncommon. Calicita, Aug. 14, '95. (468.)

DURANTA PLUMIERI Jacq. "Violetina."

A shrub, 8 to 12 feet high, in rough rocky woods, not uncommon. Cieneguita N., July 3, '95. (280.)

PETITIA POEPPIGII Schauer. "Roble guayo."

Not common, in savannahs, red soil. Cieneguita S., June 14, '95. (169.)

VITEX DIVARICATA Sw. "Ofón criollo" or "Roble güiro."

A low tree in savannahs, not frequent. Cieneguita, June 18, '95. (203.)

V. ILICIFOLIA Rich. "Granadillo de costa."

In poor, gravelly, red soil, savannahs, not frequent. Calicita R. R., 11K., June 27, '95. (239.)

CLERODENDRON ACULEATUM Griseb.

A common shrub in rocky places along brook. Cieneguita S. W., July 26, '95. (356.)

C. FRAGRANS Willd. "Mil-rosas."

An herb, not uncommon in waste places and along streets of Abreus, June 15, '95. (162.)

AVICENNIA NITIDA Jacq. "Mangle negro" "Mangle prieto."

Common in mangrove swamps and river and salt marshes. Rio Damuji, Abreus, May 23, '95. (80.)

LABIATAE. CXXXV.

OCIMUM SANCTUM L. "Albahaca cimarrona."
Common weed in waste places, fertile black soil. Rio Damuji, Rodas, Aug. 17, '95. (483.)

HYPTIS CAPITATA Jacq. "San Diego cimarron."
Not common in marshy grass land, savannahs. Cieneguita N., Aug. 30, '95. (636.)

H. SUAVEOLENS Poit. "Orégano cimarron."
In savannahs, fertile waste places, common. Cieneguita, Dec. 6, '95. (663.)

H. PECTINATA Poit.
Common in pastures and old grass lands, savannahs. Cieneguita, Sept. 26, '95. (621.)

H. GONOCEPHALA Wright. "Orégano."
In poor, red soil, open savannahs, not frequent. Cieneguita S. W., Dec. 6, '95. (669.)

SALVIA TENELLA Sw.
Common in fertile black soil, waste places along coast hills. Calicita, July 26, '95. (352.)

LEONOTIS NEPETIFOLIA R. Br. "Bastón de San Francisco."
Along river woods, fertile soil, not uncommon. Rio Damuji, Abreus, June 20, '95. (223.)

TEUCRIUM CUBENSE L. "Agrimonia."
Not uncommon along the sea-shore, Calicita, Aug. 25, '95. (507.)

NYCTAGINEAE. CXXXVII.

MIRABILIS JALAPA L. "Maravilla."
In waste places, fertile soil, probably escaped from cultivation. Cieneguita, July 3, '95. (286.)

BOERHAAVIA PANICULATA Rich. "Mata-pavo."

Common in fertile fields and waste places, Cieneguita, May 30, '95. (104.)

PISONIA ACULEATA L. "Uña de gato," "Zarza."

Very common and pernicious shrub, 6 to 8 feet high, spreading and trailing, sometimes climbing in fertile savannahs, and upland woods. Cieneguita, Feb. 15, '96. (709.)

P. DISCOLOR Chois.

Common on sandy flats along the sea-shore. Cienfuegos, Aug. 13, '95. (446 and 447.)

P. OBTUSATA Sw.

A shrub or low tree, 4 to 10 feet high, not uncommon, in savannahs, dry red gravelly soil. Cieneguita W., Mar. 4,' 96. (731.)

AMARANTACEAE. CXXXIX.

CELOSIA PANICULATA L. "Moco de pavo," "Siempreviva."

C. nitida Vahl.

A slender shrub, 1 to 3 feet high, in rough, rocky woods, uncommon. Cieneguita N., July 19, '95. (328.)

ACHYRANTHES ASPERA L. "P— de gato."

A common weed, fertile soil. Cieneguita, Sept. 3, '95. (547.)

ALTERNANTHERA MUSCOIDES Benth. and Hook.

Lithophila muscoides Sw.

A common weed on the rocky sea-shore. Castillo de Jagua, Sept. 18, '95. (573.)

A. ACHYRANTHA R. Br.

A common weed in waste places, fertile black soil. Cieneguita, July 8, '95. (305.)

A. SPINOSA Roem. and Schultes. "Bledo espinoso" and "Pinedo blanco."

In rich river woods, Rio Damuji, not common. Abreus, June 29, '95. (268.)

Gossypianthus lanuginosus Moq. (smooth form).

Small, spreading prostrate herb, in barren savannahs, dry, sandy black soil, infrequent. Cieneguita R. R., S. W. Branch, Aug. 10, '95. (405.)

Gomphrena decumbens Jacq.

Common, ascending, in grassy waste places. Cieneguita, July 30, '95. (338.)

Iresine celosioides L.

Common in fertile black soil in savannahs near brooks. Cieneguita, Aug. 20, '95. (512.)

Chenopodiaceae. CXL.

Chenopodium ambrosioides L. "Apasote."

In fertile river woods, not infrequent. Cieneguita, Aug. 20, '95. (226.)

Atriplex cristata Humb. and Bonpl. "Armuelles."

Shrubby (or suffruticose), 1 to 3 feet high, in sandy, fertile, wet soil, along the sea. Not uncommon at Calicita, July 27, '95. (373.)

Phytolaccaceae. CXLI.

Rivina laevis L. "Ojo de ratón" or "Coralitos."

Common in rough rocky woods, fertile soil. Cieneguita N., June 10, '95. (186.)

R. laevis L. var. pubescens Griseb. "Ojo de ratón" "Coralitos."

Not uncommon in rough, rocky woods, fertile soil. Cieneguita N., June 13, '95. (153.)

R. octandra L. "Guaniquí" and "Bejuco canasta."

A trailing or erect shrub, 6 to 10 feet high. Common in rough woods. Cieneguita N., June 11, '95. (195.)

PETIVERIA ALLIACEA L. "Anamú."
Not uncommon in fertile black soil, rocky, rough woods. Cieneguita N., June 24, '95. (182.)

PHYTOLACCA BOGOTENSIS HBK. (?)
Along rocky coast hills, rare. Calicita, June 12, '95. (173.)

BATIDEAE. CXLII.

BATIS MARITIMA L. "Barrilla."
Common shrub, 1 to 3 feet high, along the sea, sandy low beaches and salt marshes. Calicita, July 27, '95. (371.)

POLYGONACEAE. CXLIII.

COCCOLOBA UVIFERA Jacq. "Uva de la caleta," "Uvero."
Common on low sand hills along sea-shore. Castillo de Jagua, Sept. 16, '95. (569.)

C. ARMATA Wright. "Uverillo."
A rough, rigid shrub, 4 to 6 feet high, not uncommon. Coast hills, poor soil. Loma de Ciego, Calicita, Aug. 26, '95. (531.)

C. RETUSA Griseb. "Uvero macho."
A low tree or shrub (10 to 15 feet high), in savannahs, rare. Cieneguita S., Aug. 6, '95. (374.)

C. MICROPHYLLA Griseb. "Uverillo."
A rough, spreading, rigid shrub, 4 to 8 feet high, not uncommon along brook in barren savannahs, dry sandy or gravelly red soil. Cieneguita W. to Yaguaramos, Feb. 28, '96. (725.)

ANTIGONON LEPTOPUS Hook. and Arnot.
In fertile waste places, probably escaped from cultivation. Castillo de Jagua, Sept. 16, '95. (563.)

ARISTOLOCHIEAE. CXLVII.

ARISTOLOCHIA PASSIFLORIFOLIA Rich.

Common on coast hills, low climbing. Castillo de Jagua, Sept. 19, '95. (488.)

PIPERACEAE. CXLVIII.

PIPER ANGUSTIFOLIUM R. and P. var. ——? "Platanillo de Cuba."

A shrub, 5 to 8 feet high, common along brooks and small streams, rich black soil. Cienenguita E., May 2, '95. (8.)

P. PELTATUM L.

Along small stream, rich shaded places, rare. Cieneguita N., Aug. 20, '95. (514.)

P. UMBELLATUM L.

Common along small stream, rich, damp, shaded soil. Cieneguita E., May 2, '95. (7.)

PEPEROMIA sp. (693.)

A succulent herb, fleshy leaves, creeping on rocks in rough woods, shaded damp cañons. Cieneguita N., Dec. 4 and 30, '95.— Plate XXXVIII.

LAURINEAE. CLII.

PERSEA GRATISSIMA Gaertn. "Aguacate."

An excellent fruit. Commonly cultivated, often spontaneous. Cieneguita, Jan. 20, '96. (697.)

PHOEBE MONTANA Griseb. "Boniato del pinar."

In savannahs, fertile, black soil, infrequent. Cieneguita N., Jan. 13, '96. (692.)

NECTANDRA CORIACEA Griseb.

Not common, fertile coast hills. Calicita, May 31, '95, and Castillo de Jagua, Sept. 19, '95. (101 and 604.)

CASSYTHA AMERICANA Nees.

(Determined by Dr. Urban.) An aphyllous, herbaceous climber, clinging by papillae or suckers to low shrubs. Not uncommon in savannahs, dry poor soil, usually red. Calicita R. R., 11K., June 27, '95. (246.)

LORANTHACEAE.* CLVII.

DENDROPHTHORA DOMINGENSIS Eichl.

Common, parasitic on *Brya ebenus* DC., *Belairia mucronata*, etc., in dry savannahs. Cieneguita S., July 11, '95. (293.)

D. LEPTOSTACHYA Eichl.

Parasitic on *Belairia*, rare. Savannahs. Calicita R. R., 10K., July 17, '95. (333.)

D. WRIGHTII Eichl.

On *Terminalia Buceras* L., in upland marshes, rare. Cieneguita N., Feb. 22, '96. (710.)

D. WRIGHTII Eichl.

On *Tabebuia pentaphylla* Hemsl., in savannahs or upland woods, rare. Cieneguita W., Feb. 26, '96. (715.)

PHORADENDRON RUBRUM Griseb. "Cepa-caballero."

On *Guazuma ulmifolia* Lam., in savannahs, not common. Cieneguita, July 10, '95. (299.)

P. SPATHULIFOLIUM Krug and Urban.

Common on large trees along Calicita R. R., at 11K., July 27, '95. (348 and 347.)

PHTHIRUSA EMARGINATA Eichl.

Common on low shrubs, coast hills. Castillo de Jagua, Sept. 17, '95. (555.)

DENDROPEMON PURPURENS (L.) Krug and Urban.

On low shrubs, coast hills, rare. Castillo de Jagua, Sept. 17, '95. (613.)

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* The members of this order were determined by Dr. I. Urban.

EUPHORBIACEAE. CLX.

PEDILANTHUS TITHYMALOIDES Poit.

A low shrub, 3 to 4 feet high, commonly cultivated. Calicita, Aug. 28, '95. (498.)

EUPHORBIA BUXIFOLIA Lam.

In sandy crevices of rocks along the sea-shore. Castillo de Jagua, Sept. 16, '95. (567.)

E. HETEROPHYLLA L.

Common in fields and waste places, fertile soil. Cieneguita, May 2, '95. (5.)

E. HYPERICIFOLIA L.

Common weed in fields and waste places, Cieneguita, May 2, '95. (4.)

E. PILULIFERA L. "Yerba de boca."

Spreading, prostrate, fertile soil, fields and waste places, common. Cieneguita, May 2, '95. (2.)

E. BRASILIENSIS Lam.

A spreading or ascending common weed in fields and waste places, Cieneguita, May 2, '95. (3.)

SAVIA SESSILIFLORA Willd. "Aretillo."

A low tree or shrub, 8 to 10 feet high, in rich, rough, rocky woods, not uncommon. Cieneguita, Aug. 6, '95. (377.)

PHYLLANTHUS EPIPHYLLANTHUS L. "Panetela."

P. falcatus Sw.

Not an uncommon shrub, 4 to 6 feet high, on coast hills near the sea. Calicita, Aug. 26, '95. (502.)

JATROPHA GOSSYPIFOLIA L. "Tuatua."

A common shrub, 2 to 4 feet high, in fertile low savannahs. Cieneguita, May 8, '95. (20.)

J. HASTATA Jacq.

A shrub, 4 to 6 feet high, low fertile savannahs, along brooks, not common. Cieneguita, June 3, '95. (99.)

J. CURCAS L. "Piñón botija" and "Piñón purgante."

A common shrub, 6 to 15 feet high. (Cultivated.) Cieneguita, May 30, '95. (100.)

CROTON SAGRAEANUS Müll. Arg.

Not uncommon in savannahs, black soil. Cieneguita S., May 16, '95. (43.)

C. CUBENSIS Müll. Arg.

A shrub, 8 to 13 feet high, in rough, rocky woods, not frequent. Cieneguita N., June 4, '95. (120.)

C. LUDICUS L. "Caobilla" or "Cuabá de ingenio."

A common shrub, 3 to 6 feet high, in rocky rough woods. Cieneguita N., May 14, '95. (28.)

C. GLANDULOSUS var. GENUINUS Müll. Arg.

C. glandulosus L.

A common herb in waste places, savannahs. Cieneguita S., June 6, '95. (139.)

C. NUMMULARIAEFOLIUM A. Rich.

Not uncommon in barren savannahs, dry, gravelly or sandy soil. Cieneguita R. R., S. W. Branch. Aug. 10, '95. (394.)

C. LOBATUS L. "Fraelicillo cimarrón."

A common weed in fields and waste places, fertile soil. Cieneguita, May 2, '95. (6.)

ARGYTHAMNIA CANDICANS Sw.

A slender shrub, 3 to 5 feet high, in rough, low woods, common. Cieneguita N., May 18, '95. (53.)

CAPERONIA PALUSTRIS St. Hil.

In fertile fields and waste places, not common. Cieneguita, June 6, '95. (135.)

C. CASTANEAEFOLIA St. Hil.

In wet or marshy fertile soil along brooks, etc. Not uncommon. Cieneguita, June 17, '95. (155).

MANIHOT UTILISSIMA Pohl. "Yuca."

Commonly cultivated and sometimes escaped in fertile waste places. Cieneguita, June 17, '95. (198.)

BERNARDIA DICHOTOMA Müll. Arg.

In rough, rocky woods, infrequent. Cieneguita N., June 5, '95. (120*a*.)

B. DICHOTOMA, var. VENOSA Müll. Arg.

B. venosa Griseb.

A shrub 6 to 8 feet high, in rough, rocky woods, not frequent. Cieneguita N., Aug. 1, '95. (364.)

B. MICROPHYLLA Müll. Arg.

Adelia microphylla. A. Rich.

A shrub, 3 to 4 feet high, not uncommon in rocky coast woods along the sea. Faro Villa Nueva, Sept. 18, '95. (575.)

ACALYPHA ALOPECUROIDES Jacq.

In fertile waste places, not uncommon at Castillo de Jagua, Sept. 16, '95. (560.)

A. CHAMAEDRYFOLIA var. REPTANS Müll. Arg.

A. reptans L.

Common in waste places, fertile savannahs, black and red soil. Cieneguita, June 6, '95. (140.)

A. CHAMAEDRYFOLIA var. PENDULA Müll. Arg.

On high, rocky sea banks, common at Faro Villo Nueva E., Sept. 18, '95. (578.)

ADELIA RICINELLA L.

Common low tree in rough, rocky woods. Cieneguita N., May 20, '95. (52.)

PLATYGYNA URENS Mercier. "Pringa-moza."

A slender, shrubby climber, infrequent in open, fertile woods and savannahs. Cieneguita, May 21, '95. (40.)

TRAGIA VOLUBILIS L. "Candelilla." (?)

A slender shrubby climber, not frequent in open woods and savannahs, fertile soil. Cieneguita, May 16, '95. (39.)

SAPIUM LAUROCERASUM Desf.

Sapium laurifolium Griseb.

A large tree, 25 to 35 feet high, in fertile black soil along small stream, uncommon. Cieneguita E. Flowers in Feb. and March; seeds in June. (160.)

BONANIA CUBANA A. Rich. "Filigrana de costa."

Exoecaria Cubensis Müll. Arg.

A shrub 2 to 6 feet high, common on coast hills, dry gravelly soil. Castillo de Jagua, Sept. 19, '95. (603.)

SEBASTIANIA CORNICULATA var. GENUINA Müll. Arg.

Spreading and ascending herb, savannahs, waste places, fertile black or red soil. Cieneguita S., June 6, '95. (141.)

EXOECARIA SAGRAEI Müll. Arg. "Manzanillo del Morrillo."

Not uncommon on coast hills and sea banks. Calicita, Aug. 24, '95. (519.)

GYMNANTHES LUCIDA Sw.

A shrub 4 to 10 feet high, in rough, rocky woods, infrequent. Cieneguita N., June 5, '95, and Sept. 12, '95. (131 and 586.)

URTICACEAE. CLXII.

CELTIS TRINERVIA Lam. "Ramón de costa."

A low, spreading tree (10 feet high), in rough, rocky woods, infrequent. Cieneguita N., Sept. 12, '95. (583.)

TREMA MOLLIS Blume.

In coastal woods, fertile soil, rare. Castillo de Jagua, Sept. 19, '95. (605.)

FICUS CRASSINERVIA Desf. "Jagüey macho."

A common large tree in fertile soil along small streams. Cieneguita E., June 5, '95. (145.)

F. CRASSINERVIA Desf. (Affinis.)

A tree 20 feet high, figs warty and involucre minute. On sea-shore, rare. Calicita, Aug. 29, '95. (500.)

F. LAEVIGATA Vahl. "Pinipini," "Jagüey."

A tree on coast hills and sea banks, infrequent. Faro Villa Nueva, Sept. 18, '95. (599.)

F. LENTIGINOSA Vahl.

Low tree in rough, rocky woods, infrequent. Cieneguita N., Aug. 1, '95. (366.)

F. DIMIDIATA Griseb.

A large tree in fertile soil along small streams. Cieneguita, June 8, '95. (147.)

F. SUFFOCANS Banks.

A large tree, not uncommon along small streams, fertile soil. Cieneguita, June 6, '95. (146.)

FICUS sp.

A large tree (40 to 50 feet high). (Cultivated?). Cieneguita, July 18, '95. (314.)

CECROPIA PELTATA L. "Yagruma hembra."

A slender tree, 15 to 20 feet high, in fertile black soil along brooks and small streams. Cieneguita N., May 25, '95. (111.)

FLEURYA CUNEATA Wedd.

A delicate or fragile herb growing on rocks in shaded places, not uncommon. Cieneguita N., July 6, '95. (277.)

URERA BACCIFERA Gaud. "Chichicate."

A spiny shrub, 5 to 10 feet high, leaves and flowers with irritating nettles, not uncommon in rough, rocky woods. Cieneguita N., Jan 4, '96. (681.)

PILEA MICROPHYLLA Liebm.

A small delicate herb, in shaded fertile places on rocks, in woods, common. Cieneguita N., June 24, '95. (242.)

P. MICROPHYLLA Liebm. var. HERNIARIOIDES Lindl.

In shaded, rough woods, in crevices of rocks, not frequent. Cieneguita N., Sept. 12, '95. (585.)

P. PUBESCENS Liebm.

Uncommon, in crevices of rocks, rough woods, in fertile soil. Cieneguita N., Aug. 6, '95. (378.)

BOEHMERIA CYLINDRICA Willd. var. LITORALIS Sw.

In the edge of river marshes, common, Rio Damuji. Santa Rosalia, Aug. 2, '95. (390.)

ROUSSELIA LAPPULACEA Gaud.

Common in crevices of rocks in damp, shaded places, rough woods. Cieneguita N., Sept. 12, '95. (584.)

MYRICACEAE. CLXVI.

MYRICA MICROCARPA Benth.

Common in marshy savannahs along brooks and small streams. Cieneguita W. and S. W., Feb. 21 and 28, '96. (718.)

CASUARINEAE. CLXVII.

CASUARINA EQUISETIFOLIA Forst. "Pino."

A tree, 40 to 50 feet high, on coast hills, infrequent. (Castillo de Jagua.) Calicita, Aug. 27, '95. (510.)

BURMANNIACEAE. CLXXIV.

BURMANNIA CAPITATA Mart.

On mud in grassy marshes at source of small streams. Cieneguita S. W., Jan. 9, '96. (688.)

ORCHIDEAE. CLXXV.

BLETIA VERECUNDA R. Br.

In marshy open woods, not uncommon. Cieneguita S. W., Feb. 10, '96. (705.)

EPIDENDRUM PHOENICIUM Lindl.

Not uncommon, epiphytic on trunks of trees and palmettos in savannahs. Cieneguita S., May 15, '95. (67.)

E. FUCATUM Lindl. "Vainilla amarilla."

In savannahs, epiphytic on trees, uncommon. Abreus, May 25, '95. (87.)

E. DIFFORME Jacq.

On the branches of trees (*Terminalia Buceras*) in dark, damp woods. Cieneguita R. R., S. W. Branch, Sept. 13, '95. (644.)

E. COCHLEATUM L. "Canuela."

On trunks and branches of trees in upland marshy woods, uncommon. Cieneguita N., Jan. 7, '96. (698.)

E. FUSCATUM Sw.

On trunks of trees in dark, rough woods, rare. Cieneguita N., Dec. 30, '95. (677.)

E. RIGIDUM Jacq.

On low trunks of trees in dark, damp woods, not uncommon. Cieneguita S. W. and N., Feb. 10 and 21, '96. (737.)

POLYSTACHIA LUTEOLA Hook.

On trees in dark, damp woods, rare. Cieneguita S. W., Sept. 3, '95. (641.)

CYRTOPODIUM WOODFORDII Sims.

Cyrtopera Woodfordii Lindl.

Terrestrial in wet, marshy woods, common. Cieneguita S. W., Sept. 24, 95. (618.)

C. PUNCTATUM Lindl.

On trunks of trees and palmettos, clinging by a large mass of fibrous roots, rare. Cieneguita S. W., Sept. 3, '95. (640.)

Oncidium variegatum Sw.

On branches of trees in dark, damp woods, not uncommon. Cieneguita S. W., July 26, '95. (354.)

O. Leiboldi Reichb. fil. (?)

On the trunks of shrubs, close to the ground, coast hills near salt marsh. Loma de Ciego, Calicita, Aug. 26, '95. (532.)

Ionopsis utricularioides Lindl.

On trunks of trees and shrubs in dark, damp woods, uncommon. Cieneguita S., June 7, '95. (127.)

Ponthieva glandulosa R. Br.

Terrestrial in crevices of rocks in dark, damp woods, fertile soil, uncommon or rare. Cieneguita, Dec. 30, '95. (676.)

Spiranthes tortilis Rich.

In wet or marshy grass land, fertile soil, not frequent. Cieneguita W., Feb. 28, '96. (728.)

Habenaria bicornis Lindl.

In upland grassy marshes, not uncommon. Cieneguita S. W., Aug. 8, '95. (440.)

Zingiberaceae. CLXXVI.

Canna Indica L. "Platanillo de monte."

Commonly cultivated, and escaped in fertile soil occasionally. Cieneguita, Sept. 10, '95. (593.)

Musaceae. CLXXVII.

Musa sapientum L. "Plátano."

Common in cultivation. Cieneguita, May 30, '95. (112.)

Bromeliaceae. CLXXVIII.

Bromelia Penguin L. "Piña de raton."

Very common, cultivated as a hedge. Cieneguita, May 2, '95. (95.)

HOHENBERGIA PENDULIFLORA Mez.

"Specimens evidently belonging to this species were secured by Robert Combs at Cieneguita, Cuba, July 5, 1895, no. 466. Mr. Combs' specimens differ from the typical form (as represented by Wright's no. 1525) by having a more robust inflorescence, larger and more numerous flowers, and a more pronounced lanate pubescence throughout the entire inflorescence. The plant is said to be common on rocks and on the branches of trees at the above locality."

CATOPSIS NUTANS Griseb.

On branches of trees in open woods, infrequent. Cieneguita S. W., Sept. 3, '95. (638.)

TILLANDSIA TENUIFOLIA L.

On branches of trees and shrubs in dark, damp woods, not common. Cieneguita N., Aug. 12, '95. (639.)

T. POLYSTACHA L.

Common on trees in savannahs and open woods. Cieneguita, June 7, '95. (175.)

T. PRUINOSA L. "Curujey."

On branches of trees in dry open savannahs, rare. Cieneguita S., Dec. 7, '95. (671.)

T. UTRICULATA L. "Curujey."

On branches of trees in open woods and savannahs, common. Cieneguita, Aug. 13, '95. (633.)

T. RECURVATA L. "Agave de Méjico."

Common on branches and trunks of trees in savannahs. Cieneguita, Sept. 6, '95. (580).

T. USNEOIDES L. "Guajaquillo."

Hanging in festoons from the branches of trees in damp woods or upland wooded marshes, not frequent. Cieneguita N., July 30, '95. (343.)

IRIDEAE. CLXXX.

CIPURA PALUDOSA Aubl.
In fertile savannahs, not common. Cieneguita S., June 24, '95. (211.)

AMARYLLIDEAE. CLXXXI.

CURCULIGO SCORZONERAEFOLIA Benth. "Azafrán del país."
Hypoxis scorzoneraefolia Lam.
In savannahs, fertile black and red soil, common. Cieneguita S., May 17, '95. (42.)

ZEPHYRANTHUS ROSEA Lindl.
In damp thin soil over rock strata, along small stream, common. Cieneguita S. W., July 26, '95. (357.)

CRINUM AMERICANUM L. "Lirio," "Lirio de San Pedro."
In fertile river bottoms, damp or wet places, uncommon. Rio Damuji, Abreus, May 23, '95. (85.)

PANCRATIUM CAROLINIANUM L. "Lirio de San Juan."
Not uncommon in fertile damp or wet places along small streams. Cieneguita S. W., July 26, '95. (345.)

FOURCROYA CUBENSIS Haw. "Pita," "Maguey de cocuy."
Common in rough, rocky woods (and fertile savannahs). Cieneguita N., July 6, '95. (287.)

DIOSCOREACEAE. CLXXXIII.

DIOSCOREA MULTIFLORA Presl. "Ñame."
Climbing in open fertile woods and savannahs, not uncommon. Cieneguita S. W., Aug. 10, '95. (414.)

LILIACEAE. CLXXXV.

SMILAX HAVANENSIS Jacq. "Raiz de China," "Zarzaparilla."
Common, climbing in open woods and savannahs. Calicita (Cieneguita), June 12, '95. (172.)

Xyrideae. CLXXXVII.

Xyris communis Kth.

Not uncommon in grassy marshes at source of small streams. Cieneguita R. R., S. W. Branch, Aug. 8, '95. (445.)

Commelinaceae. CXC.

Commelina Virginica L. "Cañutillo," "Zapato del obispo."

C. elegans Kth.

In fertile, rough, rocky woods, common. Cieneguita N., May 11 and 14, '95. (23.)

Palmae. CXCIV.

Oreodoxa regia Kth. "Palma criolla," also "Palma real."

Common in fertile black soil, savannahs, streams and rivers. Cieneguita, Jan. 15, '96. (694.)

Sabal umbraculiferum Mart. "Palma cana," and "Palmeto."

Common in poor soil, savannahs. Cieneguita S., July 5, '95. (292.)

Copernicia hospita Mart. "Jata" or "Guano."

In dry sterile red soil, savannahs and coast hills, not uncommon. Calicita R. R., 10K., July 13, '95. (334.)

Copernicia sp.

In dry sterile red soil, savannahs, rare. Calicita R. R., 10K., July 13, '95 (335.)

C. Wrightii Griseb. and Wendl. "Miraguano espinoso" or "Guano espinoso."

In grassy marshes and river swamps, infrequent. Cieneguita S. W. (Santa Rosalia), Aug. 10, '95. (465.)

THRINAX ARGENTEA, Lodd. "Guano blanco" or "Palma blanca."

Common in savannahs, upland woods and coast hills. Cieneguita S. W., July 12, '95. (300.)

COCOS NUCIFERA L. "Coco" or "Palma de cocos."

Not uncommon in fertile soil. (Commonly cultivated.) Jurugua, Sept. 14, '95. (615.)

AROIDEAE. CXCVIII.

PHILODENDRON HEDERACEUM Schott.

Not uncommon in rough, rocky woods. Cieneguita N., June 5, '95. (143.)

P. LACERUM Schott.

Not infrequent, in fertile shaded places, climbing trees and rocks. Cieneguita, July 29, '95. (469.)

ANDROMYCIA CUBENSIS Rich.

Xanthosoma, per Durand, 1887.

In rough, rocky woods, fertile soil, uncommon. Cieneguita N., July 25, '95. (370.)

ALISMACEAE. CCI.

SAGITTARIA LANCIFOLIA L. "Flechera."

Common along river marshes, Rio Damuji, Santa Rosalia, Aug. 2, '95. (392.)

S. INTERMEDIA Micheli.

Common in brooks and small streams. Cieneguita, Aug. 20, '95. (515.)

NAIADACEAE. CCII.

POTAMOGETON FLUITANS L. "Lino de rio."

Common in brooks, running water. Cieneguita, June 18, '95. (159.)

NAIAS MICRODON A. Braun.

Common in running water, brooks. Cieneguita, Feb. 21, '96. (707.)

ERIOCAULEAE. CCIII.

ERIOCAULON FULIGINOSUM Wr.

Not uncommon in grassy marshes near source of small streams. Cieneguita R. R., S. W. Branch, Sept. 13, '95. (588.)

CYPERACEAE. CCVI.

CYPERUS VARIEGATUS Kth.

Common along brooks in wet grass land. Cieneguita, Aug. 9, '95. (428.)

C. HUMILIS Kth.

In marshy grass land along brooks, not common. Cieneguita S. W., Aug. 19, '95. (495.)

C. ROTUNDUS L.

Common along brooks in wet grass land. Cieneguita, Aug. 9, '95. (433.)

C. ESCULENTUS L.

Common along brooks in marshy grass land. Cieneguita, Aug. 9, '95. (434.)

C. FERAX Rich.

Not uncommon, marshy grass land along brooks. Cieneguita, Aug. 9, '95. (427.)

KYLLINGIA MONOCEPHALA Rottb.

In marshy grass land along brooks. Not common. Cieneguita, Aug. 9, '95. (429.)

ELEOCHARIS CAPITATA R. Br.

In damp, rich soil, not frequent. Cieneguita S. W., Aug. 19, '95. (626.)

E. INTERSTICTA R. Br.

In marshy grass land along small streams. Cieneguita, Aug. 9, '95. (431.)

FIMBRISTYLIS GRISEBACHII Greenman, in litt.

Abildgaardia setacea Griseb.

Common on sandy or gravelly barren soil. Cieneguita R. R., S. W. Branch, Aug. 10, '95. (400.)

F. AUTUMNALIS Roem. and Schultes.

On barren sandy or gravelly soil, savannahs, Cieneguita R. R., S. W. Branch, Aug. 10, '95. (399.)

F. LAXA Vahl.

In wet or marshy places along small streams, not frequent, Cieneguita, Aug. 7, '95. (417 and 430.)

F. COMPLANATA Link.

Common in wet or marshy grass land along brooks. Cieneguita N., Aug. 20, '95. (474.)

F. MONOSTACHYA Hassk.

In barren savannahs, sandy or gravelly soil. Cieneguita R. R., S. W. Branch, Aug. 10, '95. (397.)

RHYNCHOSPORA DEFLEXA Griseb.

In shaded, damp, fertile soil, not uncommon along small stream. Cieneguita S. W., Aug. 7, '95. (419.)

R. GRACILIS Vahl.

Common in barren savannahs, damp places. Cieneguita R. R., S. W. Branch, Aug. 10, '95. (398.)

R. CUBENSIS Griseb.

In damp, shaded places near brooks. Cieneguita R. R., S. W. Branch, Aug. 10, '95. (402.)

SCLERIA PHYLLOPTERA Wright.

Common in wet places near small streams. Cieneguita R. R., S. W. Branch, Aug. 19, '95. (489.)

S. hirtella Sw.

Not uncommon in wet grassy places near the source of small streams. Cieneguita R. R., S. W. Branch, Aug. 8, '95. (441.)

Gramineae. CCVII.

Imperata caudata Trin.

In fertile, damp waste places, not uncommon. Cieneguita S. W., Feb. 10, '96. (701.)

Saccharum officinarum L.

Commonly cultivated. Cieneguita, Jan. 1, '96. (679.)

Andropogon bicornis L. "Sape."

Common in savannahs. Cieneguita, July 6, '95. (265.)

Anthephora elegans Schreb.

Not infrequent in fields and waste places, fertile soil. Cieneguita, June 28, '95. (257.)

Paspalum plicatum Michx.

Not uncommon in fertile prairies and savannahs. Cieneguita S. E., July 1, '95. (262.)

P. paniculatum L.

Not uncommon in fertile savannahs. Cieneguita S. E., July 10, '95. (295.)

Panicum paspaloides Pers.

Along small streams in marshy places, uncommon. Cieneguita N., Aug. 9, '95. (426.)

P. colonum L. "Grama pintada."

Erect or spreading in fertile fields and waste places, not uncommon. Cieneguita, June 28, '95. (254.)

P. prostratum Lam. "Grama de Castilla."

Spreading prostrate in fertile soil, fields and waste places, common. Cieneguita, June 28, '95. (253.)

P. FUSCUM Sw.

Not uncommon in waste places, fields, etc. Fertile soil. Cieneguita, June 28, '95. (252.)

P. DISTICHUM Lam. "Araña."

In clean, shady, damp woods, fertile soil, common. Cieneguita N., July 16, '95. (321.)

P. CAYENNENSE Lam.

P. Rudgei Roem. and Schultes.

Not uncommon in old fields, etc. Cieneguita, June 28, '95. (259.)

P. MAXIMUM Jacq. "Yerba de Guinea."

Common in fertile soil along "Piña" hedges, etc. Cieneguita, July 10, '95. (294.)

P. DIVARICATUM L.

A perennial, high climbing (or trailing) on trees, etc. In rough, rocky woods, not frequent. (148.)

P. SLOANEI Griseb.

Perennial, climbing into trees and shrubs, rough rocky woods, not frequent. Cieneguita N., July 2, '95. (55.)

P. LEUCOPHOEUM HBK.

In prairies and savannahs, common. Cieneguita S., June 28, '95. (255.)

P. ROTTBOELLOIDES HBK.

In dry barren savannahs, sandy or gravelly soil, uncommon. Cieneguita R. R., S. W. Branch, Aug. 10, '95. (401.)

OPLISMENUS LOLIACEUS Lam.

Common in rich damp woods. Cieneguita S. W., Dec. 6, '95. (667.)

SETARIA SETOSA Beauv.

Not uncommon in savannahs, fertile soil. Cieneguita, July 2, '95. (264.)

CENCHRUS ECHINATUS L.

Common in fields and waste places, fertile soil. Cieneguita S., Sept. 10, '95. (597.)

STENOTAPHRUM AMERICANUM Schrank. "Grama de playa."

Not uncommon on sandy fertile beach. Loma de Pajeros, Calicita, Aug. 26, '95. (535.)

OLYRA LATIFOLIA L.

Large perennial, in rough woods, not common. Cieneguita N., June 24, '95. (210.)

O. PAUCIFLORA Sw.

In damp shady upland woods, fertile loose soil, infrequent. Cieneguita N., July 16, '95. (319.)

PHARUS GLABRA Kth.

In dark, damp, rough woods, uncommon. Cieneguita N., Aug. 1, '95. (363.)

REYNAUDIA FILIFORMIS Kth.

Common in savannahs, dry, shaded places. Cieneguita S., Sept. 10, '95. (579.)

SPOROBOLUS JACQUEMONTII Kth.

Common in savannahs and grass lands. Cieneguita S., June 28, '95. (261 and 263.)

CYNODON DACTYLON Pers.

Common in sterile waste places, as old roads, etc. Cieneguita, Aug. 31, '95. (540.)

CHLORIS ELEUSINOIDES Griseb. var. VESTITA Greenman, n. var.

"Annual: roots filiform, fascicled: culms tufted, ascending glabrous, branching at the base, only 2 to 3 decimeters high: leaves covered with a spreading pilose pubescence.— Collected by Robert Combs on the high grassy river banks of Rio Damuji at Rodas, Cuba, September 17, 1895, no. 631.

Wright's no. 3819, distributed as *Chloris Beyrichiana* HBK., in the Gray Herbarium, may also be referred here."— Plate XXXIX.

ELEUSINE AEGYPTIACA Desf.
In waste grass land, not frequent. Cieneguita and Rodas, Aug. 17, '95. (513.)

E. INDICA Gaertn. "Pata de gallina."
Erect or spreading, in fields, etc., not uncommon. Cieneguita, June 28, '95. (260.)

LEPTOCHLOA VIRGATA Beauv. "Pata de gallina."
Common in fields and savannahs. Cieneguita, June 28, '95. (256.)

ARUNDO DONAX L.
Not common in wet soil. Castillo de Jagua, Sept. 17, '95. (624.)

ERAGROSTIS POAEOIDES Beauv. "Escobilla."
Spreading in open waste places, common. Cieneguita, July 8, '95. (266.)

E. CILIARIS Link.
Not frequent. Rio Damuji, Rodas, Aug. 17, '95. (480.)

CONIFERAE. CCIX.

PODOCARPUS sp.?
In savannahs, poor gravelly red soil. Calicita R. R., 11K., July 17, '95. (297.)

CYCADACEAE. CCX.

ZAMIA sp.
In rough, rocky woods, rare. Cieneguita N., Sept. 12, '95. (647.)

Vascular Cryptogams.

Rhizocarpeae.

Marsilea polycarpa Hook. and Grev.

In ponds, not frequent, or uncommon. Cieneguita R. R., S. W. Branch, Jan. 9, '96. (690.)

Lycopodiaceae.

Selaginella stolonifera Spr.

Common in damp shady woods. Cieneguita S. W., July 9, '95. (303.)

Psilotum triquetrum Sw.

On side of cañons in dark, rough woods, common. Cieneguita N., July 31, '95. (351.)

Filices.

Adiantum villosum L. "Culantrillo velludo."

In rough, rocky woods, in dark, damp cañons, not uncommon. Cieneguita N., July 31, '95. (337.)

A. crenatum L.

On shady, fertile banks of small streams, not frequent. Cieneguita, Dec. 3, '95. (657.)

A. fragile Sw. "Culantrillo de pozo."

On rocks of high river banks, rare, Rio Damuji. Rodas, Aug. 17, '95. (484.)

Pteris longifolia L.

Along the walls of the fort in crevices, uncommon. Castillo de Jagua, Sept. 17, '95. (559.)

Asplenium dentatum L. "Doradilla" or "Culantrillo."

In rough, rocky woods, in crevices of rocks, damp, shaded places, not uncommon. Cieneguita N., July 19, '95. (326.)

A. formosum Willd.

On dark, damp, shaded rocks, in rough woods, not frequent. Cieneguita N., Sept. 1, 95. (637.)

Aspidium trifoliatum Sw.

On rocky, shaded, wet banks of brooks and small streams. Not uncommon. Cieneguita E., July 3, '95. (283.)

A. patens Sw.

Nephrodium patens Desv.

On damp, shaded, rocky banks of small streams; common. Cieneguita E., July 3, '95. (284.)

A. macrophyllum Sw.

Common in damp, fertile soil. Cieneguita E., July 3, '95. (282.)

Polypodium pectinatum L.

In crevices of rocks, rough, rocky woods; rare. Cieneguita N., July 25, '95. (349.)

P. aureum L.

On trunks of palmettos and sometimes on ground (Calicita) in savannahs; not uncommon. Cieneguita S. W. and Calicita R. R., 10K., July 9 and 13, '95. (317.)

P. phyllitidis L.

On sides of rocky precipices, in rocky woods, uncommon. Cieneguita, N., July 5, '95. (285.)

P. Swartzii Baker.

P. serpens Sw.

Creeping and climbing on rocks and up the trunks of shrubs, etc., in damp, shaded places, rocky woods, not uncommon. Cieneguita N., July 25, '95. (350.)

Vittaria lineata Sw.

On the trunks of palmettos, fronds pendent; in fertile, damp woods along small streams, rare. Cieneguita W., Feb. 28, '96. (727.)

ACROSTICHUM AUREUM L.

Aquatic or in marshes along small streams or rivers. Not uncommon. (Santa Rosalia.) Cieneguita, July 19, '95. (325.)

ANEMIA ADIANTIFOLIA Sw.

In savannahs, fertile black soil, not uncommon on shaded side of banks. Cieneguita E. and S. E., Aug. 2, '95. (379.)

LYGODIUM VOLUBILIS Sw.

Climbing by twining in shrubs, open savannahs, common. Cieneguita S., July 5, '95. (281.)

EXPLANATION OF ILLUSTRATIONS.

PLATES XXX.–XXXIX.

Plate XXX.—*Pictetia sessilifolia* Wright, natural size.

Plate XXXI.—*Desmodium incanum* DC., var. *angustifolium* Griseb., natural size.

Plate XXXII. — *Caesalpinia Cubensis* Greenman, n. sp., one-half size.

Plate XXXIII. — *Acacia polypyrigenes* Greenman, n. sp., one-half size.

Plate XXXIV. — *Rondeletia Combsii* Greenman, n. sp., one-half size.

Plate XXXV. — *Catesbaea nana* Greenman, n. sp., natural size.

Plate XXXVI. — *Anastraphia Northropiana* Greenman, n. sp., natural size.

Plate XXXVII. — *Tabebuia petrophila* Greenman, n. sp., natural size.

Plate XXXVIII. — *Peperomia* sp., natural size.

Plate XXXIX. — *Chloris eleusinoides* Griseb., var. *vestita*, Greenman, n. var., natural size.

ADDENDA.

Sterculiaceae.

Melochia pyramidata L.

A slender, spreading, suffruticose herb or shrub, 2–3 ft. high, not uncommon. Cieneguita, July 2, '95. (273.)

Sapindaceae.

Schmidelia Cominia Sw.

A shrub 5–10 ft. high, not uncommon in open woods. Cieneguita R. R., S. W. Branch, Aug. 10, '95. (403.)

Boragineae.

Cordia nitida Vahl.

A low tree, in savannahs, rare. Cieneguita S., June 20, '95. (233.)

Acanthaceae.

Hygrophila hispida Nees.

In marshy places along small streams, etc., not uncommon. Cieneguita, Aug. 20, '95. (516.)

Labiatae.

Salvia occidentalis Sw.

A slender, ascending annual herb, common in waste grass lands. Cieneguita, Dec. 12, '95. (659.)

Amarantaceae.

Chamissoa altissima HBK.

A trailing and climbing shrub or suffruticose herb, not uncommon in fertile low woods. Cieneguita, Dec. 3, '95. (655.)

Euphorbiaceae.

Acalypha setosa A. Rich.

In fertile river woods, uncommon. Rio Damuji, Rodas and Abreus, Aug. 17, '95. (477.)

Cyperaceae.

Dichromena ciliata Vahl.

In fertile savannahs, black soil, common. Cieneguita S., June 7, '95. (126.)

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PLATE XXX.

PICTETIA SESSILIFOLIA.

PLATE XXXI.

DESMODIUM INCANUM, var. ANGUSTIFOLIUM.

CAESALPINIA CUBENSIS.

PLATE XXXIII

ACACIA POLYPYRIGENES.

PLATE XXXIV.

RONDELETIA COMBSII.

PLATE XXXV.

CATESBAEA NANA.

PLATE XXXVI.

ANASTRAPHIA NORTHROPIANA.

PLATE XXXVII.

TABEBUIA PETROPHILA.

PLATE XXXVIII.

PEPEROMIA sp.

PLATE XXXIX.

CHLORIS ELEUSINOIDES, var. VESTITA.

AN UNUSUAL PHYTO-BEZOAR.

WILLIAM TRELEASE.

In January, 1897, Dr. Francis Eschauzier, of San Luis Potosi, Mexico, sent to me two specimens (Plate XL.), one a ball of surprising accuracy of surface, measuring a little over three and one-half inches in diameter and weighing seven and one-half ounces, and the other one-half of a similar ball, about four inches in diameter and weighing four ounces,— stating that sixteen such balls of about the size of the specimens sent had been taken from the stomach of a bull at the Hacienda de Cruzes, and adding that he believed them to be composed entirely of an agglomeration of the fibers of some cacti, an undigested portion of which formed the nucleus. Subsequent inquiry resulted in the additional information that the chief food of cattle at that season of the year consisted of five Opuntias, and that the animal from which the specimens were obtained was wild, of fighting stock, and consequently allowed to seek food where it could be found, instead of being fed upon cacti which had been roasted, as is the custom with other stock. My informant further stated that the wild bulls drink very little water while feeding upon cacti, and that the animal in question, which was ten years old, had not exhibited any signs of illness, though for some time the large size of its abdomen had attracted the attention of the vaqueros, but, owing to the intractability of the animal, no examination of it could be made until after its death.

The specimens, which were exhibited to the Academy Feb. 15, 1897, are of a brown color, and in appearance somewhat suggest felt or rubbed sole leather, and on examination prove to be composed, aside from the small nucleus at the center, of the barbed hairs with which the pulvini of the Platopuntias are armed. To the barbs with which these hairs are covered is due their power of felting together, and there is every indication that, starting about some small nucleus of vegetable fiber, they have been compacted into the dense, felty texture by the visceral movements of the animal, to which, causing friction against one another, their perfectly round form is attributable.

It is well known that the Opuntias produce spines and two kinds of trichomes. In some of the Cylindropuntias, each spine is invested by a deciduous sheath, which is downwardly barbed, so that a person or animal brushing carelessly against a plant is certain to remove some of the barbed sheaths. In the Platopuntias, to which the ordinary flat-stemmed prickly pears, and the species upon which the Mexican cattle are fed, belong, the spines, when present, are destitute of such a sheath, and protect the plant simply because of their rigidity and pungency. The spines originate in what have been called pulvini, which in this genus of cacti are coated with delicate, flexible hairs, divided by partitions into a number of cells, and stiff, thick-walled hairs, several millimeters in length and from one to two tenths of a millimeter in diameter at the base. These are very lightly attached to the epidermis of the plant, so that when the pulvinus is touched they are certain to be removed in considerable numbers, the fine points of the stiffer ones penetrating the skin, and the barbs with which they are closely beset preventing their ready withdrawal.

Balls formed largely of the hair of animals are often found in the stomachs of ruminants, to which they have found their way when the animals have licked themselves, and not infrequently smaller balls, with a hard, glossy surface, are found in the stomachs of cattle, horses and, as Dr. Eschauzier informs me, of goats. In general, such a formation is spoken of as a bezoar, and all of the principal agricultural museums contain good specimens of them. One of the largest of the ordinary hair balls which has come to my notice is preserved in the museum of the Iowa Agricultural College, and is stated to weigh four pounds and eleven ounces and to measure twenty-five and one-half inches in circumference. The smaller, harder structures, which seem to be primarily of biliary composition about some sort of nucleus, rarely measure more than two inches in diameter, with a dry weight of one or two ounces.

In the human stomach, concretions comparable with bezoars have occasionally been observed. In 1894, Dr. W. B. Outten* recorded one of a conical shape which measured over five inches in length and about five inches in diameter in its broadest portion and weighed fourteen ounces, and was accompanied by another similar but somewhat smaller gastrolith weighing seven and eight-tenths ounces. These masses appeared to have formed about a quantity of vegetable connective tissue, intermingled with starch, etc., and subsequently increased by the same materials, yeast cells, etc.; and it is stated that the nucleus was formed through the patient having gorged himself with bread and persimmons, the fiber of which bound together the starchy matter.

The only structures of which I have found record which are closely comparable with the specimens sent by Dr. Eschauzier, are described by Mr. Coville,† who records the formation in the stomachs of horses of somewhat similar balls (in one case, as many as thirty of which were found in the stomach of a single animal), which are also occasionally found in the large intestine. These balls are described as uniform in all respects save size, being almost exactly spherical, of yellowish-brown color, with a smooth, even surface, and, on removal, saturated with the intestinal juices. On drying, they shrank but little and varied in diameter from three to four and one-half inches, and were of a dull brown color, having the appearance of a fine quality of felt. In texture they were so firm that the surface could not be indented with the thumb, yet the weight is said to have been unexpectedly light, as one about four inches in diameter weighed only four and three-fourths ounces. When cut open, these balls were found to be solid and to consist of a uniform felt-like material throughout, showing faint concentric layers of slightly different color; and a microscopical examination

* A Case of Double Gastrolith Removed by Gastrotomy. * * * The Medical Fortnightly. St. Louis, August 15, 1894.

† Coville: Crimson Clover Hair Balls. Circular No. 8, U. S. Dept. of Agriculture, Div. of Botany, June 15, 1896.

demonstrated that they were composed of minute, rather stiff hairs, seldom more that one-tenth of an inch in length, pointed at one end, and covered with fine barbules directed toward the pointed apex, which usually faced the surface of the ball. Further investigation showed that these hairs were derived from the calyx of the crimson clover, the assumption being that the horses had fed upon over-ripe plants of this species (*Trifolium incarnatum*), the hairs which accumulated in the stomach being aggregated into spherical felted balls in the manner assumed for the above-described Mexican specimens composed of Opuntia hairs.

In discussing the use of oat bran as a food for domestic animals, especially horses and donkeys, Dr. Harz* characterrizes it as a dangerous food material, because it favors the formation of large bezoars, which he had previously discussed in an extensive paper,† in which is given a classification of structures of this kind, with a very considerable citation of earlier literature.

It is a frequent practice in Texas to cut the branches of cacti which are fed to stock into half-inch lengths. In this way, every one of the obliquely set longer spines of *Opuntia Engelmanni* (and of some other species which are so used) is almost certain to be cut off, so that the danger from the spines is removed. This treatment, however, does not destroy the barbed hairs of the pulvini, of which the bezoars under consideration are composed. It is also the practice, in some places, to roast the fragments as a means of completely removing the spines and barbed hairs, but this is objected to by some feeders, because the roasting has been asserted to add to the laxative properties of the cactus.‡ Where some such treatment has not been resorted to, injury to the animals not infrequently results; and in the bulletin referred to, Dr. Vasey gives a number of instances in which cattle have

* Landwirtschaftliche Samenkunde, ii. 1315.

† Beiträge zur Kenntniss der Pflanzenbezoare des Pferdes und Rindes. Deutsche Zeitschrift für Thiermedicin und vergleichende Pathologie, i. 393–407. 1875.

‡ Vasey, Grasses of the South. U. S. Dept. of Agriculture, Botanical Division, Bulletin No. 3, 52. 1887.

died from an accumulation of spines in the mouth and stomach, an effect somewhat comparable with that caused by the awns of *Hordeum* when cattle feed upon these.

Considering that in the West and Southwest of our own country, as well as in Mexico, Opuntias are not infrequently fed to cattle in considerable quantities, it is surprising that other cases similar to the one here recorded have not been reported, but to my knowledge they have not.

Issued November 30, 1897.

PLATE XL.

PHYTO-BEZOAR AND SECTION.

A CONTRIBUTION TO THE HERPETOLOGY OF MISSOURI.*

JULIUS HURTER.

It is only for the last few years that my son Henry, who is also an enthusiast in this particular line, and I, have extended our excursions into Jefferson County, where we have found a very interesting field in the outrunners of the Ozark mountains, where we begin to encounter the hardier species of the Subtropical realm which the late Professor Edw. D. Cope subdivided into the Austroriparian and Sonorian subregions. The farther south we proceed in the Ozark mountains the more numerous become not only the species but also the specimens, so that, when we reach the southern slope of these mountain chains in Missouri, as we had the opportunity of doing this year (but unfortunately a little too late in the season), one would think he was near the Gulf of Mexico, so plentiful do these animals become.

I may call attention to the fact that the Ozark mountains, up to this date, have not been well investigated in either their fauna or flora. The literature is also very meager. For example, Professor D. S. Jordan, in his Manual of Vertebrate Animals of the Northern United States, including the district north and east of the Ozarks and east of the Missouri river, stops right there and leaves our mountains as a "terra incognita," to science. I would like to remind you also of the fact that reptiles and batrachia are not migratory, like birds or mammals, and for this reason they give a clearer idea of the geographical realm to which they belong.

I will now consider unrecorded species for the fauna of the State of Missouri. Besides two Rattlesnakes and the Copperhead, which we encounter all over the State, we find in our southern frontier counties another Pit viper, called

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* Presented to The Academy of Science of St. Louis, December 6, 1897.

the Cottonmouth, Black Moccasin or Water Moccasin (*Agkistrodon piscivorus* Lacépède), a real poisonous snake not to be confounded with what the farmers and fishermen in the northern and central part of the State call Water Moccasin, which is the common Watersnake (*Natrix sipedon* Linnaeus), a non-poisonous snake, but which, in old specimens, has a very close resemblance to the true Cottonmouth, so that it takes a person already very familiar with the habits of either of them to distinguish one kind from the other. In the year 1892, when we had a very high river and all the bottom lands opposite the city of St. Louis were inundated so that the Watersnakes had sought a refuge in some of the larger trees yet projecting out of the water, we captured a few of them by approaching the trees with a skiff.

At the request of the Agricultural Department of Washington, D. C., I sent them some very large specimens of the common Watersnake, accompanied by a large Cottonmouth, just to show the close resemblance of the two kinds.

The next species I wish to mention is a true Watersnake (*Natrix fasciata* Linnaeus), the Banded or Southern Watersnake. We found these to be very abundant in Butler and Stoddard Counties. They have the same habits as all other water snakes, and those which we found and captured were all gorged with small pikes.

Holbrook's Watersnake or the Diamond Watersnake (*Natrix rhombifer* Hallowell) is our next species. I have caught specimens of this kind right opposite St. Louis, in Madison, St. Clair and Monroe Counties, Illinois, but had not the opportunity to find any in Missouri until this year, when I found them in Butler and Stoddard Counties. They were plentiful, and also show a little different marking, particularly on the ventral side of the body, from those which we caught in Illinois. They represent plainly only a variety of the common Watersnake, as Professor Samuel Garman in his synopsis of North American snakes has arranged them.

The last kind of serpent to report as new to the State is *Haldea striatula* Linnaeus, the Little Brown Snake, a small slender animal hardly over a foot in length. We found these for the first time in the neighborhood of Pevely, Jefferson County, on a sunny slope of the Ozarks, under some rocks. Their marking is also a little different from that of those that I have found in some more Southern States, — Texas and Alabama.

Another very peculiar snake is *Tantilla gracilis* Baird & Girard, a so-called "suspicious snake." It belongs to a class of snakes called Opisthoglypha, serpents having grooved teeth or fangs situated in the back of the jaw, contrary to the Proteroglypha, which have the fangs in the front of the jaw, to which class belong the deadly Cobra of India and the Coral Snakes of America. In the species under consideration, the fangs in the rear of the mouth are generally a little separated from the rest of the teeth and are directed backwards and grooved on their posterior or concave side. These grooves communicate with the poison ducts. Most of these snakes are only small, as are also the specimens under consideration, and therefore could not inflict on a person a dangerous wound, whereas the small animals, which they catch, are said to be worked back in the mouth, stung by these fangs and so paralyzed by the poison as to become an easy prey for the snake. This species is so far only mentioned from Texas, but I have found specimens only a few miles from the city of St. Louis, very likely their most northern and eastern record. In Jefferson County they become more abundant. This serpent is a representative of the Sonorian region.

Among the chelonians or turtles we made one good find, as we discovered the Louisiana Mud Turtle, but so far only in one specimen, near Poplar Bluff, Butler County. It was found under a log, a good distance away from any water. Professor H. Garman, in his synopsis of Reptiles and Amphibians of Illinois, records *Kinosternum pennsylvanicum*, the Eastern Mud Turtle, as common in southern Illinois; but our specimen is *Kinosternum louisianae* Baur, and quite different from its eastern congener, which is found all through the States of Louisiana, Texas and Arkansas. Very likely this will be the most northern limit to its distribution.

To the list of batrachia I have to add two species. The first is *Plethodon erythronotus* Green, so far never recorded from the western side of the Mississippi River. The late

Professor Edw. D. Cope, in Bulletin No. 34 of the United States National Museum, 1889, North American Batrachia, writes on page 134, "This species, including all varieties, has an extensive range, being found throughout the United States east of the Mississippi River." Last spring I was surprised by my friend Mr. Colton Russell, of our city, bringing me a salamander, which I recognized at once as the species under consideration, and which he had found not far from Creve Coeur Lake, St. Louis County. I afterwards found a few more in the same neighborhood, but they were not very abundant. The second kind of salamander is the handsomely marked species *Amblystoma opacum* Gravenhorst. We found eleven of them in Butler County, and three were brought to me by Mr. George Miller, of St. Louis, who collected them in Stoddard County. The salamander seems to be quite common in that neighborhood.

I wish also to call attention to the following species, which I have found within the limits of the State in the last few years:—

Crotaphytus collaris Say, the Collared Lizard or Bull Lizard, as the farmers call it, which is recorded in North American Fauna, No. 3, 1890, page 104, as being found in Kansas, Indian Territory, Arkansas, Texas, New Mexico, and Mexico. Say's specimens, in the National Museum, came from the Verdigris River, near its junction with the Neosho River, in the Creek Nation, Indian Territory, and furnish the most eastern record, so I was not a little astonished when we happened to find this large lizard near Pevely, Jefferson County, in the outrunners of the Ozark Mountains. We afterwards also found numbers of specimens in the mountainous and more southern counties, *e. g.*, Washington, Phelps, St. Francois, Madison and Iron Counties. This lizard carries its tail more elevated when running, and not straight out backwards as all the other lizards do. The species belongs to the Sonorian region, and we find it here at its most eastern limit. This is the largest species of lizard in the State, and we come now to consider also the smallest kind, *Lygosoma laterale* Say, the Ground Lizard. This nimble animal is quite common in all the Southern States, and also in all the southern counties of

Missouri, but it reaches its most northern recorded limit at Cliff Cave, only eleven miles south of the city of St. Louis, where we have collected so far two specimens. As soon as we come to Jefferson County, they become more plentiful. The species belongs to the Austroriparian region. *Bascanium flagellum* Shaw, the Coach Whip Snake, has only of late years been recorded from the State. The late Professor E. D. Cope, when he visited St. Louis three years ago and examined my collection, told me that he had found this snake in Stone County, Southwestern Missouri, but since that time we have been fortunate enough to capture some old as well as young specimens in the neighborhood of Pevely, Jefferson County. They are considered by no means common, and are very swift. I have also received one specimen from Mr. O. Funke, from near Rolla, Phelps County.

In conclusion I wish to mention two other batrachians. One is a little toad peculiar to America, *Engystoma carolinense* Holbrook. This toad is very common in the Southern States. Dr. Kennicott sent some that he caught in New Madrid County, Mo., to the National Museum. I have found some specimens in Butler County, and three at Cliff Cave, St. Louis County, which is, to all appearance, the most northern locality of this subtropical species. These toads are found under rocks, sometimes on the top of the bluffs. They are very hard to see, as they are partly hidden in the ground and also protected by their color.

Our last specimen is the so-called Hellbender or Mud Devil (*Cryptobranchus alleghaniensis* Daudin). This is one of the largest of salamanders, and next in size to the Giant Salamander of Japan. It lives in creeks fed by spring water, aud those that I have, come from a place called Boiling Spring, near Arlington, Phelps County, Mo. They are often caught by fishermen on the hook baited with minnows, and are sluggish animals but very voracious.

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