frontis piece

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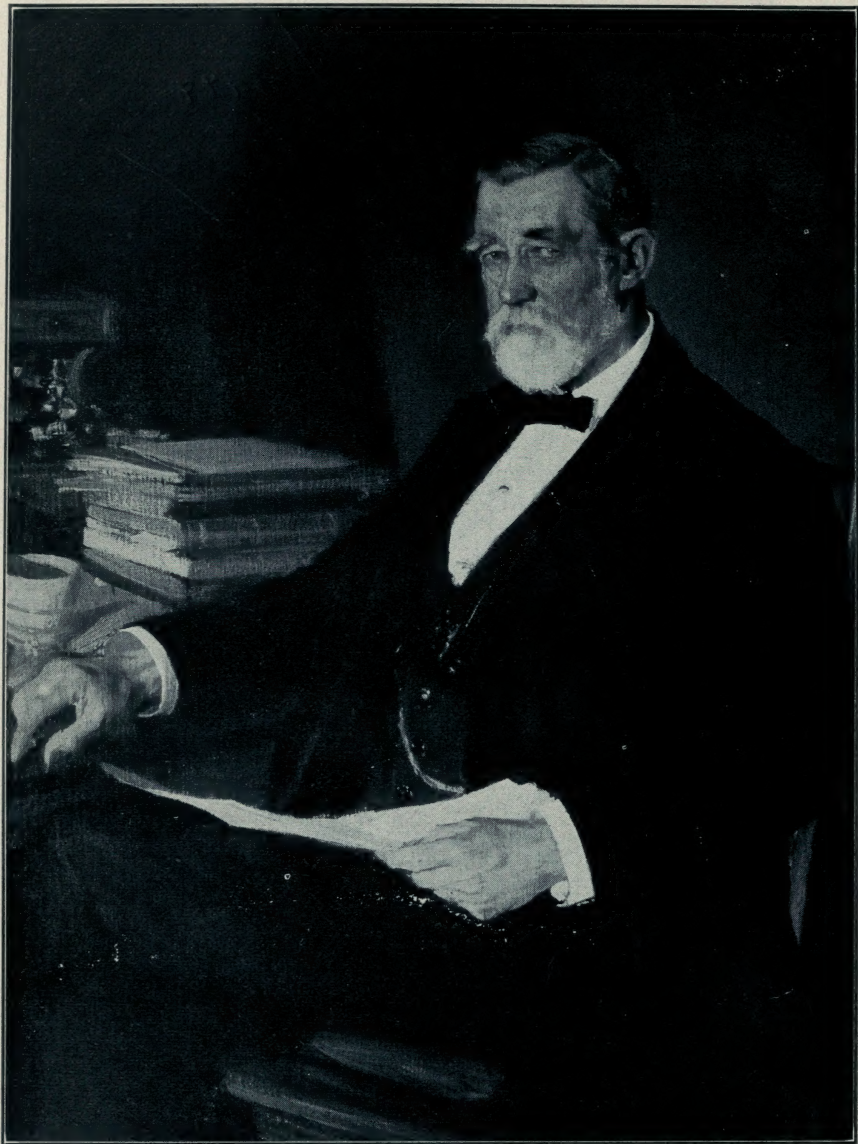

Strauss Photograph from Portrait by Richard Miller, 1906.

very sincerely Yours

G. Baumgarten

TRANSACTIONS

OF

THE ACADEMY OF SCIENCE OF ST. LOUIS.

VOL. XIX.

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CONTENTS.

CORRECTIONS.

P. 3, line 12—For *Thompson* read *Thomson*.
9 from bottom—For *ironization* read *ionization*.
6 from bottom—For *ironized* read *ionized*.
P. 6, last line—Read *used*.
P. 111, line 8—After *Heller* insert *
Plate XXIV. Figs. B and C should have been transposed.

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McMillan, Mrs. Eliza........25 Portland Pl.
McMillan, William Northrop..Century Bldg.

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Lewald, Geh. Oberreg. Rath Theodor..................Berlin, Germany.
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Ostwald, Prof Wilhelm.......University of Leipzig, Germany.
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Wassermann, Prof. Dr. A.....University of Berlin, Germany.
Wittmack, Geh. Reg. Rath Prof. Dr. L...............University of Berlin, Germany.

---

† Deceased.

3. Active Members.

Abbott, James F.[2] .... Washington University.
Alleman, Gellert[1] .... Swarthmore College, Swarthmore, Pa.
Allen, George L. .... 26 Westmoreland Pl.
Allen, Terry W. .... 5061 Lindell Boul.
Allison, James E. .... Merchants' Laclede Bldg.
Allison, Nathaniel .... Humboldt Bldg.
Alt, Adolf .... 316 Metropolitan Bldg.
Altheimer, Benjamin .... 4349 Westminster Pl.
Ameiss, F. C. .... 3906 Olive St.
Ammerman, Charles .... McKinley High School.
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Armbruster, Wm. J. .... 3622 Shenandoah St.

Bagby, Julian[1] .... New Haven, Mo.
Bain, Samuel McCutchen[1] .... University of Tennessee, Knoxville, Tenn.
Baldwin, Roger N. .... 3739 Windsor Pl.
Barck, Carl .... Humboldt Bldg.
Barnard, George D. .... Vandeventer and Laclede Aves.
Barroll, Joseph R. .... 4603 Berlin Ave.
Baskett, James Newton[1] ...... Fourth and Park Sts., Belleville, Ill.
Baumgarten, Walter .... Humboldt Bldg.
Bay, J. Christian[1] .... Crerar Library, Chicago, Ill.
Beckwith, Thomas[1] .... Charleston, Mo.
Beede, J. W.[1] .... State University, Bloomington, Ind.
Bemis, S. A. .... Fourth and Poplar Sts.
Bender, Cloyd Raymond[1] ..... 307 Glen Ave., Council Bluffs, Iowa.
Bernays, Walter .... 3623 Laclede Ave.
Berninghaus, J. A. .... Central National Bank.
Bessey, Charles Edwin[1] .... University of Nebraska, Lincoln, Neb.
Bessey, Ernst A.[1] .... Michigan Agricultural College, East Lansing, Mich.

[1] Non-resident.
[2] Member of the Entomological Section.

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Blankinship, Joseph William. . 4008a Flad Ave.
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Bock, George W.[2] . . . . 2904 Allen Ave.
Boeckeler, William L. . . . . 4441 Laclede Ave.
Boland, Charles C. . . . . Dolph Bldg.
Borgmeyer, Charles J. . . . . St. Louis University.
Bostwick, Arthur E. . . . . 4654 Berlin Ave.
Boyle, Wilbur F. . . . . New Bank of Commerce Bldg.
Bradshaw, Preston J. . . . . Liggett Bldg.
Brandenburger, Louis A. . . . . . 3614 Cleveland Ave.
Brandenburger, W. A. . . . . . . 1406 Syndicate Trust Bldg.
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Brennan, Martin S. . . . . 6304 Minnesota Ave.
Brimmer, George G. . . . . 6900 Michigan Ave.
Britton, F. H.[1] . . . . Kirkwood, Mo.
Brockman, F. W. . . . . 3710 N. Grand Ave.
Brookings, Robert S. . . . . 5125 Lindell Boul.
Brookmire, James H. . . . . 315 North Fourth St.
Brown, Arthur A. . . . . 4023 West Pine Boul.
Brown, Daniel S. . . . . 2212 DeKalb St.
Brown, George Warren. . . . . . . 40 Portland Pl.
Brown, Willi. . . . . 5351 Waterman Ave.
Browne, Clarence I. . . . . 4630a Delmar Ave.
Buckley, Ernest Robertson[1] . . . Rolla, Mo.
Buehler, H. A.[1] . . . . Rolla, Mo.
Burg, William. . . . . 4323 Washington Boul.
Burnett, E. C. . . . . University Club.
Busch, Adolphus. . . . . Busch Pl.
Busch, Aug. A. . . . . Busch Pl.
Bush, Benjamin Franklin[1] . . . Courtney, Mo.
Butler, William M. . . . . Yeatman High School.

Cale, George W., Jr. . . . . 12 Lennox Pl.
Campbell, James A. . . . . Mermod Jaccard Bldg.
Carleton, Murray. . . . . 1135 Washington Ave.
Carpenter, George O. . . . . 12 Portland Pl.
Carr, Peyton T. . . . . 62 Vandeventer Pl.
Carter, Howard[1] . . . . Webster Groves, Mo.
Carver, George Washington[1] . . Tuskegee, Ala.

Caspari, Charles E.	4060 Westminster Pl.
Catlin, Daniel	Security Bldg.
Chambers, C. O.	Missouri Botanical Garden.
Chandler, Harley P.	5539 Page Ave.
Chappell, W. G.	Buckingham Club.
Chenery, Winthrop Holt	Washington University.
Christie, Harvey L.	1605 Pierce Bldg.
Clark, Enos[1]	Kirkwood, Mo.
Clopton, Malvern B.	Humboldt Bldg.
Cole, John J.	316 South Seventh St.
Colnon, R. S.	506 Merchants' Laclede Bldg.
Conzelman, Theophilus	5260 Washington Boul.
Cook, Abraham	4208 Pine St.
Cook, Francis E.	4398e Olive St.
Cook, Isaac T.	Chemical Bldg.
Cook, Jerome E.	4254 Lindell Boul.
Coulter, Samuel M.	Washington University.
Craig, Moses	Missouri Botanical Garden.
Cramer, Gustav	Care Cramer Dry Plate Co.
Crandall, George C.	3674 Lindell Boul.
Crawford, Hanford	4442 Lindell Boul.
Crook, A. R.[1]	State Natural History Museum, Springfield, Ill.
Crunden, Frank P.	Second and Gratiot Sts.
Cupples, Samuel	3673 Pine St.
Curley, Francis E. A.	6143 Berlin Ave.
Curtis, Chester B.	Central High School.
Curtis, William S.	Washington University.
Dameron, Edward Caswell[1]	Clarksville, Mo.
Danforth, Charles H.[1]	Tufts College, Mass.
Davis, Dwight F.	220 Security Bldg.
Davis, H. N.	56 Vandeventer Pl.
Davis, John D.	815 Merchants' Laclede Bldg.
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Densford, H. E.[1]	Kirkwood, Mo.
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Dieckmann, Charles A.[2]	2816 Potomac St.
Diehm, Ferdinand	6175 Kingsbury Pl.
Doan, George P.	42 Portland Pl.

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Dorsett, Walter B. . . . . Linmar Bldg.
Dougan, Lewis M.[2] . . . . Shaw School.
Douglas, Archer W. . . . . 5079 McPherson Ave.
Drosten, F. W. . . . . 2011 Park Ave.
Drushel, J. A. . . . . Teachers' College.
Duncan, John H. . . . . Humboldt Bldg.
Duncan, M. E. . . . . 915 Olive St.
Duncker, Charles H. . . . . 3636 Page Ave.

Ebeling, A. W.[1] . . . . Warrenton, Mo.
Eberle, E. G.[1] . . . . 416 Jackson St., Dallas, Texas.
Eimbeck, August F.[1] . . . . New Haven, Mo.
Eliot, Edward C. . . . . 5468 Maple Ave.
Emerson, John B. . . . . Syndicate Trust Bldg.
Emmel, Victor E. . . . . Washington University, Medical Department.
Engler, Edmund Arthur[1] . . . . . 11 Boynton St., Worcester, Mass.
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Erker, Adolph P. . . . . 604 Olive St.
Espenschied, Charles . . . . 3500 Washington Ave.
Euston, Alexander . . . . 3730 Lindell Boul.
Evers, Edward . . . . 1861 North Market St.
Ewing, Arthur E. . . . . 5956 West Cabanne Pl.

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Fawcett, H. S.[1] . . . . Gainesville, Fla.
Ferriss, James H.[1] . . . . Joliet, Ill.
Filley, John D. . . . . 40 Westmoreland Pl.
Fischel, Walter . . . . 5284 Westminster Pl.
Fischel, Washington E. . . . . . . Humboldt Bldg.
Fordyce, John R.[1] . . . . 2223 Louisiana St., Little Rock, Ark.
Fordyce, S. W. . . . . 21 Washington Terrace.
Francis, David R. . . . . 4421 Maryland Ave.
Franck, Charles H. . . . . Liggett Bldg.
French, George Hazen[1] . . . . . . Carbondale, Ill.
Frerichs, Frederick W. . . . . 4320 Washington Boul.
Frick, John Henry[1] . . . . Warrenton, Mo.

Fruth, Otto J................3060 Hawthorne Boul.
Fry, Frank R...............4609 McPherson Ave.
Fuhrmann, Richard H.......3221 California Ave.
Fullgraf, Charles W..........7077 Pernod Ave.
Funkhouser, Robert Monroe..4354 Olive St.
Furth, Jacob................723 Pierce Bldg.

Gager, C. Stuart[1]............Central Museum, Eastern Parkway, Brooklyn, N. Y.
Garman, Harrison[1]..........Lexington, Ky.
Gates, Reginald R...........Missouri Botanical Garden.
Gecks, Frank................3453 Magnolia Ave.
Geitz, H. A.[1]................61 Montauk Ave., Belle Harbor, Long Island, N. Y.
Gellhorn, George............Metropolitan Bldg.
Gerling, H. J................Teachers' College.
Gifford, William L. R........Mercantile Library.
Gill, Charles M.............Teachers' College.
Gillette, C. P.[1]...............Fort Collins, Colo.
Glasgow, Frank A...........3894 Washington Ave.
Glatfelter, Noah Miller.......4720 North Twentieth St.
Glazebrook, Thomas B........1718 Olive St.
Goldstein, Max A...........3858 Westminster Pl.
Goltra, Edward F...........4416 Lindell Boul.
Goodman, Charles H.........4500 Olive St.
Gratz, Benjamin.............Rialto Bldg.
Graves, William W..........Metropolitan Bldg.
Green, John.................2670 Washington Ave.
Greer, E. O..................2750 Park Ave.
Greger, Darling Kennett[1]....Westminster College, Fulton, Mo.
Gregg, Cecil D..............920 Market St.
Grindon, Joseph............3894 Washington Ave.
Gundelach, Charles H........4523 Washington Boul.
Gundelach, William J.......4477 Washington Boul.
Gundlach, John H...........3615 North Broadway.
Guthrie, Robert J...........Pierce Bldg.
Guy, William E.............10 Portland Pl.

Haarstick, Henry C.........St. Louis Union Trust Bldg.
Hall, Fred B................4579 Morgan St.

Hambach, Gustav[3] .... 2061 San José Avenue, Alameda, California.
Hard, M. E.[1] .... Kirkwood, Mo.
Harder, Ulrich .... 8015 Florissant Ave.
Harris, Cortlandt .... 425 North Broadway.
Harris, James Arthur[1] .... Station for Experimental Evolution, Cold Spring Harbor, Long Island, N. Y.
Hartmann, Rudolph .... 3859 Flora Boul.
Held, George A. .... International Bank.
Hendrich, Walter F. .... 6228 Washington Boul.
Herf, Oscar .... 48 Gay Bldg.
Hidden, Edward .... Commonwealth Trust Bldg.
Hill, Charles Van Dyke ...... Third National Bank Bldg.
Hoffman, Philip .... 3657 Delmar Ave.
Hoke, William E. .... 304 North Third St.
Holman, C. L. .... 716 Locust St.
Holmes, J. A. .... Tenth and Spruce Sts.
Hough, Warwick .... 5884 Cates Ave.
Houwink, J. J. .... 3505 Franklin Ave.
Hughes, Charles Hamilton .... Metropolitan Bldg.
Hughes, Marc Ray .... Metropolitan Bldg.
Hume, H. Harold[1] .... Glen St. Mary, Fla.
Hurter, Julius .... 2346 South Tenth St.
Hus, Henri Th. A.[1] .... University of Michigan, Ann Arbor, Mich.
Huttig, Charles H. .... Third National Bank.

Ilhardt, William K. .... Euclid and Delmar Aves.
Irish, Henry C. .... Missouri Botanical Garden.
Ives, Halsey Cooley .... City Art Museum.

Johnson, Albert L. .... New National Bank of Commerce Bldg.
Jonas, Ernest .... 465 North Taylor Ave.
Jones, Breckenridge .... 45 Portland Pl.
Jones, Robert McKittrick ..... 6 Westmoreland Pl.

Kammerer, Alfred L. .... Tower Grove and Flad Aves.
Keiser, Edward H. .... Washington University.

[3] Elected a life-member January 3, 1882.

Keller Joseph M............3712 Westminster Pl.
Kennett, Alfred Q..........Washington University.
Kennett, Luther M..........3507 Lucas Ave.
Kessler, George E...........529 Frisco Bldg.
Kessler, J. J.................224 South Vandeventer Ave.
Keyes, Charles R.[1]...........944 Fifth St., Des Moines, Ia.
Kinealy, John H............503 Granite Bldg.
King, Goodman.............78 Vandeventer Pl.
Kinsella, W. J..............4422 Lindell Boul.
Kirchner, Walter C. G........1127 North Grand Ave.
Klem, Mary J..............3133 Nebraska Ave.
Knapp, H. P...............Eighteenth and Olive Sts.
Knight, H. F................4433 Westminster Pl.

Lang, George, Jr............213 North Second St.
Langsdorf, Alexander S......Washington University.
Larkin, E. H................109 St. George St.
Leavitt, Sherman[1]...........University of Tennessee, Knoxville, Tenn.
Lefevre, George[1] ....University of Missouri, Columbia, Mo.
Leonard, L. L................Rialto Bldg.
Letterman, George W.[1].......Allenton, Mo.
Le Van, W. C.[1].............116 Taylor Ave., Kirkwood, Mo.
Lewis, E. G.[1]...............University City, Mo.
Lichter, John J.............1740 Simpson Pl.
Lloyd, Francis Ernest[1].......Alabama Polytechnic Institute, Auburn, Ala.
Lloyd, Hiram................Odd Fellows' Bldg.
Loeb, Hanau Wolf...........Humboldt Bldg.
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Luedde, William H..........Metropolitan Bldg.
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Lutz, Frank J..............Josephine Hospital.

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Mack, Charles Jacob.........113 North Broadway.
Mallinckrodt, Edward, Jr.....26 Vandeventer Pl.
Mardorf, W. C................2136 South Grand Ave.
Markham, George Dickson...4961 Berlin Ave.

Mason, Silas C.[1]............133 East Avenue 52, Los Angeles, Cal.
Matthews, Leonard..........5447 Cabanne Pl.
Mauran, John Lawrence.....1620 Chemical Bldg.
McBride, W. J.[1].............Haskell & Barker Car Co., Michigan City, Ind.
McCourt, Walter Edward.....Washington University.
McCubbin, J. B.............Metropolitan Bldg.
McCulloch, Richard.........3869 Park Ave.
McCulloch, Robert...........3869 Park Ave.
McKittrick, Thomas H.......911 Washington Ave.
McLeod, N. W..............Lumbermen's Bldg.
Meier, Theodore G..........5220 Washington Boul.
Mesker, Frank..............421 South Sixth St.
Meyer, Andrew, Jr...........3218a Missouri Ave.
Meyer, Jesse S..............3894 Washington Boul.
Michael, Elias..............Rice, Stix Dry Goods Co.
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Miller, Alten S..............Twelfth and Locust Sts.
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Moore, Robert..............61 Vandeventer Pl.
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Morrison, Gilbert...........McKinley High School.
Morse, Sidney[1].............University City, Mo.
Mudd, Harvey G............408 Humboldt Bldg.
Mueller, Ambrose[1]..........Webster Groves, Mo.

Nagel, Charles..............3726 Washington Boul.
Nasse, August..............2323 Lafayette Ave.
Nauer, Albert R.............4634 Nebraska Ave.
Nicolaus, Henry............2149 South Grand Ave.
Nipher, Francis E...........Washington University.
Nisbet, Fritz................611 Locust St.
Noble, John W.............3043 Pine St.
Nolker, William H..........Fifteenth and Pine Sts.
Norvell, Saunders...........LaSalle Bldg.

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Opie, Eugene L............Washington University, Medical Department.
O'Reilly, Andrew J..........1720 Pierce Bldg.
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Outten, W. B..............3515 Pine St.

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Pammel, Louis Hermann[1]....Ames, Iowa.
Pantaleoni, Guido...........15 Lennox Pl.
Parker, George Ward[1].......45 Broadway, New York City.
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Perkins, Albert T...........401 North Fourth St.
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Pitzman, Julius.............1900 South Compton Ave.
Plant, Frederick S...........802 North Main St.
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Post, Martin Hayward.......5371 Waterman Ave.
Priest, Henry Samuel........New National Bank of Commerce Bldg.
Prynne, Charles Martyn......Century Bldg.
Pyle, Lindley...............6116 Washington Boul.

Randolph, Tom.............4386 Lindell Boul.
Rassieur, Leo...............Fourth and Market Sts.
Rathmann, Charles G........3886 Hartford St.
Rau, Philip[2]................4932 Botanical Ave.
Ravold, Amand.............5248 Vernon Ave.
Reber, H. Linton............Kinloch Bldg.
Reber, Maxine..............301 New City Hall.
Redlich, C. F..............Nat'l. Bank of Commerce Bldg.
Reed, George M.[1]............809 Virginia Ave., Columbia, Mo.
Reller, A. H...............24 Gast Pl.
Ricker, Maurice[1]............1039 Nineteenth St. Des Moines, Iowa.
Ridgely, Franklin L.........3720 Lindell Boul.
Robarts, Heber..............5899 Cates Ave.

Robbins, Walter.............3737 Washington Ave.
Robert, Edward Scott........4140 Lindell Boul.
Roever, William Henry......Washington University.
Rolfs, F. M.[1]................Mountain Grove, Mo.
Rolfs, Peter H.[1].............Gainesville, Fla.
Rose, Hugh B...............401 North Fourth St.
Rosenwald, Lucian[1]..........412 Delaware St.,
Kansas City, Mo.
Rowse, E. C.................Chemical Bldg.
Ruf, Frank A...............5863 Cabanne Pl.
Rusch, Henri................City Hall.
Ryan, Frank K.............Times Bldg.

Sargent, Charles Sprague[1].....Jamaica Plains, Mass.
Sauer, William E............Humboldt Bldg.
Scanlan, Philip C............City Hall.
Schisler, Edwin..............2600 South Grand Ave.
Schlueter, Robert E.........909 Park Ave.
Schmidt, Louis..............Franklin Bank.
Schnell, L. W.[2].............4541 Varrelmann St.
Schramm, Jacob............Missouri Botanical Garden.
Von Schrenk, Hermann......Tower Grove and Flad Aves.
Schrowang, Otto............Panama Bldg.
Schwarz, Ernest[2]............6310 Newstead Ave.
Schwarz, Frank.............1813 Lafayette Ave.
Schwarz, Henry............440 North Newstead Ave.
Schwarz, Herman[2]...........720 Clark Ave.,
Webster Groves, Mo.
Schweitzer, Paul[1]............Columbia, Mo.
Schweyer, George...........4252 Blaine Ave.
See, Thomas Jefferson Jackson[1].Naval Observatory,
Mare Island, Cal.
Selby, Augustine Dawson[1]....Wooster Ohio.
Senseney, E. M..............5738 Clemens Ave.
Senter, Charles Parsons......1 Beverly Pl.
Shaffer, Philip A............Washington University,
Medical Department.
Shahan, William E..........5234a Morgan St.
Shannon, James I...........St. Louis University.
Shapleigh, Alfred Lee........3636 Delmar Ave.
Shapleigh, John B...........Humboldt Bldg.
Sheldon, F. E...............Chemical Bldg.

Shepley, John F............50 Vandeventer Pl.
Shimek, B.[1]................Iowa City, Iowa.
Shoemaker, William Alfred...4386 Westminster Pl.
Shutt, C. H.[1]..............25 Lebanon Ave., Belleville, Ill.
Simmons, E. C...............Ninth and Spruce Sts.
Simmons, Wallace D.........Ninth and Spruce Sts.
Skinker, Thomas K.........Pierce Bldg.
Sluder, Greenfield...........3542 Washington Ave.
Smith, Arthur George[1].......Iowa City, Iowa.
Smith, D. S. H..............4388 Westminster Pl.
Smith, Irwin Z..............87 Vandeventer Pl.
Smith, Jared G.[1]............Kealakekua, Hawaiian Islands.
Spencer, H. N...............2725 Washington Ave.
Standley, Paul C.[1]...........Division of Plants, National Museum, Washington, D. C.
Starkloff, H. M..............3623 Cleveland Ave.
Starr, John E.[1]..............50 Church St., New York City.
Staudinger, B................3556 Lindell Boul.
Stelzleni, G. M..............1215 North Grand Ave.
Stennett, W. H.[1]............203 Linden Ave., Oak Park, Cook Co., Ill.
Stevens, Charles D...........948 Laurel Ave.
Stevens, Wyandotte James....4448 Olive St.
Stindé, George C............5146 McPherson Ave.
Stix, Charles A..............Stix, Baer & Fuller Dry Goods Company.
Stocker, George J...........2833 South Kingshighway Bl.
Strecker, John K., Jr.[1].......Baylor University, Waco, Tex.
Studniczka, Henry..........2012 St. Louis Ave.
Sultan, Fred W..............112 North Second St.
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Suppan, Leo.................2648 Russell Ave.

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Thacher, Arthur.............5185 Lindell Boul.
Thomas, John R.............4128 Washington Boul.
Thompson, Charles Henry[2]...Missouri Botanical Garden.
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Thompson, Henry C., Jr.....4642 Cook Ave.
Thurman, John S............521 North Taylor Ave.
Timmerman, Arthur H......5374 Vernon Ave.
Tittmann, Harold H.........5024 Westminster Pl.
Todd, Charles A..............3723 Delmar Ave.
Trelease, William............Missouri Botanical Garden.
Tuholske, Herman...........465 North Taylor Ave.
Turner, Charles H.[2]...........Sumner High School.
Turner, Wilson P. H........411 Olive St.
Tuttle, Daniel S..............74 Vandeventer Pl.
Tyler, Eliza Edward[1]........University of Missouri, Columbia, Mo.

Van Ornum, John Lane......Washington University.
Vickroy, Wilhelm Rees.......2901 Rauschenbach Ave.

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Waldo, C. A................Washington University.
Walsh, Julius S.............Fourth and Pine Sts.
Watts, Millard F............5740 Cabanne Pl.
Weber, George L............6912 Bruno Ave.
Weichsel, Hans..............6400 Plymouth Ave.
Wells, Rolla..................4228 Lindell Boul.
Werner, Louis...............Fullerton Bldg.
Werner, Percy...............5505 Cates Ave.
Wheeler, H. A...............3439 Lucas Ave.
Whelpley, Henry Milton......2342 Albion Pl.
Whitaker, Edwards..........300 North Fourth St.
Whitelaw, Oscar L..........409 North Second St.
Whitten, John Charles[1].......Columbia, Mo.
Widmann, Otto..............5105 Morgan St.
Wiedemann, H. E...........721 Holland Bldg.
Wielandy, Paul J...........Sixteenth and Locust Sts.
Wiener, Meyer..............3854 Westminster Pl.
Wiggins, Charles............32 Vandeventer Pl.
Winkelmeyer, Christopher....4585 West Pine St.
Wislizenus, Frederick A......Washington University.
Witt, Thomas D..............4374 Laclede Ave.
Wolfner, Henry L...........4563 Forest Park Boul.
Woodward, Calvin Milton.....3013 Hawthorne Boul.
Wright, George M...........4457 Westminster Pl.

Zahorsky, John..............1460 South Grand Ave.
Zellweger, John.............1900 Adelaide Ave.

ABSTRACT OF HISTORY.

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 a 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 merely usufructuary.

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. Each patron and active member not in arrears is entitled to one copy of each publication of the Academy issued after his election.

Since the organization of the Academy, 1,274 persons have been elected to active membership, of whom, on December 31, 1910, 433 were carried on the list. Six patrons, Mr. Edwin Harrison, Mrs. Eliza McMillan, Mr. William Northrop McMillan, Mr. Henry W. Eliot, Mr. William Keeney Bixby and Mr. Edward Mallinckrodt, have been elected. Elections to honorary membership number 19 (page vi), and 226 persons (Vol. X., p. xii) have been elected to corresponding membership.

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 officers.

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, John B. Johnson, James B. Eads, William T. Harris, Charles V. Riley, Francis E. Nipher, Henry S. Pritchett, John Green, Melvin L. Gray, Edmund A. Engler, Robert Moore, Henry W. Eliot, Edwin Harrison, Adolf Alt and Calvin M. Woodward.

MEETINGS.

The regular meetings of the Academy are held at its building, 3817 Olive Street, at 8 o'clock, on the first and third Monday evenings of each month, a recess being taken between the meeting on the first Monday in June and the meeting on the third Monday in October. 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.

The following dates for regular meetings for the year 1911 have been fixed by the Council:

Jan	Feb	Mar	April	May	June	Oct	Nov	Dec
	6	6	3	1	5		6	4
16	20	20	17	15		16	20	18

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 about 18,500 books and 16,000 pamphlets, and is open during certain hours of the day for consultation by members and persons engaged in scientific work.

PUBLICATIONS AND EXCHANGES.

Nineteen octavo volumes of Transactions 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 414 institutions or organizations of aims similar to its own.

MUSEUM.

After the loss of its first museum, in 1869, the Academy lacked adequate room for the arrangement of a public museum, and, although small museum accessions were received and cared for, its main effort, of necessity, was 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.

The Museum is at present located on the third floor of the Academy Building and has in it a number of specimens illustrating the various branches of natural science, among which may be mentioned the Yandell Collection of fossils, a collection of some 600 exotic butterflies, a collection of Mound Builder pottery and skulls from near New Madrid, Mo., and a collection of 25 meteorites. Our material forms but a nucleus of a museum which the Academy hopes to establish—a museum which we trust will be of benefit to the public and to the educational institutions of the city.

RECORD.

From January 1 to December 31, 1910.

The following list of papers were presented at the meetings during this period:

January 17, 1910:

LeRoy McMaster.—Relations Between Organic Ferments and Colloidal Suspensions.

F. E. Nipher.—On the Nature of the Electric Discharge. The One-Fluid and the Two-Fluid Theories.

(Published in Transactions of The Academy of Science of St. Louis, Vol. XIX, No. 1, 1910.)

February 7, 1910:

Martin S. Brennan.—Halley's Comet.

Charles J. Borgmeyer.—Stereo-model of Halley's Comet.

February 21, 1910:

Charles H. Thompson.—Three new Mexican Plants.

March 7, 1910:

Carl Barck.—The Snake Dance of the Hopi Indians.

March 21, 1910:

Julius Hurter.—A Life History of the Blind Salamander of Missouri.

Adolf Alt.—On the Histology of the Eye of Typhlotriton spelaeus from Marble Cave, Missouri.

(Published in Transactions of The Academy of Science of St. Louis, Vol. XIX, No. 6, 1910.)

April 4, 1910:

Robert J. Terry.—The Morphology of the Pineal Region in Teleosts.

April 18, 1910:

Frank Mesker.—China, and the Great Wall.

May 2, 1910:

Charles A. Todd.—The Preservation and Mounting of Wet Preparations for Museums.

Francis E. Nipher.—The Nature of the Electric Discharge.

(Published in Transactions of The Academy of Science of St. Louis, Vol. XIX, No. 4, 1910.)

May 16, 1910:

William Trelease.—The Geographical Distribution of Agave in the West Indies, and its Probable Mode of Introduction.

June 6, 1910:

Walter Edward McCourt.—The Unfolding of the Map of the World.

October 17, 1910:

William Trelease.—The Smallest of the Century Plants.

(Published in Popular Science Monthly, December, 1910.)

J. L. Van Ornum.—The Effect of the Presence of Vegetable Mold on the Strength of Concrete and Mortar.

November 21, 1910:

Julius Hurter.—The Poisonous Snakes of Missouri.

December 5, 1910:

Ulrich Harder.—Evolution with Reference to the Acquisition of the Erect Posture, its Disadvantages and the Decline of Certain Faculties in Man.

December 19, 1910:

Robert J. Wallace.—The Construction, Equipment and Work of a Modern Observatory.

Meeting of January 3, 1910.

The Academy of Science of St. Louis met in the Academy Building, 3817 Olive Street, at 8 p. m., January 3, 1910; President Trelease in the chair; attendance 21.

The President delivered his address as President of the Academy for the year 1909.[4]

The Treasurer's report for the year 1909 was submitted.[5]

The report of the Curators for 1909 was read.[6]

The report of the Librarian for 1909 was presented.[7]

The report of the Entomological Section was submitted.[8]

The Nominating Committee reported the results of the election of officers for 1910, as follows:

President	William Trelease
First Vice-President	D. S. H. Smith
Second Vice-President	F. E. Nipher
Recording Secretary	Walter E. McCourt
Corresponding Secretary	Geo. T. Moore
Treasurer	H. E. Wiedemann
Librarian	Wm. L. R. Gifford
Curators	Julius Hurter
	Joseph Grindon
	Philip Rau
Directors	Otto Widmann
	Adolf Alt

Professor Geo. R. Dean was elected to membership.

January 17, 1910.

President Trelease in the chair; attendance 25.

Dr. LeRoy McMaster read a paper on "Relations between Organic Ferments and Colloidal Suspensions."

The term fermentation means changes in organic substances induced by certain living organisms, or by certain substances derived from animal or vegetable sources. Ferments are divided into two

[4] Transactions, Vol. XVIII, page lxiii.
[5] Transactions, Vol. XVIII, page lxvi.
[6] Transactions, Vol. XVIII, page lxvii.
[7] Transactions, Vol. XVIII, page lxvi.
[8] Transactions, Vol. XVIII, page lxvii.

classes, organized ferments, or those which cause fermentation during the growth and reproduction of living organisms, and unorganized ferments, or those secreted by the living organisms, which may be extracted from the cells in which they have been found and are known as enzymes.

Solutions are of two kinds, crystalloidal, or those which are known as true solutions, inasmuch as they show an osmotic pressure and have a freezing point lower and a boiling point higher than the original solution, and colloidal solutions, which have these properties to a slight extent only, if at all. Colloidal suspensions resemble true solutions less closely than colloidal solutions. The electrical method of Bredig is the most important one in preparing these suspensions, which have a homogeneous appearance under the microscope.

The features common to enzymes and colloidal suspensions are that they act catalytically, especially upon hydrogen dioxide, as the investigations of Bredig have shown; the activity of each increases with a rise of temperature until a certain maximum is reached. Both enzymes and suspensions are very sensitive to the presence of foreign substances. Some substances act as inhibitors while others act as accelerators to both.

Professor F. E. Nipher presented an abstract of his paper "On the Nature of the Electric Discharge. The One-Fluid and the Two-Fluid Theories."

The President then briefly set forth the present situation regarding the endowment fund, and the Secretary read the form of contract which it was proposed should be entered into by the Academy and the St. Louis Union Trust Co. and certain subscribers. This contract provided for the establishment of an endowment fund of at least $15,000.00, $7,000.00 of which is to be set apart for that purpose by the Academy, and at least $8,000.00 to be contributed by certain individuals interested in the welfare of the institution. This entire fund is to be placed in the hands of the St. Louis Union Trust Co. as Trustee, to be held by it for a period of twenty-five years and may not be diverted or impaired in any way. The net income during the twenty-five years of the trusteeship is to be paid to the Academy and at the end of this period the trust property and accumulated income is to be turned back to the Academy to be used as it may determine.

After reading and discussion of the contract, the following resolutions, which were recommended to the Academy by the Council, were unanimously passed:

Be it resolved, that the said sum of $7,000.00 be appropriated for the purpose of establishing an endowment fund, and that the officers of this association be and are hereby empowered and directed,

1. To execute the said agreement in the form herein above set forth.

2. To pay to the St. Louis Union Trust Co. as Trustee thereunder when demanded by it, the said sum of $7,000.00, as a contributor to the said endowment fund.

3. When making such payment of the said sum of $7,000.00 to further pay to said Trust Co. as Trustee in the name of John A. Holmes the sum of $500.00 already transferred to the Academy by him as a subscriber to said endowment fund.

February 7, 1910.

President Trelease in the chair; attendance 175.

Reverend Martin S. Brennan read a paper on "Halley's Comet."

Reverend Charles J. Borgmeyer exhibited and explained a stereo-model, showing the path of Halley's Comet during the period of its present appearance.

Dr. Charles A. Todd was elected to membership.

February 21, 1910.

Dr. Adolf Alt in the chair; attendance 26.

Mr. C. H. Thompson presented descriptions, illustrated by herbarium material and living specimens, of three new Mexican plants.

March 7, 1910.

President Trelease in the chair; attendance 52.

Dr. Carl Barck delivered a most interesting lecture on "The Snake Dance of the Hopi Indians."

Mr. Philip Rau presented to the Academy Museum a fine specimen of a nest of *Vespa maculata,* from Kimmswick, Mo.

A resolution was adopted endorsing the bill pending in the House of Representatives to protect migratory birds in the United States; and the Corresponding Secretary requested to urge the Missouri members to work and vote for the bill. In introducing his motion Mr. Widmann read the following:

In November, 1905, I had a paper before the American Ornithologists' Union at its twenty-third Congress in New York City, entitled "Should Bird Protection Laws and their Enforcement be in the Hands of the National Government?" This same question is now put to Congress in bill 10,276, introduced into the House of Representatives May 28, 1909, by Hon. John W. Weeks of Massachusetts.

The bill reads as follows:

"Be it enacted, by the Senate and House of Representatives of the United States of America in Congress assembled, that all Geese, Swans, Brants, Ducks, Snipe, Plover, Woodcock, Rail, Pigeons, and all other migratory birds, which, in their northern and southern migrations, pass through or do not remain permanently the entire year within the borders of any state or territory, shall hereafter be deemed to be within the custody and protection of the Government of the United States, and shall not be destroyed or taken contrary to regulations hereinafter provided for.

Sec. 2. "That the Department of Agriculture is hereby authorized to adopt suitable regulations to give effect to the previous section by prescribing and fixing closed seasons, having due regard to the zones of temperature, breeding habits, and times and line of migratory flight, thereby enabling the department to select and designate suitable districts for different portions of the country, within which said closed seasons, it shall not be lawful to shoot or by any device kill or seize and capture migratory birds within the protection of this law, and by declaring penalties by fine or imprisonment, or both, for violations of such regulations.

Sec 3. "That the Department of Agriculture, after preparation of said regulations, shall cause the same to be made public, and shall allow a period of three months in which said regulations may be examined and considered before final adoption, to cause same to be engrossed and submitted, to the President of the United States for approval: Provided, however, that nothing therein contained shall be deemed to affect or interfere with the local laws of the states and territories for the protection of game localized within their borders, nor to prevent the states and territories from enacting laws and regulations to promote and render efficient the regulations of the Department of Agriculture provided under this statute."

Experience has shown the impossibility of obtaining uniform and adequate legislation for migratory birds from state legislatures. The formulating of a good protective law is a task which requires more knowledge of the habits of birds than legislators can be expected to possess, and there is the danger that with every new session of a legislature a good law may be changed, usually through the agency of parties who find the law injuring their business. It is known that business men with a little money as a persuader have convinced law makers in our own state that if certain laws were passed or not changed they would have to go out of business, or rather go into some other business, less injurious to the public welfare.

To show you how these state laws are constantly changed, the balance sheet of last year's legislative gains and losses is instructive.

Gains are:—Massachusetts and North Dakota prohibited spring shooting. Montana and Nebraska protected the Doves throughout the year. Idaho accorded protection to the Blackbirds. North Carolina passed a number of local game laws. Oklahoma and North Dakota enacted the so-called "Model Law," and California established a bird day.

Losses are:—Illinois removed protection from all hawks, and New Mexico from road runners. Oklahoma left the Doves without any closed season, Pennsylvania classed Loons and Grebes as game birds with an open season, and removed protection from Shrikes, Eagles, Buzzards, Ospreys, Cranes, Herons, and Bitterns. Utah removed protection from Blackbirds, Blue Herons, Bitterns, Squaks, Magpies, and Kingfishers. West Virginia removed protection from all Hawks, Owls, Eagles, Crows, and Kingfishers. Indiana, Nevada, Oregon and Nebraska extended spring shooting two or three weeks. Idaho permitted shooting in January and February, and Washington in January, February and March.

But even more important than the making of the game and bird protection law is its enforcement. It is a well known fact that local officials do not appreciate the good of bird protection and are unwilling to prosecute friends and neighbors for violation of unpopular laws. For the last twenty-five years, and long before game laws were ever thought of, we have had in Missouri a law prohibiting the killing or catching of song and insectivorous birds and the robbing of their nests, but sheriffs and constables, whose duty it was to enforce the law, ignored it so constantly that it became a dead letter.

When game laws were created, it was necessary to employ special officers with a regular salary; this led to the present system of game wardens adopted by most states. Unfortunately, this game warden system is also subjected to the moods of the General Assembly, and it was shown in our own state a few years ago how easy it is to make the law inefficient by simply omitting the appropriation for the salary of district game wardens. The Forty-fourth General Assembly appropriated only enough money to pay a big salary to the state game and fish commissioner and for the expenses of his office and travels, but nothing for deputy game wardens. Governor Folk sanctioned the bill against the wishes of the Audubon Society and it became a law, wholly worthless for the reason that one head game warden without a force of assistants can do nothing except draw his salary.

The last General Assembly re-enacted the entire game law with desirable modifications, but the next legislative session may change it again or deprive it of its effectiveness. But under present conditions even the best game warden system is inadequate for the care of birds, other than game. The aim of the game warden is to preserve game in the interest of the hunter; being hunters themselves they naturally do not care very much for the preservation of other than game birds, and, like most people, think that small birds are fit for nothing, and that it makes little difference whether they are killed or not. Nor is this latter view confined to certain classes of our population; very few of our county judges see the use of stringent laws prohibiting the killing of birds, and convictions or judgments are hard to obtain in such courts. Laxity in the enforcement of state laws is the reason why federal laws are more highly respected, because violators brought before federal judges seldom escape severe punishment.

Formerly it was thought that everybody had a right to kill any wild bird at any time and any place he had a chance to do so. When it became apparent that something had to be done to prevent the threatened extermination of game, the states claimed ownership of all game and wild birds and created laws based on this claim of ownership. By closer scrutiny of the question we find that this claim cannot be satisfactorily established, since with the exception of few species, mainly Quail, Grouse and Turkey, all game birds and nearly all non-game birds are migratory and most of them are only transient visitors in the United States. Ducks, Geese, Snipes and Plovers have their breeding grounds in Canada and spend the winter south of the United States. In fact there are very few wild birds which remain on the same ground the entire year; most of them spend the summer in one state, the winter in another and in traveling to and fro stop temporarily in a number of states on both ways. This forces us to regard migratory birds as guests, not of a county or state, but of the Nation at large. What is true of land birds holds equally good of sea birds, which come to our shores to breed, or fly along our coasts to feed, or visit them temporarily in their migrations. They are as much the guests of the Nation as the inland birds and are entitled to the care and protection of the country at large. A few attempts to protect them on their breeding grounds have been made by the National Association of Audubon Societies, and lately President Roosevelt set aside by executive orders fifty-three parcels of ground used by bird colonies for nesting purposes, chiefly along our coasts—a few in the interior. Valuable as this is, it is not sufficient, for, to preserve these beautiful and interesting creatures for future generations, we have to protect them all the year round from wanton slaughter by the wily plume hunter. This is a very difficult task which the all-powerful National Government only can take upon its shoulders, but a Nation so charitable and humane as that of the United States can ill afford to withhold the largest measure of protection to such defenseless creatures as her feathered wards, the migratory birds.

The following were elected to membership: Chas. H. Franck, Wm. E. Hoke, C. L. Holman, Geo. E. Kessler, Geo. C. Stindé and Frank C. Thompson.

March 21, 1910.

President Trelease in the chair; attendance 30.

Mr. Julius Hurter gave the life history of the Blind Salamander of Missouri, showing specimens at various stages of development.

Dr. Adolf Alt exhibited and explained the structure of the eye of this salamander, illustrating his talk with many interesting and instructive lantern slides.

Mr. Alten S. Miller was elected to membership.

The death of Mr. Rufus J. Lackland was reported.

April 4, 1910.

Dr. Adolf Alt in the chair; attendance 30.

Dr. Robert J. Terry presented a paper on "The Morphology of the Pineal Region in Teleosts."

Professor F. E. Nipher exhibited and explained photographic plates showing the gradual development of an electric discharge.

Mr. J. W. Beede was elected to membership.

April 18, 1910.

Dr. Adolf Alt in the chair; attendance 70.

Mr. Frank Mesker gave a lecture illustrated by lantern slides from photographs taken in China, including the Great Wall.

Mr. Charles H. Turner was elected to membership.

May 2, 1910.

President Trelease in the chair; attendance 16.

Dr. Charles A. Todd presented a paper on "The Preservation and Mounting of Wet Preparations for Museums."

Professor F. E. Nipher presented in abstract and illustrated by lantern slides a communication on "The Nature of the Electric Discharge."

May 16, 1910.

President Trelease in the chair; attendance 25.

The Corresponding Secretary read the following:

In the death of Alexander Agassiz, a corresponding member of the Academy of Science of St. Louis for forty-four years, the Academy wishes to record its loss and to express its appreciation of Mr. Agassiz's great service to science.

The President reported that after a contribution of $2,500 and a transfer from the current treasury account of $1,000 had last year raised the Academy endowment to $6,500, which, by the further gift of Mr. John Holmes, had been increased to $7,000, a circular letter sent to all members of the Academy had brought in the further sum of $500 contributed by Messrs. Gustav Baumgarten, M. S. Brennan, D. I. Bushnell, E. C. Dameron, W. E. Fischel, George Lang, Jr., E. H. Larkin, Edward Mallinckrodt, Jr., Frank Mesker, J. S. Thurman and T. D. Witt—which had been added to the endowment from time to time as received.

It was further reported that under authorization voted by the Academy in the early part of this year, the President and Treasurer had recently transferred to the Saint Louis Union Trust Company this sum of $7,500, to which a few members of the Academy, Messrs. W. K. Bixby, George O. Carpenter, Peyton Carr, Benjamin Gratz, Edward Mallinckrodt, D. S. H. Smith and William Trelease, and Mrs. Eliza McMillan, had added a like sum,—the total of $15,000, under the agreement sanctioned by the Academy, to be held in trust for a period of twenty-five years and the proceeds of its investment collected and turned over to the Academy for its current use.

Calling attention to the rules concerning the election of patrons, the President stated that among these contributors to the Academy's endowment (in addition to Mrs. McMillan, who is already a patron of the Academy), Mr. W. K. Bixby and Mr. Edward Mallinckrodt had given over $1,000 each, and recommended that these gentlemen be elected patrons of the Academy.

Dr. William Trelease gave an illustrated account of "The Geographical Distribution of *Agave* in the West Indies and its Probable Mode of Introduction."

Three main types of Agave are recognized in the West Indies; one confined to the southwestern Cuban region, another to the Inaguas, and the third ranging through the entire archipelago. Subtypes of the latter are limited respectively to the Greater Antilles, the Bahamas, the Caribbees, and the Leeward Islands and the adjoining Venezuelan coast. Within these groups specific differentiation is observable so that each island isolated by a 100-fathom channel has its endemic species, the islands with a common coastal plain possessing little if at all differentiated forms. The almost entire absence of the genus from South America and the geographic grouping of species and super-species in the West Indies indicate that Agave penetrated from the Central American mainland, where it centers, and overran the terrain before the disruption into islands, two or perhaps three parent stocks being involved.

Mr. William Keeney Bixby and Mr. Edward Mallinckrodt were unanimously elected Patrons of the Academy.

Mr. Cloyd Raymond Bender was elected to membership.

June 6, 1910.

President Trelease in the chair; attendance 40.

Professor Walter Edward McCourt gave an account, illustrated by lantern slides, of "The Unfolding of the Map of the World."

Mr. McCourt related how the knowledge of new lands has been acquired by discoveries and explorations, beginning with the small area about the Mediterranean Sea and gradually widening the geographic horizon, until we have the world of today, as we know it. Mr. McCourt also told of the various ideas of peoples (from these early times, 3000 B. C.) concerning the shape and features of the earth, and the various changes taking place on it. The talk was amply illustrated by lantern slides, including many ancient and fanciful maps of the world, to show how our present ideas concerning the earth have come to be.

The death of Mr. Henry W. Scheffer was reported.

October 17, 1910.

President Trelease in the chair; attendance 52.

Professor William Trelease exhibited and illustrated by lantern slides "The Smallest of the Century Plants."

Professor J. L. Van Ornum gave a summary of his recent experiments showing the effect of the presence of vegetable mold on the strength of concrete and mortar.

Professor F. E. Nipher gave a review of his recent work on the electric discharge.

The death of Dr. Gustav Baumgarten and of Judge Jacob Klein was reported.

NOVEMBER 21, 1910.

President Trelease in the chair; attendance 40.

The gift of the late Dr. Baumgarten's personal file of the Academy's Transactions, as well as extra copies of the rare first and second volumes, from Dr. Walter Baumgarten and Miss Alma Baumgarten, was reported.

Mr. Julius Hurter read a paper on "The Poisonous Snakes of Missouri," illustrating his talk with specimens.

The following were elected to membership; Nathaniel Allison, Roger N. Baldwin, Thomas Beckwith, S. A. Bemis, Chas. C. Boland, Louis A. Brandenburger, James H. Brookmire, Jas. A. Campbell, C. O. Chambers, Isaac T. Cook, Jerome E. Cook, Francis E. A. Curley, H. E. Densford, George Dock, A. W. Ebeling, Walter Fischel, George Gellhorn, Chas. M. Gill, Thos. B. Glazebrook, Cortlandt Harris, Edward Hidden, J. J. Houwink, Ernest Jonas, Breckinridge Jones, Joseph M. Keller, Luther M. Kennett, H. F. Knight, W. C. LeVan, Wm. H. Luedde, Frank J. Lutz, J. B. McCubbin, Elias Michael, Thomas Middleton, E. T. Mitchell, John Campbell Morfit, Sidney Morse, Albert R. Nauer, Wm. H. Nolker, Saunders Norvell, Eugene L. Opie, E. G. Payne, Hugh B. Rose, Henri Rusch, Jacob Schramm, Philip A. Shaffer, James I. Shannon, Thomas K. Skinker, G. M. Stelzleni, W. H. Stennett, Henry C. Thompson, Jr., and Hans Weichsel.

The death of Mr. Pierre Chouteau and of Mr. David F. Kaime was reported.

DECEMBER 5, 1910.

President Trelease in the chair; attendance 35.

Messrs. Leonard Matthews, J. F. Abbott, Ben Blewett, J. H. Gundlach and R. N. Baldwin were appointed a committee to assist the movement for a Zoological Garden for St. Louis.

Dr. Ulrich Harder read a paper on "Evolution with Reference to the Acquisition of the Erect Posture, its Disadvantages and the Decline of Certain Faculties in Man."

Professor F. E. Nipher presented his newest results on his work on the Electric Discharge.

Dr. Robert J. Terry, Mr. H. C. Irish, and Dr. R. R. Gates, were elected to serve as a committee to nominate officers for the year 1911.

The following were elected to membership: James E. Allison, J. A. Berninghaus, Preston J. Bradshaw, Geo. P. Doan, John B. Emerson, Edward F. Goltra, Robert J. Guthrie, Fred B. Hall, Chas. Van Dyke Hill, Marc Ray Hughes, Albert L. Johnson, W. J. Kinsella, L. L. Leonard, C. Dewitt Lukens, Henry Samuel Priest, A. H. Reller, Walter Robbins, E. C. Rowse, George Schweyer, F. E. Sheldon, Paul J. Wielandy and Charles Wiggins.

DECEMBER 19, 1910.

President Trelease in the chair; attendance 30.

Professor Robert J. Wallace gave an illustrated account of the "Construction, Equipment and Work of a Modern Observatory."

The following report from the Nominating Committee was read:

St. Louis, Mo., Dec. 17, 1910.

The nominating committee, elected at the last meeting of the Academy of Science, begs to submit and place in nomination the following names for officers for the ensuing year:—

For President	William Trelease
For First Vice-President	D. S. H. Smith
For Second Vice-President	Francis E. Nipher
For Recording Secretary	Walter E. McCourt
For Corresponding Secretary	George T. Moore
For Treasurer	H. E. Wiedemann
For Librarian	Wm. L. R. Gifford
For Curators	Julius Hurter
	Joseph Grindon
	Philip Rau
For Directors	Otto Widmann
	Adolf Alt

Respectfully submitted,

R. J. TERRY,
(Signed) R. R. GATES,
H. C. IRISH.

The following were elected to membership: Abraham Cook and H. Linton Reber.

REPORTS OF OFFICERS.

President's Address.

Fellow Members:

It is my privilege again to report a year of well-being and progress in the Academy.

Fifteen meetings have been held, with an average registration of twenty-three, but an attendance fully doubling this number. On an invitation in which we participated, the National Academy of Sciences held its autumn meeting in St. Louis, in the early part of November, thereby honoring the community and encouraging and stimulating its scientific activities. This meeting afforded us an opportunity to tender to the public, on behalf of our guests, a lecture by the dean of American geologists—Professor Chamberlin—presenting impressions derived by him during an extensive educational mission to that little-known land, China; and indirectly brought us a masterly address by one of America's most distinguished zoologists—Professor Wilson—arranged by the Washington University chapter of the honorary scientific society of Sigma Xi, attendance on which was made possible by action of the Council suspending our own session of November seventh. The officers of the National Academy have been pleased to speak of the St. Louis meeting as a satisfactory one, and its sessions were given an unusual and pleasing touch of reminiscence by the presence on the walls of the meeting-room of portraits of Chauvenet, Eads and Engelmann,—all, in their day, honored and valued members of the National Academy, as of our own organization.

Perhaps in no single respect has the real scientific activity of our body been so gratifyingly manifested as in its Entomological Section, which has held eight meetings through the year and has brought together the nucleus of a general collection of insects, supplementing the beautiful butterflies which, through Mrs. Bouton's interest and effort, were presented to the Academy some years since. Though little enlarged, otherwise, the museum has been maintained, in the customary manner and made accessible to the public; and the practice of opening it after our evening meeting has been continued through the year. The librarian reports the usual increase in our library, betterments in its condition, and maintenance and suitable extension of our scientific affiliations.

Toward the end of the season the Academy, helpful in every effort to better the community in the line of our own activities, gave approval to a movement looking to the establishment of a zoological garden in St. Louis, and a committee has been appointed for suitable co-operation, chosen from members of the Academy who at the same time are representative of the most important civic interests to which such a movement should appeal.

The publications of the Academy have been carried through the year in the usual manner,—gratifying as to quantity and quality, and, in addition to a concluding brochure containing an abstract of proceedings for the year, etc., the nineteenth volume of our Transactions will contain ten worthy contributions to knowledge which have seen the light in 1910. The encouraging financial condition that was reported a year since, continues. The treasurer reports a current balance of $119.04. By further subscription, the endowment reported at the end of 1909 was increased to $7,500.00, which was doubled in the early part of the year through the generosity of a few members, so that this safeguard of our realty and of our publishing activities now stands at $15,000.00, which, by vote of the Academy, has been placed in trust for a term of twenty-five years at the end of which the principal will require re-investment,—the income, only (netting about 5 per cent) being available for current use.

In the course of the year much needed renovations have been made in our building, the initial cost of which, assumed by the Engineers' Club, is covered by a corresponding reduction in the rental paid by the Club. What is expected to be a material betterment in the quiet and ventilation of the meeting room is being made by the provision of apparatus for delivering an ample supply of tempered pure air, with removal of the vitiated air, permitting the windows to be covered at all seasons with pads which are expected to intercept much of the noise from the street which now interferes seriously with the use of the room, especially in the summer, when windows are opened to secure a circulation of air. The initial cost of this installation—the efficiency test of which is awaited with keen anticipation—is borne by the Engineers' Club, the Academy assuming the operating expense.

Death has claimed again a heavy toll from our members: Gustav Baumgarten, Pierre Chouteau, David F. Kaime, Jacob Klein, Rufus J. Lackland, Henry W. Scheffer. Notwithstanding these losses and the customary resignations of sustaining members, the membership has experienced a net increase of fifty-three (14 per cent.), and at the end of the year stands at four hundred and thirty-three, the highest figure yet reached. The list is a roll of honor, including, in addition to the still lamentably few productive investigators of the community, the names of those whose interest and work and gifts are making the "new St. Louis."

Gratifying to your officers, is your increasing individual activity in sustaining and enlarging this membership, on which, as I stated a year ago, rests and must continue to rest the Academy's power for good. In 1909, thirty-three names of sponsors appeared on the proposals of the 135 members elected; last year, the eighty-eight proposals submitted bore sixty-two signatures. May not a further diffusion of activity in presenting suitable names be hoped for this year? The task is easy, the value and privilege of membership are clear, and the cause is worthy.

(Signed) William Trelease,
President.

Treasurer's Report.

Receipts.

Balance from 1909	$ 231.15
Dues from members	1,805.50
Rent from tenant societies	691.34
Telephone (Engineers' Club)	10.00
Academy's Transactions sold	59.95
Washington University (books)	40.00
Interest on balance, September 8, 1910	5.61
Interest on real estate loan	82.50
Balance from Union Trust Co	89.99
Income from endowment fund	181.95
Total receipts for the year	$3,197.99

Expenditures.

Salaries	$1,200.00
Water license	41.00
Gas and electric light	55.63
Fuel	244.36
Telephone	58.10
Printing	1,057.98
Current expenses	421.88
Total expenditures for the year	$3,078.95
Balance December 31, 1910	119.04
	$3,197.99

Endowment Account at Union Trust Co.

Balance from 1909	$4,460.83
Interest accrued, May 5, 1910	29.16
Total on hand, May 5, 1910	$4,489.99
Withdrawn for endowment fund, May 5, 1910	$4,400.00
Withdrawn from Academy's funds	89.99
	$4,489.99

This account is closed.
The total endowment fund is now $15,000.00.

Respectfully submitted,

(Signed) H. E. Wiedemann,
Treasurer.

Librarian's Report.

The Librarian reported that the accessions to the library for the year 1910 by exchange with 113 home and 301 foreign societies amounted to 84 volumes and 76 pamphlets, and by donation 28 volumes and 30 pamphlets.

The Transactions for the year were sent to 107 home and 232 foreign societies.

Dr. Walter Baumgarten and Miss Alma Baumgarten donated a full set of the Academy's Transactions, from the library of their father.

Curator's Report.

The Curators reported that during the year donations were received from:

Mr. Philip Rau, a fine specimen of a nest of *Vespa maculata*, from Kimmswick, Mo., and one hundred insect cases for the use of the Entomological Section.

Report of the Entomological Section.

St. Louis, Mo., Jan. 16, 1911.

To the Academy of Science of St. Louis:

Another year has passed in which the Entomological Section has done work of which it may well be proud. Eight meetings were held and at each one of these considerable enthusiasm was shown.

At the January meeting Prof. J. F. Abbott was elected to succeed himself as chairman and Mr. Hermann Schwarz as secretary. Mr. Hermann Schwarz reported on the meeting of Illinois and Missouri entomologists held at the home of Dr. Wm. Barnes, of Decatur, Ill., January 16th. The enormous collection of North American Lepidoptera possessed by Dr. Barnes proved instructive far beyond the expectations of many. The conference was attended by twenty-two persons. Mr. J. T. Monell described the manner in which aphids puncture leaves. Mr. Rau, Mr. Monell and others spoke of the good work done by the Section during the past year and the cheerful outlook for its future.

At the February meeting Prof. J. F. Abbott read a paper on "Mimicry in the Genus *Limenitis* L. and the Papilioninae, Models of *L. ursula*."

At the March meeting Mr. Phil Rau read a paper on "Life History and Color Changes in *Stagomantis carolina*," illustrating same with a number of lantern slides made of photographs taken by himself of insects under observation.

At the April meeting Dr. C. H. Turner presented a paper on "The Homing of Ants." Mr. Philip Rau offered to present the Section with one hundred paste-board boxes to be used as temporary receptacles for insects donated by members of the Section to the museum collection. Mr. Louis Schnell and Mr. Hermann Schwarz were elected custodians of the prospective collection.

At the May meeting Dr. Carl Fisch spoke of "Parasites in the Intestines of Insects," supplementing his talk with a number of microscopic slides. The boxes donated by Mr. Rau were thankfully accepted.

At the field meet held jointly with the St. Louis Entomological Club at West Kimmswick, Mo., July 16-17th, the most interesting insect found was *Satyrus alope.* This butterfly occurs very rarely about St. Louis but here it was quite plentiful.

At the October meeting Mr. Philip Rau presented to the museum a case containing specimens in each stage of development of *Samia cecropia.* The same gentleman read a paper on "Further Notes on the Cecropia Moth."

At the December meeting Dr. C. H. Turner read a paper entitled, "Color Vision of the Honey Bee." The subject proved to be one of intense interest and was therefore thoroughly discussed.

The average attendance for the last eight meetings was six members and four visitors. The Section at present consists of ten members.

Respectfully submitted,

(Signed) HERMANN SCHWARZ,
Secretary of the Section.

Memorial to Dr. Gustav Baumgarten.

The following appreciation of our late associate, Dr. Gustav Baumgarten, was prepared by Dr. John Green:

Gustav Heinrich Ernst Baumgarten
June 1,1837—September 20, 1910.

It was my rare privilege to make the acquaintance of Dr. Baumgarten early in 1867,—an acquaintance which proved to be the beginning of an association of forty-three years in the teaching of medicine, and of an abiding friendship now a gracious memory.

Dr. Baumgarten had already won recognition by leaders in the profession as distinctively the exponent of scientific medicine in this community. His broad knowledge perfectly coördinated and at instant command, his gift of direct and lucid exposition, his unwavering fidelity to duty, and above all his intellectual honesty and punctilious regard for the rights of others, were distinguishing attributes of the wise physician, the helpful consultant, and the impressive teacher.

Dr. Baumgarten's life work was in the practice and teaching of internal medicine, but in following this predilection he was ever mindful of the essential oneness of medical science as the summation of knowledge garnered from many fields. So every year brought accession of wisdom and power;—his growth was continuous and symmetrical to the end.

Single-minded in his reverence for truth and deliberately exact in formulating his convictions, he was impatient of self-assertion and rhetorical display in discussing scientific problems. His own utterances, always pertinent and illuminating, were characterized by a judicial discrimination that compelled the respect of receptive hearers. In the local Society of German Physicians he found congenial companionship, and gave freely of his best in impromptu friendly debate and in carefully studied papers. For thirty years and to the very last he was constant in his attendance at its meetings and at the informal reunion of members after adjournment. In the Association of American Physicians he was the peer of acknowledged leaders in scientific medicine. Honorary distinctions came to him unsought; the giver more honored than the recipient.

Dr. Baumgarten was a man of distinctively broad culture. The Latin and Greek of a curriculum assimilated to that of the gymnasium lived anew in his terse and incisive English. His native German, formed on the best models, was equally the perfect mirror of his thought. He valued mathematics as the exemplification of close reasoning from defined postulates. Biology was in the widest sense the Science of Life. Literature was a cult and a recreation; the sympathetic characterizations of Fritz Reuter and the whimsical conceits of Jean Paul and of Stockton appealed strongly to his genial sense of humor—*humani nihil a se alienum putabat.*

Of the eighty-five active members of the Academy listed in 1867 only five were carried on the roll at the date of its semi-centennial celebration, March 10, 1906. The number is now reduced to four. In the days of relatively small membership and sparse attendance at meetings Dr. Baumgarten was its efficient Librarian and supervisor of the exchange of Transactions with affiliated societies. Later, as one by one old associates were removed, he ceased to frequent our meetings. His sustained loyalty to the Academy is attested by his remarkable record as an active member, from 1856, and by his unfailing appreciation of efforts to realize the high aspirations of its founders:—Engelmann loved him, and he revered Engelmann's memory.

In all the relations of life, he was *sans peur et sans reproche.* In the circle of his chosen friends he was affable and often playful. All were better for having known him. If it were required to write his epitaph in a single phrase, it might well be in the finely appropriate words of Virgil:—

MENS SIBI CONSCIA RECTI

ON THE NATURE OF THE ELECTRIC DISCHARGE. THE ONE-FLUID AND THE TWO-FLUID THEORIES.

FRANCIS E. NIPHER.

It is now nearly three years since the writer began a search for some direct and tangible evidence which would determine the direction of flow of the electric current in a conductor. The phenomena revealed by the study of radio-active bodies had shown that we have in the β particles an agent which fills the requirements of an "electric fluid." The α particles are evidently incapable of flowing through a conducting wire. But it did not seem impossible that the α particles might be composed of a nucleus and a similar fluid which might have the properties of the positive fluid.

In the present paper an attempt will be made to present evidence with which all are familiar, and which has been accumulating during many years, which seems important in determining the nature of the current in a wire conductor. Additional evidence will be presented which seems to be inconsistent with the two-fluid theory.

The results of Wheatstone's work on the velocity of an electric disturbance are in harmony with either the one-fluid or the two-fluid hypothesis. An examination of Wheatstone's paper[1] revealed the fact that his drawings of the rotating mirror show a device which is incapable of a rotation of 800 times per second. The mirror is not central on the shaft. The spark knob which permitted the passage of the spark when the mirror was in the proper position for observing the image of the spark board was balanced by a similar knob on the opposite side of the shaft. But in order that only one spark should

Presented before The Academy of Science of St. Louis, Jan. 17, 1910.

[1] Phil. Tr. R. Soc. 1834.

occur in a revolution, the balancing knob was displaced along the shaft. This results in another unbalanced moment which must be carried by the pivots on which the shaft is mounted. It was estimated that the pivots would at 800 revolutions per second, have carried lateral revolving thrusts amounting to 75 or 80 pounds. It was therefore determined to repeat this work. Through the courtesy of the Department of Physics of the University of Chicago the construction of a rotating mirror was secured from patterns used in the building of a mirror for that department. A mile of wire was contributed by the Kinloch Telephone Company of St. Louis, and Wheatstone's line was reproduced in the hallway of Eads Hall at Washington University. The reflected images of the sparks on the spark board were thrown into a large copying camera. Datum sparks when the mirror was at rest could thus be obtained, and the sparks produced during rotation could also be obtained. When both terminals of the large 8-plate influence machine were put to the line it was found impossible to obtain Wheatstone's result. A series of small sparks was shown in the end gaps at the machine terminals, followed by a single spark in the middle gap. Finally one end of the line was grounded and the other presented to either terminal of the machine. It was then found that when either the positive or the negative discharge was sent through the line, the spark nearest to the machine occurred first, the middle spark second, and the spark nearest to the ground occurred last. The sparks came at regular time intervals. Wheatstone's conclusion was therefore verified.[2]

The question then arises, are these disturbances discharges of the positive and negative fluids, or are they disturbances in the nature of compression and rarefaction waves in a fluid? Wheatstone's result does not decide between these two possible hypotheses. Rowland's

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[2] Probably Wheatstone's drawings represent apparatus used in preliminary work, and not the apparatus which he finally used for obtaining his published results.

famous experiment on the electromagnetic effect due to the motion of a charged body, establishes the fact that a positively charged body, moving in space, produces the same electromagnetic field as a negatively charged body moving along the same path with equal velocity in the opposite direction. These two actions are, however, not identical, since they involve the motion of masses of matter in opposite directions.

The positive luminiscence in the Geissler tube is not necessarily a discharge of positive electricity, although it seems to proceed from the positive terminal. J. J. Thom~~p~~son found that this positive luminescence in a tube 15 meters in length moved outward from the positive terminal, with a velocity somewhat more than half that of light. But this may only be a result of the negative discharge. A stream of water issuing with great velocity from a pipe may wear a channel into the earth, and this channel may lengthen for a time in the direction of flow

CORRECTIONS. page 2A.

Academy of Science of St. Louis, Vol. XIX. No. 1.

Page 3, line 12 from top, for *Thompson* read *Thomson.*
" " 9 from bottom, for *ironization* read *ionization.*
" " 6 from bottom, for *ironized* read *ionized.*
" 6, bottom line read *used.*

to be a "positive discharge" into Lake Erie.

The positive luminescence in Thomson's long tube may be explained as follows:

The i~~r~~onization of the column of gas at the anode end begins at the anode wire. Negative particles pass from molecules in contact with it to the wire. These molecules thus i~~r~~onized are then capable of accepting negative particles from their neighbors who are slightly more remote from the anode. In other words, they have acquired the property of conduction. It is as though the length of the anode wire had been extended into the tube. In the language of the two-fluid theory, positive electricity has be-occur in a revolution, the balancing knob was displaced along the shaft. This results in another unbalanced moment which must be carried by the pivots on which the shaft is mounted. It was estimated that the pivots would at 800 revolutions per second, have carried lateral revolving thrusts amounting to 75 or 80 pounds. It was therefore determined to repeat this work. Through the courtesy of the Department of Physics of the University of Chicago the construction of a rotating mirror was secured from patterns used in the building of a mirror for that department. A mile of wire was contributed by the Kinloch Telephone Company of St. Louis, and Wheatstone's line was reproduced in the hallway of Eads Hall at Washington University. The reflected images of the sparks on the spark board were thrown into a large copying camera. Datum sparks when the mirror was at rest could thus be obtained, and the sparks produced during rotation could also be obtained. When both terminals of

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If the water were invisible, and if the recession of Niagara Falls from Lake Ontario to Lake Erie should occur in ten minutes, the phenomenon might be thought to be a "positive discharge" into Lake Erie.

The positive luminescence in Thomson's long tube may be explained as follows:

The ionization of the column of gas at the anode end begins at the anode wire. Negative particles pass from molecules in contact with it to the wire. These molecules thus ionized are then capable of accepting negative particles from their neighbors who are slightly more remote from the anode. In other words, they have acquired the property of conduction. It is as though the length of the anode wire had been extended into the tube. In the language of the two-fluid theory, positive electricity has begun to flow from the anode. This operation extends throughout the tube, up to the dark space at the cathode. At the cathode end the negative particles appear. In the arc light such a cathode stream shows itself capable of beating a crater into the end of the positive carbon, and raising the temperature of that carbon a thousand degrees or more above that of the negative carbon. In the Geissler tube this cathode stream apparently beats the gas molecules away from the cathode. They are beaten towards the positive terminal of the tube. A condition is thus formed around the cathode which approaches that in the Crookes tube. We may have then in this space a region of increased "resistance" to the passage of the discharge. A kind of automatic valve action may be thus brought about. A system of standing waves may result, in the air column, somewhat resembling that in an organ pipe. All of this would involve, at any one point in the tube, harmonic changes in pressure in the gas, such as exist in an organ pipe, and harmonic changes in the "resistance" offered to the discharge. If the cathode has a form which gives proper direction to the cathode stream a counter discharge of positive ions towards the cathode end of the tube may be brought about.

Such periodic changes in the gas column of the Geissler tube would of course be attended by many complex auxiliary phenomena which are not to be found in vibrations in the air column of an organ pipe, produced by a continuous blast of air. It certainly seems possible that the cathode stream across the dark space around the cathode, even when a constant current source is used, may be the cause of the periodic vibrations of a more or less regular character involved in the striae and dark spaces. Why should such mechanical considerations not enter into the explanation of these long known phenomena?

It certainly does not seem possible that the positive ions can emerge from within the metal conductor forming the anode. They are what is left of the atom, when the negative particles have been detached from atoms of a substance having gaseous form. In a gas we may have freely moving positive ions as well as freely moving negative ions. This is the condition in the Geissler and Crookes tubes. In a solid conductor we may also have a displacement of negative ions. The positive ions cannot move. They constitute the conductor. In such a conductor, so far as position is concerned, molecules are always and constantly related to neighboring molecules as gaseous molecules are when they collide. The lower the temperature of the solid, the more nearly the molecules approach each other, and the more easily negative ions or particles are displaced from molecule to molecule. In other words, conduction is improved by a decrease of temperature. In the solid conductor, there is no evidence of the existence of a positive current. The positive ions which exist in the gases of the Crookes and Geissler tubes could not flow through a copper wire.

There has been of late a tendency to return to the one-fluid theory. A few phenomena will be described which appear to favor Franklin's view of the nature of electricity.

In 1900 in a paper in these transactions entitled, "On Certain Properties of Light-Struck Photographic Plates,"[3] I have described a phenomenon which has some resemblance to what has been called ball lightning. Figures 8, 9 and 10 of that paper show traces on a photographic film, made by a slowly moving point of light. The motion of the point of light was always in the direction of flow of a negative discharge, and came from the negative terminal of an influence machine. A metal disc having a diameter of a centimeter was armed with a pin-point. The point was bent over so that when the disc was placed on the film, the point made intimate contact with the film. The point rested upon a short pencil mark on the film. A slight moistening of the pencil mark is of advantage. The knobs of the machine should be widely separated, and it is of advantage to place a large sheet of

[3] Trans. Vol. X, No. 6.

glass midway between them, so that no disruptive discharge may occur. The disk is to be in metallic connection with the negative terminal. A point of light emerges from the pin-point or the pencil mark, and moves slowly over the film, curving towards the positive terminal of the machine, and leaving a darkened trail behind. Along this trail an invisible negative flow is taking place, as can be seen by bringing near to it a device which has earned the name of "teazer." This consists of two pins, tied or soldered together at their head ends, the points being in opposite directions. This is mounted at its middle point by means of sealing wax, to a long tube of glass. One of these points when presented to the pin-point on the disk will usually start the ball discharge, if it fails to appear.

It was found to be impossible to obtain these ball discharges from the positive side of the machine. When the teazer was used, these discharges would come from the point on the teazer and would move towards the positive terminal. Plate I of this present paper shows such discharges. At the top of the figure were placed two disks armed with pins, which were connected to the + and — terminals of the machine. Below were two similar disks opposite to those above mentioned, mounted on the same photographic plate, which was 10×12 inches in size.[4] These disks were in metallic connection with two large gas torches hung on insulated supports in the air outside of the building. The torches were fed by means of long rubber tubes, ending in short metal pipes to which the line wires were soldered. Ball discharges came one after the other from the negative terminal, some of which went to the torch terminal opposite, some turning towards the positive terminal of the machine. Ball discharges also appeared from the torch opposite the positive terminal and went to that terminal. The plate was exposed and developed in daylight, the developer being

[4] Separate plates for the + and — circuits permit them to be more widely separated, and give better results. Smaller plates may then be used.

hydrochinone, which was weak in sodium carbonate. Similar results may be obtained by replacing the torches by metal wires, each being armed with about 500 pin-points. The black lines on the film are shown even when the plate is fixed without being developed. The discharges are not discharges through the air or over the surface of the film. They are within the body of the film itself, and the film shows a distinct depression along the discharge lines.

These effects may be produced between the terminals of the machine, without any ground lines. Similar and much larger ball discharges may be made on a surface of wood by means of a powerful spark-coil operated by a direct current with interrupter. If an alternating current is used in the primary, ball discharges may be obtained from both terminals simultaneously. They may be led into various paths, but cannot be brought together. The tracks are burned into the wood, and are two or three millimeters in breadth.

A Crookes tube may be placed in either of these discharge lines, from the terminals of an influence machine, both lines being carried to independent ground contacts. If placed in the positive line, the cathode terminal of the tube must be turned to the ground. This ground may be on a torch, or on a many-pointed conductor, or the cathode may be grounded directly on a water pipe. Equally good X-ray pictures may be obtained in the positive or in the negative lines, with equal times of exposure. When placed in the positive line, however, the tube seems to operate in a less positive manner than when operating in the negative line. When this was first done by the author in 1902, the behavior of the tube and discharge line created the suspicion that there was a condition in this line which was in the nature of a rarefaction. Electric discharges from all surrounding objects, seemed to be flowing in upon the tube and the positive line. These objects were tipped with brush discharges. The cathode discharge seemed to be somewhat unsteady and was easily disturbed by the movement of near-by objects. Attention was called to this phenomenon and to the "ball-lightning" discharge in my paper before the International Congress of Arts and Science in 1904.[5] These phenomena indicate that the negative current is the agent which seems to be concerned in electrical action. On the negative side of the machine, negative discharge to the ground is accompanied with leakage from the machine terminals and line to the surrounding air. On the positive side a negative flow from the ground to the machine seems to be accompanied with an inflow or leakage of negative electricity from the surrounding air to the positive terminals and line. There is nothing to make necessary the assumption that any positive discharge is taking place through the conducting wires in any of the experiments here described. The positive ions which appear in the gases of the Geissler and Crookes tubes are gaseous atoms from which negative electrical particles have been separated, by reason of a forced circulation of these negative particles through the entire circuit.

In order to examine more directly the nature of the discharge from or towards separately grounded lines of the influence machine the method here to be described was employed. One terminal of the machine was connected with an earth connection (G_1, Fig. 1) in the yard outside of the building, a spark gap of one or two centimeters being made at the machine terminal. The discharge from the other terminal across a spark-gap of about 30 cm., was led to an independent ground (G_2) on an adjoining side of the building. The conductors in both lines were No. 8 copper wires. The line having the long spark discharge through it contained a high resistance R, near its ground end. This resistance was composed of three or four strips of porous cloth bandage, placed in parallel, their ends being placed in tumblers of salt water. This resistance could be varied by changing the

[5] Present Problems. Vol. IV, pp. 92–101 of the Proceedings.

distance between the tumblers, which rested upon glass supports.[6]

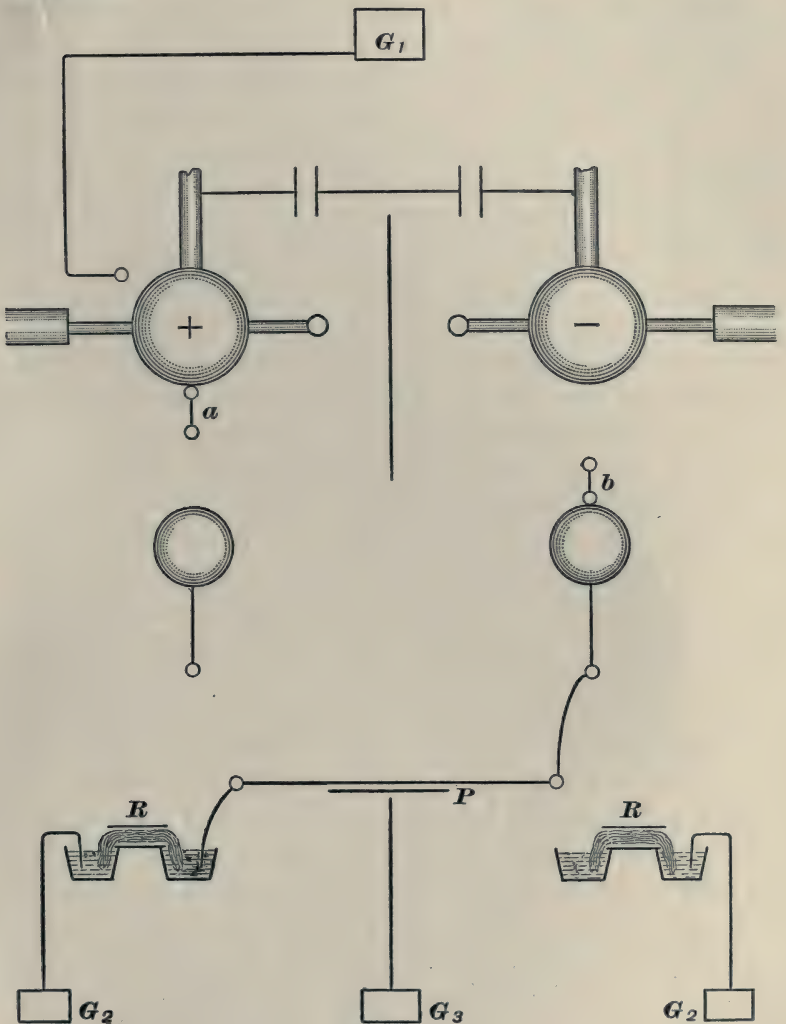


Fig. 1.

Between this resistance and the machine end was inserted a No. 34 copper wire, which passed horizontally

[6] A convenient form of resistance is obtained by threading one or more strips of the cloth bandage through a glass tube. The ends of the tube rest upon the brims of tumblers, the cloth conductor dipping into salt water in the tumblers.

across the film of a photographic plate P, Fig. 1, supported at its edges on insulating supports. This wire was held in proper tension by means of brass springs, from which silk cords passed to the wire, and its position with respect to the film of the photographic plate was adjusted by means of hard rubber supports on either side of the plate having adjusting screws of insulating material. Below the center of the plate a distance of about 1.5 cm. was the pointed end of a copper wire, which was grounded on the water pipe, G_3. The resistance R was so adjusted that a spark discharge would not pass from the wire above the film around the plate P to the grounded wire below, but would be on the point of doing so. This adjustment was made for the exposures in the positive and also in the negative line.

Plate II. shows a 5×7 inch photographic plate across which 5 spark discharges from the negative terminal were passed. The fine wire which carried the discharge was in contact with the film. This wire was surrounded by a glow of light, but the resistance between the plate and the ground was not sufficient to force discharges over the film. To have made this resistance greater would have brought about a spark discharge around the plate, when the pointed ground conductor was put in position, although it was not in position during this exposure. The effect produced by introducing this ground wire G_3 is shown in Plate III. This plate was otherwise exposed exactly as the former plate. The ground wire terminated 1.5 cm. below the center of the plate. The result in Plate III. may be explained as follows:

1. *By the two-fluid hypothesis.* The negative discharge through the wire in contact with the film, is attended by a positive discharge from the ground wire to the lower face of the plate. This positive discharge is spread over an area coincident with the blackened area which the negative discharge is shown to cover in Plate III. The glass plate on which the photographic film is spread is in a condition like that of the glass wall of a Leyden jar which

has been charged from the negative terminal of the machine.

2. *By the one-fluid hypothesis.* The negative discharge flowing under compression through the wire above, finds in the grounded wire below a line of leakage. This ground wire greatly increases the potential drop at that point. A negative discharge from the lower face of the glass plate passes to the ground wire below. Simultaneously a negative discharge from the upper wire flows over the film, and tends to flow downward to the ionized molecules of glass in the lower face of the glass plate. It constitutes a bound charge.

The discharge effects shown may be explained by either hypothesis. Plates IV and V show two plates which have been exposed in precisely the same way when the discharge through the wire above came from the positive terminal of the machine. The spark length was about twice as great as the negative sparks in Plates II and III. This could be done without producing sparks around the plate when the ground wire was placed below the photographic plate. In such exposures adjustable spark terminals *a* and *b*, Fig. 1, were used. They are so placed that the negative discharge passes from a large knob to a small one. In case of a reversal of the electrification of the machine, the adjustable terminals are transferred to the other terminal of the spark gaps. When the negative discharge is being used, the positive spark gap is shortened in length to one or two centimeters. It will be seen that the discharge lines in Plate IV for the positive discharge extend outwards several centimeters from the wire, while in Plate II for the negative discharge there are no discharges over the film of the plate. When the spark length in the negative line is made four times as great as was the case in the formation of Plate II, and when the ground resistance is a spark-gap of ten centimeters, the number of sparks passed through the wire being increased to an hundred, the only effect is to broaden the black line shown in Plate II. There are no discharge lines such as are shown in Plate IV. It is with difficulty that the negative discharge is forced out of a straight wire and over the film, although the wire is surrounded by a luminous glow extending outward a centimeter or more from the wire. There are rudimentary lines shown in this black belt. The negative particles can be much more easily forced from one positive ion to the next within the body of the copper conductor, than into a photographic film in contact with the wire. This seems to be true notwithstanding the fact that the negative particles are easily drawn from the film surface into the wire through several centimeters of distance when the copper wire is in an ionized condition in the positive circuit. This inward flow must cross the discontinuity at the contact of film and wire. It is evidently not the resistance offered by this discontinuity, which accounts for the difficulty of forcing the electricity out of the wire on the compression side of the machine. The discharge lines shown in Plate IV begin at the wire and increase in length during the discharge. This may easily be shown by drawing pencil lines on the film. Some of these discharge lines will terminate on these pencil marks, while others not thus arrested will continue to lengthen to a greater distance from the wire. Such a result, with a different form of discharge wire, is shown in Fig. B, Plate X. It might be supposed from this result in Plate IV that positive discharges can be forced outward over the film from the positive wire, while the negative discharge cannot easily be forced to leave the wire, under like conditions. It might be supposed that the electricity in the positive wire is therefore under greater compression.

If these discharge lines from the positive wire are due to a positive discharge outward from the wire, then the placing of the grounded wire below the center of the plate should permit a negative discharge to flow upwards, and to distribute itself over the under side of the glass plate. This should produce a condenser effect similar to that shown in Plate III. This is what is required by the two-fluid hypothesis. The result actually produced is shown in Plate V. This effect presented on this plate seems entirely inconsistent with the two-fluid theory.

Assuming the one-fluid theory the result shown on Plate V may be explained as follows:

The electric current is flowing from the ground to the positive terminal of the machine. The condition within the wire may be described as one of rarefaction, such as exists on the exhaust side of a pump. Electricity is leaking into this wire from the photographic film, and it is leaking up from the grounded wire below the center of the plate, to the under surface of the plate. The inflow over the film to the wire, is repelled from the central area which is being charged by the grounded wire below. The electricity streams to the wire around this area. The electricity distributed over the lower face of the glass plate, tends to flow upward through the plate, to replace the charge which has streamed from the upper surface to the wire. The grounded wire is now a line of leakage into the discharge wire. The fogging shown on the center of Plate V is due to the upward discharge from the grounded line. This is shown by the two figures of Plate VI. These figures show two photographic plates which were placed back to back. The plate shown in Fig. A was placed with its film in contact with the discharge wire when the positive discharge was sent through it. The film of the other plate faced downwards towards the end of the grounded wire. The upper plate shows no trace of a fogging effect. The upper film may, however, be fogged on its under side if the time of exposure is increased. If the upper discharge wire is raised from the film, both films may be strongly fogged from a pointed wire below, when no trace of any effect from the discharge wire itself is observable on the upper surface of the upper film. Such a result is shown in the two figures of Plate VII. The fogging shown on the upper plate

A after fixing was not observable during the developing of the film when it was viewed from above. It was seen on turning the plate over so as to expose the under side. This fogging had therefore been produced through two glass plates.

Plate VIII shows two photographic plates exposed back to back in the same manner, when the negative discharge was passed through the upper wire. From the film of the lower plate B a negative discharge passed to the grounded wire below. This downward discharge proceeded from an area which was coincident with that of the blackened area on the upper film A. This is revealed by the presence of small black points here and there towards which fine discharge lines proceed, and from which the discharge passed to the wire below. The form of these lines seems to have been somewhat affected by electro-magnetic induction from the discharge wire across the upper film. The fogging effect on a film from which electricity passes to a conductor, is much less than that caused by a like discharge of electricity against the film. It is this difference, which has always been ascribed to a difference between positive and negative discharges.

The exposure of plates like those shown in Plates III and V, where the grounded wire was in place, was varied as follows:

A blast of air from a large tank of 800 liters capacity and maintained at constant pressure of two and a half atmospheres, was blown across the end of the grounded wire below the photographic plate. The blast swept through the gap between this end and the photographic plate. This was done with both positive and negative discharge. The blast was also directed along the discharge wire in contact with the upper film. Not a trace of any effect on the discharge lines could be detected, although the blast was maintained throughout the entire exposure.

The results thus far described seem to show conclusively that the apparent emission of positive electricity from the positive terminal of the influence machine, is really a drawing in of the negative "fluid" from the bodies which are thus "positively electrified."

Another line of experiment which was begun in 1907 consists in passing a discharge from the influence machine around right angles in a fine wire placed in either of the separately grounded lines. The object sought was to determine whether there was any difference in the fogging effect on a photographic film on the two sides of an angle. It was found impossible to simultaneously examine the two sides of the same angle. The arrangements shown in Fig. 2 were both employed. The fine wire

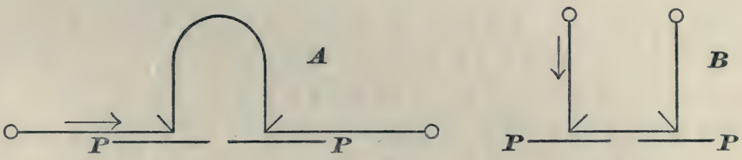


Fig. 2.

(No. 32) was bent sharply around thin bamboo splinters. The resistance between the angles and the ground was made as small as was possible, but wet string resistances were placed between the angles and the spark-gaps at the terminals, in order to quiet any oscillations that might possibly be produced. In the earlier work, the photographic plates were placed in hard rubber holders, which rested on a sheet of glass upon which the angles were mounted. The covers and bottoms of these holders had various thicknesses, from one to three-sixteenths of an inch. It was found that under these conditions, when proper adjustments had been secured, the greatest fogging effect was produced on the plate towards which the negative discharge passed downwards around the angle and then across the plate. In the negative line arrangement A of Fig. 2 was used. In the positive line arrangement B was used. In this line the negative discharge passed from the ground to the machine. The effect was greatest at the angle nearest the ground, in both cases. The wires were raised above the plates to such a height that the fogging effect was confined to a small area immediately below the angle. This area was sharply defined.

It was found very difficult to obtain any fogging effect from the positive line. It required with the thicker covers above the plates, from eight to ten thousand sparks when the machine was working to its utmost limit, and the negative spark-gap was reduced to one cm. to obtain effects which fifty sparks of the same length would produce in the negative line. No discordant results were ever obtained in the positive line. In the negative line many were obtained. After a couple of years of almost daily experimenting, it was found that fatigue or after effects were produced in the hard rubber covers, which were of sufficient influence to reverse the effects in short exposures. An illustration of this after effect is shown in Fig. C of Plate IX. It was found that the fogging effect could be converged to a black focal line on the film, by means of a small cylindrical fiber of red or white glass laid upon the film below the angle and at right angles to the wire. Such effects are shown in Fig. A of Plate IX. The ends of such focal lines showed, after developing, branching discharges, which proved conclusively that electricity was escaping along the fiber in a lateral direction with respect to the discharge wire above. Such discharges from the ends of a focal line are shown in Fig. B, Plate IX, which is an enlarged copy of a portion of Fig. A, where the glass fiber crosses the fogged area. When such a glass fiber had been long and recently exposed, and was then used on another plate, it gave a perfectly white shadow picture, such as is shown in C of Plate IX. This also indicates that the apparent refraction effects shown in Figs. A and B are not due to ultra violet light or to ether waves.

Fig. A of Plate X shows shadow pictures of five red glass fibers which had never been on the film of this plate, but which had previously been exposed on another film in the same holder.

This figure also shows fainter images of the glass fibers in the position they had been in on a still earlier exposure, the hard rubber frame on which the fibers were mounted having been turned end for end. In these exposures the holder was placed between two plates acting as a condenser, and 100 spark discharges were sent across a 30 cm. spark gap in parallel with the condenser. A shadow image of the hard rubber frame is also visible.

These sources of disturbance having been discovered the angle wires were surrounded by black curtains in order to protect the photographic plates from the light due to the sparks at the machine, and the plates were then exposed directly to the wires at the angles. The plates were supported on insulating supports at their outer lateral edges. Below the plates was a layer of air, separating the plate from the sheet of glass serving as a table top. It was then found that the films exposed to the angles in the positive line were acted upon as quickly as those in the negative line. It was finally learned that this result was due to negative discharges from the films to the positive wire, and that it was not a fogging of the film by a discharge from the wire to the film, as was apparently the case when the film was protected by the hard rubber holder. Fig. B of Plate X shows such a result. Here the limiting effect of pencil marks on the film is shown. Fig. C of Plate X shows a similar limitation of a discharge from an angle in the negative line. Here the negative leakage is outward from the discharge wire, while in Fig. B the flow is inward towards the positive discharge wire. In both cases the discharge lines or fogged areas on the film begin to form immediately below the wire, and elongate outwards, as has been explained. It was this experience which led to the results given in Plates II, III, IV and V, which have been previously explained.

Some work has been done on the momentum effects around the angles in the negative line, with plates uncovered, and previous results have been confirmed. The differences between th two sides of the angle are, however, less marked than those obtained when the plate was enclosed. It is, however, felt that additional attention must be given to this branch of the subject. There does not seem to be any reasonable doubt of the existence of momentum effects at the angle, but the action is complicated by other effects, some of which have not received sufficient attention to permit of discussion at present.

For example, the effect of spark discharges of this character on a platinum wire of 0.005 cm. diameter may be cited. After such a wire had been in daily use for about three weeks as an angle-wire, it was found that a system of regular wavelets had formed over its whole length, of about 80 cm. The waves were very regular in form. The wave length was 0.090 cm. and the amplitude from crest to crest was 0.015 cm. The wire was under tension of 4 grams weight. The wet cloth resistances were in constant use, so that electrical oscillations were eliminated. These wavelets seem to be much more regular in form than those described by Planté. This may be due to a difference in the conditions of the discharge. He is said to have used a continuous current from storage cells.

That the linear velocity of the current particles in a conductor must be very great follows from the following considerations, which were pointed out by the author in 1895:[7]

Imagine two conducting spheres having radii equal to that of the earth, or 6.37×10^8 cm. Let them be charged to potentials +25 and —25 volts. Connect them with a wire containing in circuit a 50-volt 1-ampere lamp, the resistance of the wire conductor being neglected. In order to maintain the potential difference on the two spheres constant, and thus maintain normal candle power in the lamp while all of this store of electricity is being used,

[7] Nipher. Electricity and Magnetism, p. 390, § 222.

the two spheres must be forced to collapse to zero radius at a uniform rate of motion.

Since $\frac{Q}{r} = V$ we have

$$dQ = V\,dr = i\,dt$$

$$\text{or} \quad t = \frac{V}{i}\,r = \frac{50}{300} \quad \frac{6.37\times10^8}{3\times10^9} = 0.0354.$$

The time during which the operation of the lamp could be maintained by this amount of electricity is therefore 0.035 second. We must therefore think of this operation as being continuously repeated 28 times a second in order to maintain a 50-watt lamp in normal operation. The velocity with which the radii must shorten from 6.37×10^8 cm. (4000 miles) to zero during each stroke of the piston of this electrical pumping service, is 1.8×10^{10} cm. per second, or about 113,000 miles per second. This is more than half the velocity of light.

It is said by physicians who use electricity in the treatment of disease that when a patient is placed on an insulating stand, a sponge treatment with the positive terminal of an influence machine, gives very different results from those produced by the negative terminal. If the conclusions of this paper are correct, the reason for this difference is somewhat like that which explains the difference between the action of cold and hot water. In the one case Franklin's "fluid" is being drawn out of the patient, and in the other case it is being forced in under pressure.

The phenomena discussed in this paper show that everywhere in and around an electric system composed of the machine and its conductors, the negative particles are the direct active agents. If we consider a branching spark discharge we may perhaps assume that the breaking down of the air begins at the positive terminal. A Geissler-tube condition progresses outward from that terminal. Tributary discharges branch off from the main discharge-channel as it progresses towards the negative terminal. The system is like that of a river with its tributaries, which wears a channel in the earth. The channel develops and deepens progressively in a direction opposite to that in which the stream flows. It may be that such a condition in the air between the spark-knobs of a machine brings about the result which has long been known, to-wit: The spark length is greatest when the negative discharge passes from a large knob to a small knob. The diverging system of tributary discharge lines terminates on the large knob. This is readily seen by transferring the movable conductors, *a, b,* of Fig. 1, to the opposite terminals of the gaps. This arrangement is a convenient one for determining in a lighted room which is the negative terminal of the machine.

EXPLANATION OF PLATES.

Plate I.—Tracks of slowly moving discharges from negative terminals.

Plate II.—Photographic plate in contact with the negative discharge line.

Plate III.—Plate exposed as in II with the end of a grounded wire near the back of the plate.

Plates IV, V.—Plates exposed like those of II and III to the positive line.

Plate VI.—Plates exposed back to back as in V. The film of Fig. A was in contact with the positive discharge wire. The film of B faced the end of the grounded wire.

Plate VII.—Plates exposed as in VI, the discharge wire being a couple of mm. from the film of plate A. The fogging on both plates is due to the grounded end of the leakage wire.

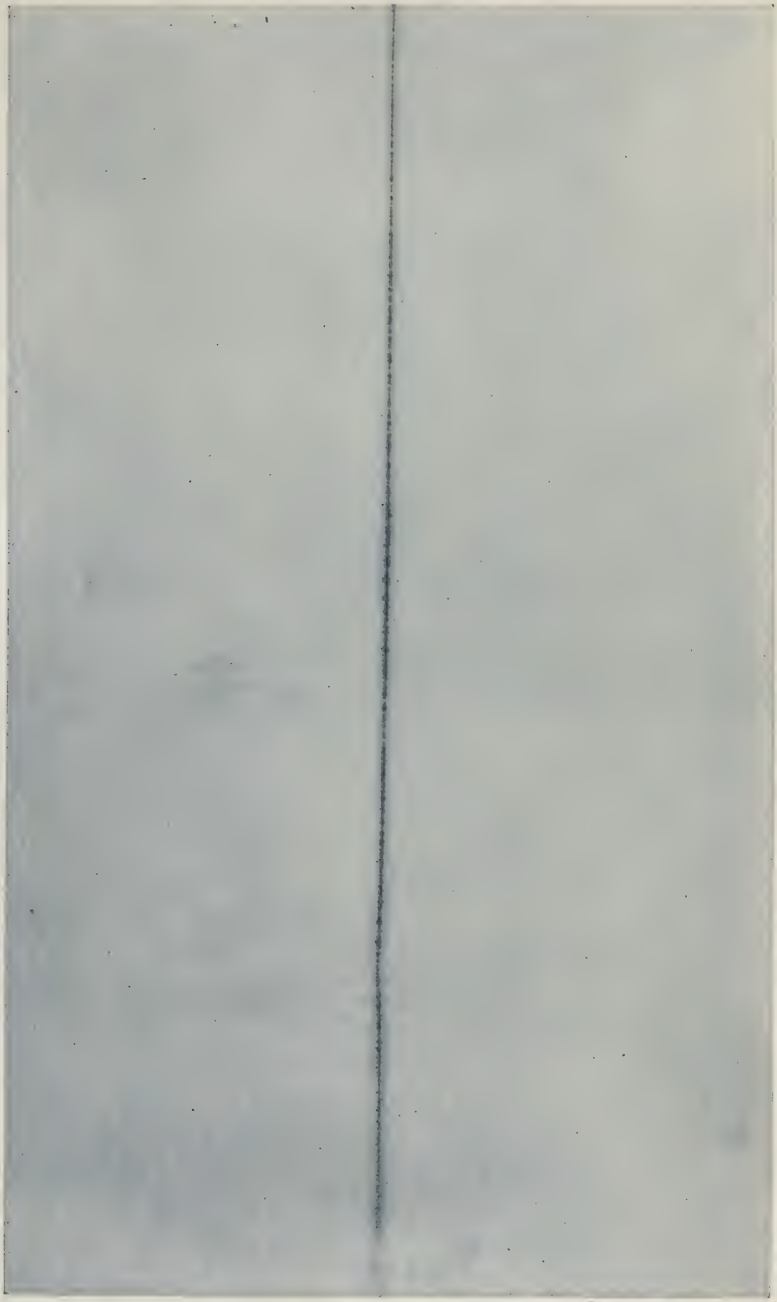
Plate VIII.—Plates exposed like VI, on the negative discharge wire.

Plate IX.—Fig. A. Apparent refraction of electrical fogging by a red glass fiber laid on the film. A white glass fiber laid across the red one, and was not in contact with the film. Fig. B. An enlarged view of the focal line of A showing branching discharges from its ends. Fig. C. Fatigue effect in the glass fiber.

Plate X.—Fig. A. Fatigue effects in the hard rubber holders. Fig. B. Arrest of positive discharge lines by pencil marks on the film. Fig. C. Arrest of negative outflow from a fogged area by pencil marks on the film.

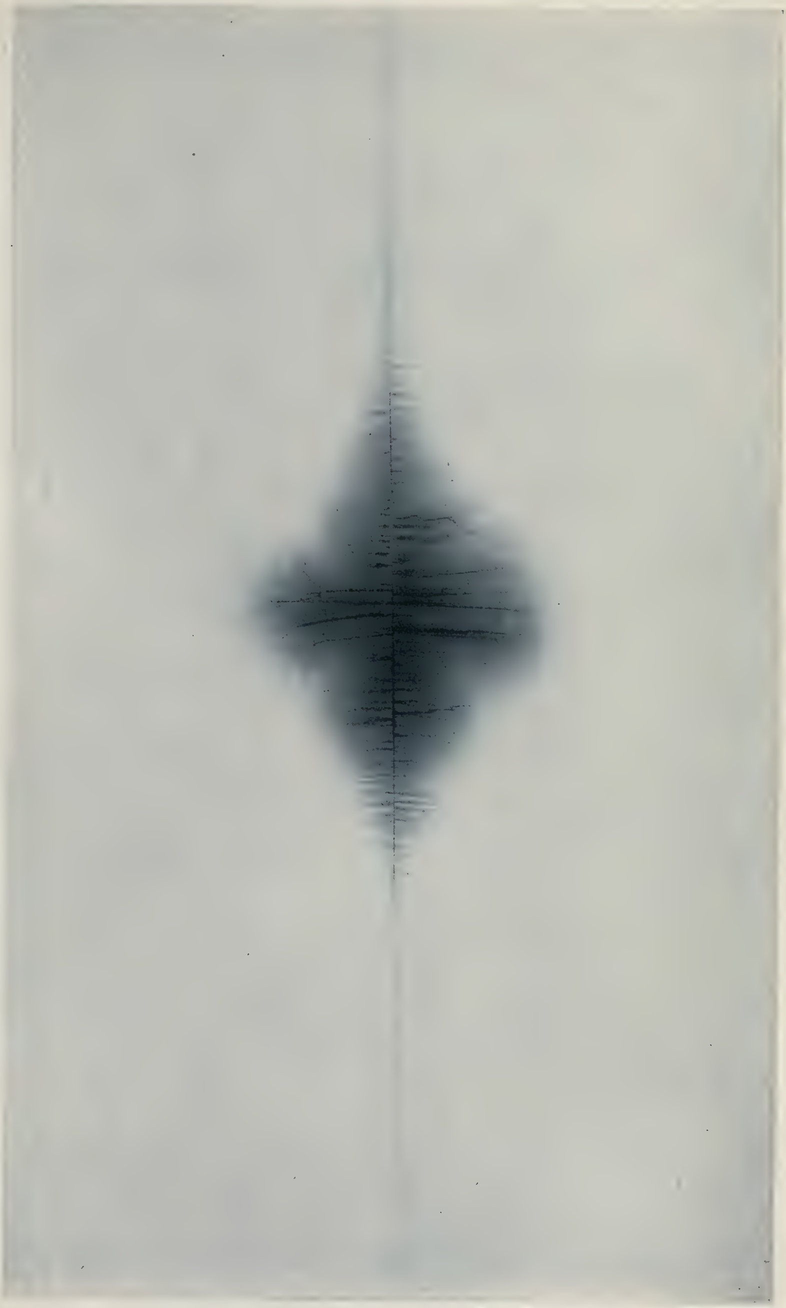
Issued February 18, 1910.

BALL LIGHTNING DISCHARGES.



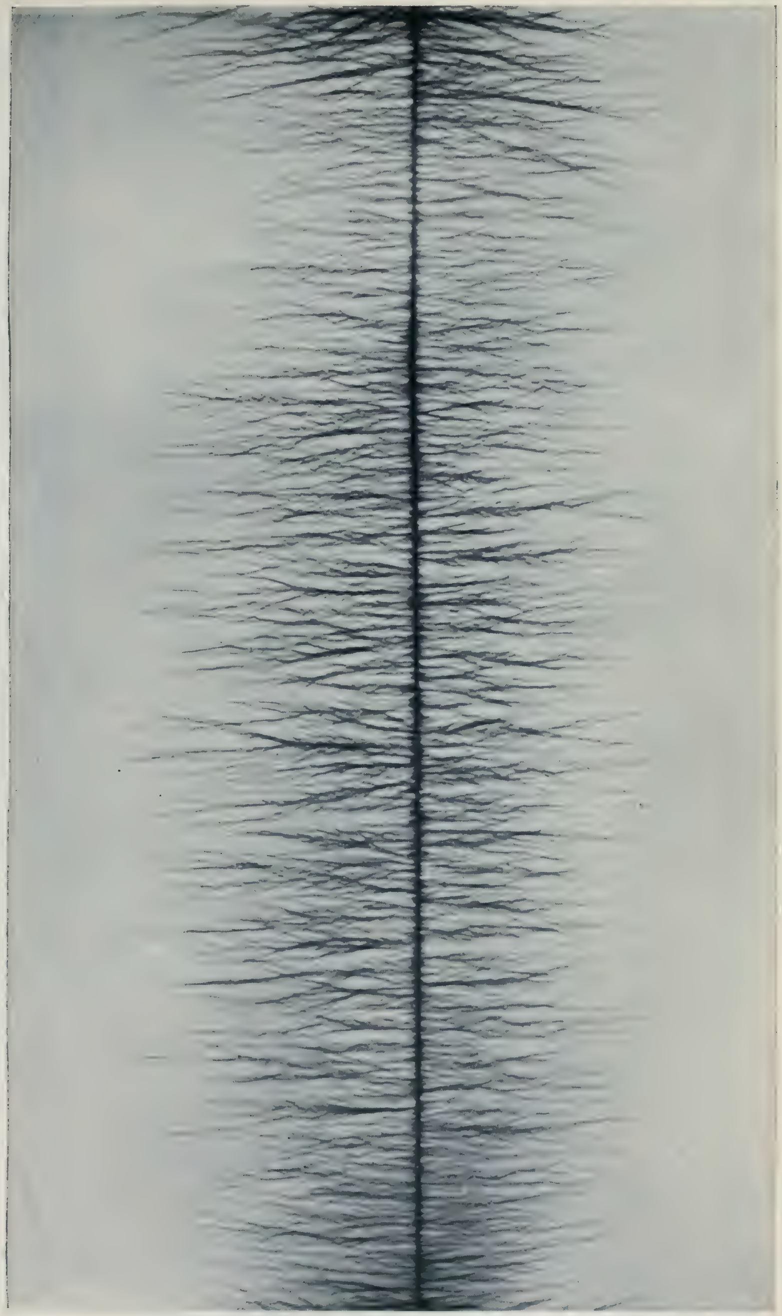
NEGATIVE LINE.

20

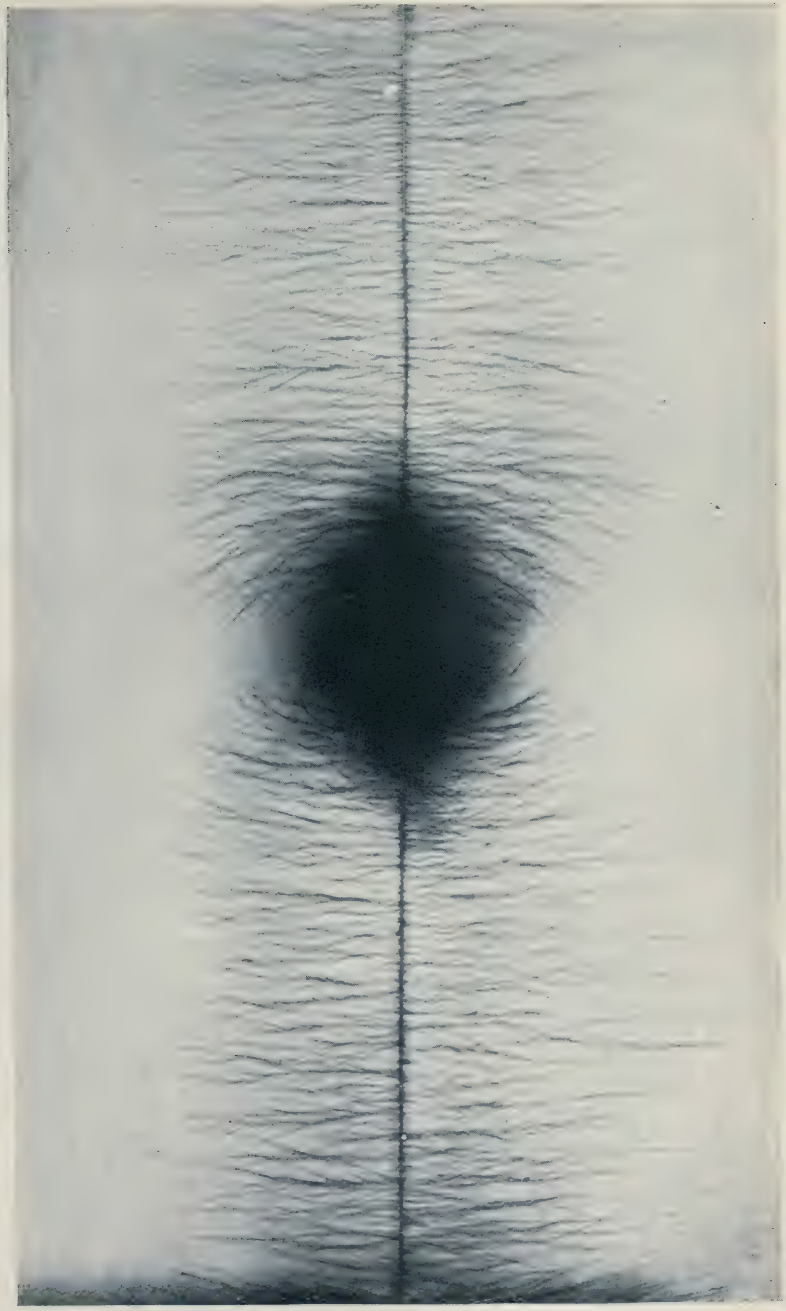


NEGATIVE LINE. GROUNDED POINT BELOW.

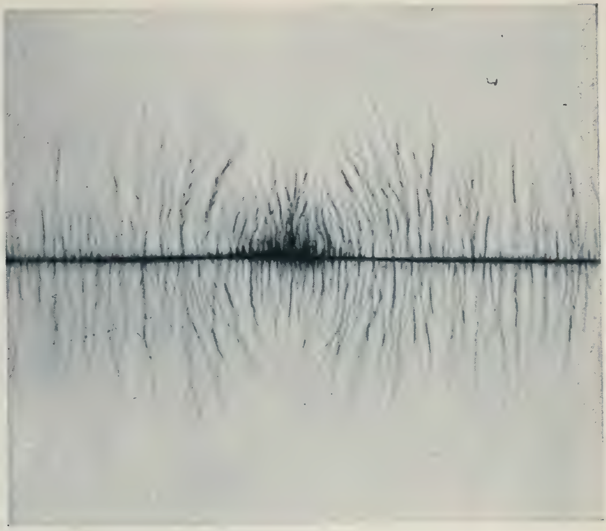
20

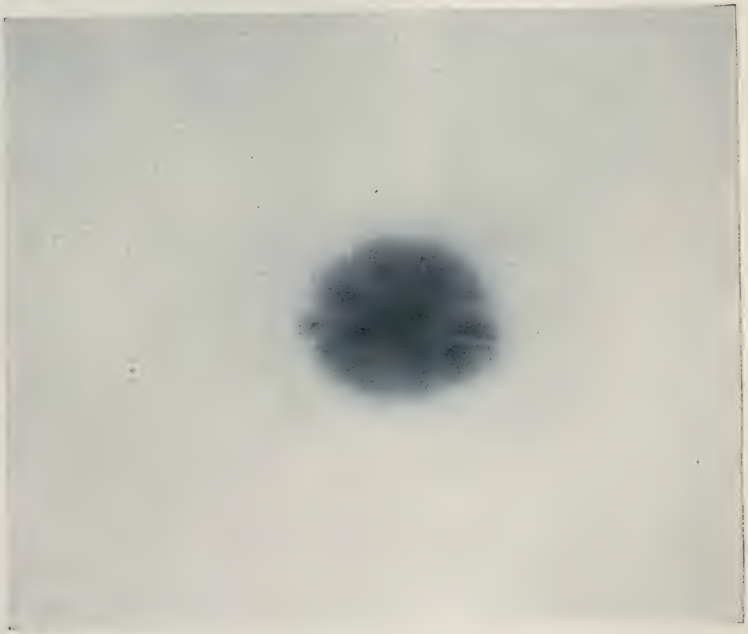


POSITIVE LINE.

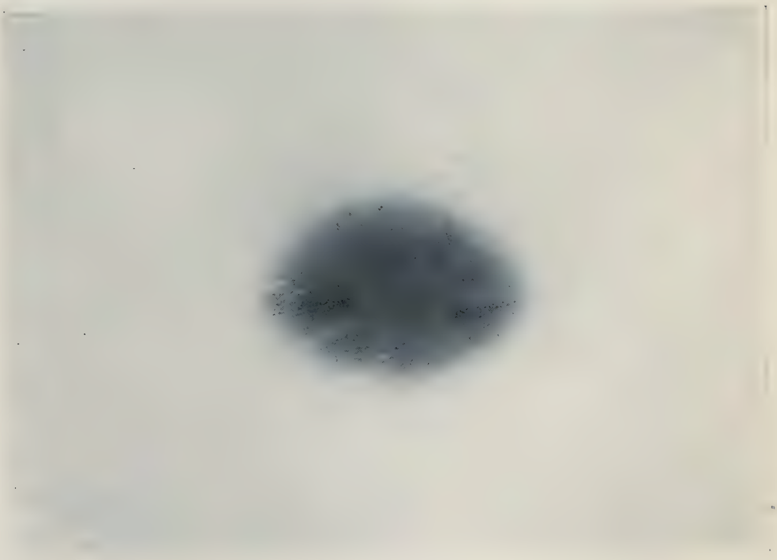


POSITIVE LINE. GROUNDED POINT BELOW.

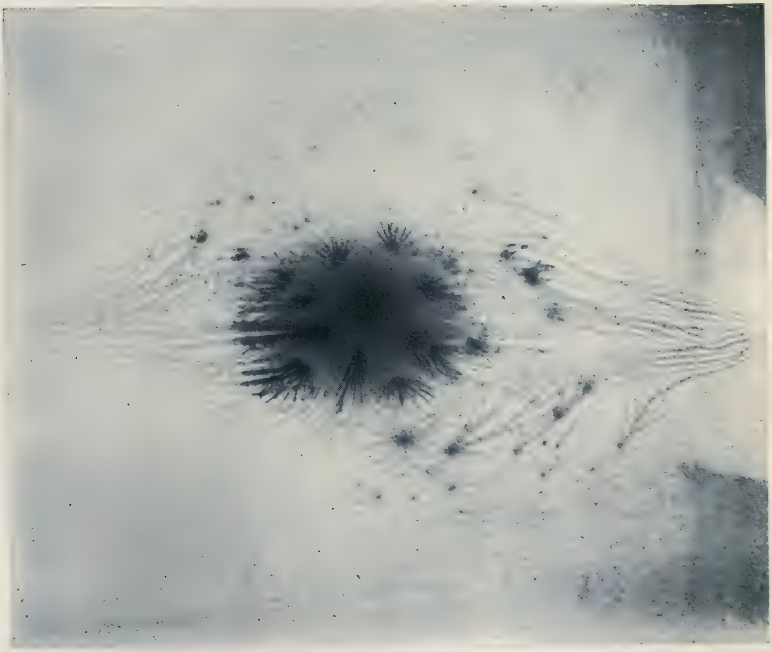




FIGS. A AND B.

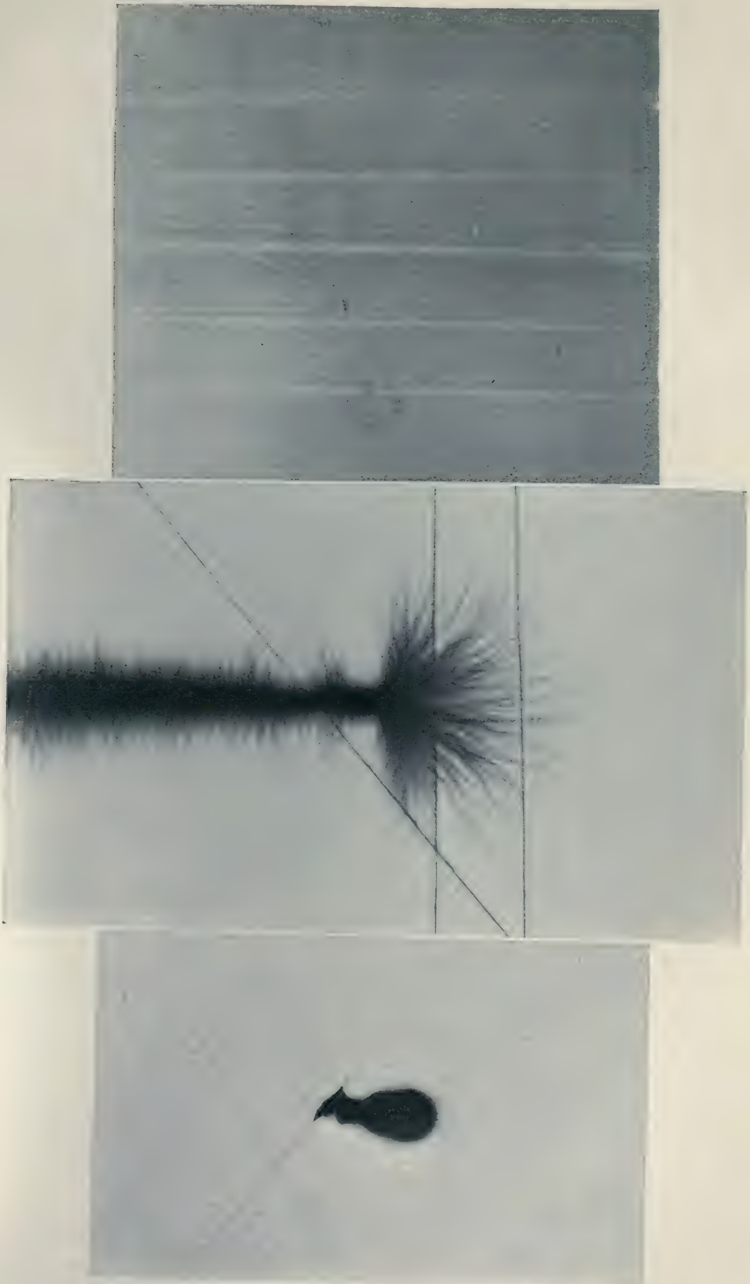


FIGS. A AND B.



FIGS. A AND B.

FIGS. A B AND C.



FIGS. A B AND C.

OBSERVATIONS ON THE DURATION OF LIFE, ON COPULATION AND ON OVIPOSITION IN SAMIA CECROPIA, LINN.*

Philip Rau.

I. Introduction.

I became interested in Weismann's writings on the duration of life in insects and was attracted by the apparent opportunity of doing more work along these lines. In the greater number of his citations it is not stated whether the lives of both sexes, in any one species, be of equal or of unequal lengths, and in but few instances does he give any exact information on the duration of the life of the male, or of the fertilized or the unfertilized female.

I, therefore, decided to make further observations on the duration of life in the male and also on the fertilized and unfertilized female; on copulation and oviposition; on the relation of the duration of life to perfect or imperfect oviposition; on the relation of time spent in copulo to perfect or imperfect oviposition; and on the relation of ages of parents at the time of copulation to perfect or imperfect oviposition.

The material selected for these observations was the common Cecropia moth, *Samia cecropia* Linn.

The cocoons, sixty-nine in number, were gathered early in April, 1909, in the fields near the river Des Peres, just south of Forest Park, St. Louis, Mo. They were placed in wire cages (11 1/2 x 10 1/2 x 24 inches) and kept in an outhouse to insure them against premature hatching. The imagines emerged at intervals from May 14th to June 14th (forty-three males and twenty-five females); from one cocoon none hatched, and none was parasitized.

Notes were made on twelve copulating pairs and on four unfertilized females. Lack of facilities made it im-

* Read before the Entomological Section September 30, 1909, and presented by title to The Academy of Science of St. Louis, December 6, 1909.

possible to make more extended observations. The imagines were placed under the same climatic conditions and were given an opportunity to mate as soon as possible after hatching. The material proved to be good for just such observations, as all the matured individuals of this family have rudimentary mouth parts, and the Cecropia moths take no food.

The observations and notes were never made at greater intervals than six hours; the last notes were made each day near midnight, the first in the morning about six, and during the day notes were made at intervals of about three hours. The time upon which the tables are based is the time when the notes were made, not the time when the act (mating, hatching, dying, etc.) may have occurred. This method is not mathematically exact, since it is impossible to be present at the precise moment when the insects mate or hatch or die. I think, however, that my figures are as exact as could possibly be obtained. The observations extended from the time when the first pair was seen in copulo, May 16, 1909, until the death of the last male on June 22, 1909.

It gives me great pleasure to here acknowledge my indebtedness to Professor A. C. Eycleshymer of St. Louis University and Professor J. F. Abbott of Washington University for valuable suggestions in the preparation of this paper.

II. Observations on Life Cycle.

1. duration of life of male.

(*a*) *The duration of life of male from hatching until death.*

Notes derived from observations in six instances. In the following tables the designations are for each copulating pair:

KNOWN AS	DAYS	HOURS
A 10[a]	11	5:30
A 8	10	23:30
A 14	10	4
A 10	9	17
A 12	9	16
A 15	8	14:40

In A 10[a] we see the longest duration of entire life of male, 11 days 5 hours and 30 minutes. In A 15 we see the shortest duration of entire life of male, 8 days 14 hours and 40 minutes. The average duration of entire life of male for the six instances is 10 days 1 hour and 26 2/3 minutes.

(*b*) *The duration of life of male from the time when first observed in copulo until death.*

The notes are derived from observations in ten instances, and exclude male A 1, which met with accidental death.

KNOWN AS	DAYS	HOURS
A 5	13	1:30
A 3	12	23:30
A 8	10	9:30
A 11	10	1
A 4	10	0:30
A 14	9	5:30
A 12	9	0:30
A 10a	8	13
A 15	7	1
A 10	7	0:30

The longest duration of life of male from copulation until death was A 5, 13 days 1 hour and 30 minutes. The shortest duration was A10, 7 days and 30 minutes. The average duration was 9 days 17 hours and 39 minutes.

(*c*) *The duration of life of male from the time when copulation terminated until death.*

Notes derived from observations in ten instances.

KNOWN AS	DAYS	HOURS
A 5	12	1:30
A 3	12	0
A 4	9	16
A 8	9	9
A 14	9	5:30
A 12	9	5
A 11	9	1
A 10a	7	1:30
A 15	6	14:30
A 10	6	1

The greatest duration of life of male from the termination of copulation until death was A 5, 12 days 1 hour and 30 minutes. The shortest duration of such life was A 10, 6 days 1 hour. The average duration of life of male from the termination of copulation until death was 9 days and 42 minutes.

In the face of Weismann's theory that the duration of life is an adaptation, and finding the species to be monagamous, we should expect them to die very soon after leaving the female, instead of spending a useless life of from 6 to 12 days, as the foregoing figures show. It may be of interest to here state that the longest useless life is found in A 5, being 12 days 1 hour and 30 minutes, while the useful life of its mate, as I shall show later, was cut short before she had time to deposit her remaining 112 eggs.

(*d*) *On the length of time each male outlived its mate.*

Notes derived from observations in ten instances.

KNOWN AS	DAYS	HOURS
A 3	8	11
A 5	7	15:30
A 8	6	9:30
A 12	4	0:30
A 14	3	1:50
A 4	3	0
A 11	2	18
A 10	1	0:30
A 15	0	21
A 10[a]	0	12:30

In A 3 we find the male to have outlived its mate by 8 days 11 hours. This, however, was the longest period. The shortest length of time that any male survived its mate was A 10[a], 12 hours and 30 minutes. Perhaps the shortness of the life of the male A 10[a] was due to the fact that the two pairs A 10 and A 10[a] were placed together.

The ten males survived their mates on the average by 3 days 18 hours and 38 minutes.

2. DURATION OF LIFE OF FEMALE.

(*a*) *The duration of life of fertilized female from hatching until death.*

Notes derived from observations in seven instances.

KNOWN AS	DAYS	HOURS
A 8	9	19:30
A 9	9	4:30
A 10a	8	16:30
A 14	7	21:50
A 15	7	18
A 12	7	7
A 10	6	16

In A 8 we have the longest duration of entire life of female, 9 days 19 hours and 30 minutes. In A 10 we have the shortest duration of entire life of the female, 6 days and 16 hours. The average entire duration of life of female was 8 days 4 hours and 28 4/7 minutes.

(*b*) *Comparison of entire life of male and female.*

The duration of shortest lived male was 8 days 14 hours and 40 minutes. The duration of shortest lived female was 6 days and 16 hours. The shortest lived male outlived the shortest lived female by 1 day 22 hours and 40 minutes. The longest duration of life of female was 9 days 19 hours and 30 minutes. The longest duration of life of male was 11 days 5 hours and 30 minutes. The longest lived male outlived the longest lived female by 1 day and 10 hours. The average duration of life of male over the average duration of life of female was 1 day 20 hours and 58 2/21 minutes.

Without exception, in each copulating pair we find the male to have outlived its mate, regardless of age at the time of copulating. One is apt to suspect that the males outlived their mates because they may have been younger at the time of mating, but the figures given below will show that the males survive the females whether both be of equal age or whether the females be younger or older. In each of the twelve copulating pairs the males always outlived their mates. The figures below are only for those upon which the exact time of hatching is known.

KNOWN AS	DAYS	HOURS	
A 8	♂ 5	5:30	younger than ♀
	♂ lived 6	9:30	longer.
A 9	♂ 2	1	older than ♀
			male escaped.
A 10	♂ 2	0:30	older than ♀
	♂ lived 1	0:30	longer.
A 10a	♂ 2	0:30	older than ♀
	♂ lived 0	12:30	longer.
A 12	♂ 1	15:30	younger than ♀
	♂ lived 4	0:30	longer.
A 14	♂ 0	20	younger than ♀
	♂ lived 3	1:50	longer.
A 15	♂ 0	0:20	younger than ♀
	♂ lived 0	21	longer.

(*c*) *The duration of life of unfertilized females from hatching until death.*

Notes derived from observations in four instances. B is the conventional designation for the unfertilized female.

KNOWN AS	DAYS	HOURS
B 2a	9	
B 1a	8	
B 1	8	
B 5	7	0:30

The shortest duration of life of the unfertilized female was 7 days and 30 minutes. The longest duration of life of unfertilized female was 9 days. The average duration of life of unfertilized female was 8 days 7 1/2 minutes.

(*d*) *Comparison of the entire duration of life of fertilized and unfertilized female.*

The longest duration of entire life of fertilized female was 9 days 19 hours and 30 minutes. The longest duration of entire life of unfertilized female was 9 days. The longest lived fertilized female outlived the longest lived unfertilized female by 19 hours and 30 minutes. The shortest duration of entire life of fertilized female was 6 days and 16 hours. The shortest duration of entire life of unfertilized female was 7 days and 30 minutes. The shortest lived unfertilized female outlived the shortest lived fertilized female by 8 hours and 30 minutes. The average duration of entire life of fertilized female was 8 days 4 hours and 28 4/7 minutes. The average duration of entire life of unfertilized female was 8 days 7 1/2 minutes. The average duration of life of fertilized female was greater than the average duration of life of unfertilized female by 4 hours and 21 1/14 minutes.

In the fertilized females notes were made in seven instances; in the unfertilized females notes were made in four instances. Were the number of observations equal in each case, no doubt the average duration of fertilized and of unfertilized female life would be about equal.

(*e*) *The duration of life of fertilized female from time when first observed in copulo until death.*

Notes derived from observations in twelve instances.

KNOWN AS	DAYS	HOURS
A 10a	8	0:30
A 11	7	7
A 4	7	0:30
A 14	6	15:40
A 9	6	6
A 15	6	4
A 10	6	0
A 5	5	10
A 1	5	9
A 12	5	0
A 3	4	12:30
A 8	4	0

The greatest length of life of female from the time of copulo until death was 8 days and 30 minutes. The shortest length of life of female from the time of copulo until death was 4 days. The average duration of life of female from the time of copulo until death was 5 days 23 hours and 25 5/6 minutes.

(*f*) *The number of days which elapsed in the life of the fertilized female from hatching until the first eggs were deposited.*

Notes derived from one observation.

A 15 hatched June 12th, first eggs deposited on June 15th; a lapse of 3 days.

(*g*) *The number of days which elapsed in the life of the unfertilized female from hatching until the first eggs were deposited.*

Notes were derived from observations in two instances.

KNOWN AS	DAYS
B 1	4
B 5	3

(*h*) *Comparison of the number of days which elapsed in the life of the fertilized and unfertilized female from hatching to first egg laying.*

In the one case of the fertilized female the length of time was 3 days. In the two unfertilized females the average length of time was 3 1/2 days.

The object of these notes was to ascertain whether or not the eggs are deposited when the female reaches a definite age regardless of being or not being fertilized, but the data are too insufficient for any definite conclusions.

(*i*) *The number of days which intervened between the ending of copulation and the time when the first eggs were deposited.*

Notes derived from observations in five instances.

KWOWN AS	FIRST EGGS DEPOSITED
A 1	Same day
A 3	Same day
A 4	One day later
A 5	One day later
A 15	One day later

The foregoing figures show that in three cases the first eggs were deposited one day after the pairs were severed, in two cases the eggs were deposited on the same day.

J. J. Davis[1] shows that in twenty Cecropia moths that were mated, sixteen began ovipositing on the evening of the second day, and four on the evening of the third day

[1] Entomological News, 368. D 1906.

following the morning when copulation began, which goes to show that if we add to this the length of time spent in copulo, which averages over twenty-one hours, we find that the greater number of females began ovipositing on the same day that copulation terminated, only four beginning one day later.

(*j*) *The number of days which elapsed in the life of the fertilized female from the day when the last eggs were deposited until death.*

Notes derived from observations in five instances.

KNOWN AS	DAYS
A 4	3
A 1	1
A 5	1
A 3	0
A 15	0

In four out of five observations we find that death overtook the insect on the same day or one day after oviposition. In one case, A 4, we found the female, after depositing 217 eggs, spending the last three days of its life without ovipositing, while, upon dissection after death, 91 eggs were found in the abdomen. The pair A 4 were accidentally severed while they were in copulo 8 hours and 30 minutes, and a connection was never again resumed. Perhaps this was the direct cause of the three days' duration of life between egg laying and death without further oviposition, while in the other cases death overtook the individuals, as it were, almost in the midst of the egg laying.

III. Observations on Copulation and Oviposition.

(*a*) *The length of time each pair remained in copulo.*

Notes derived from observations in twelve instances.

KNOWN AS	DAYS	HOURS
A 1	1	5:15
A 8	1	0:30
A 5	1	0
A 11	1	0
A 3	0	23:30
A 10	0	23:30
A 10a	0	23:30
A 14	0	22:30
A 12	0	17:30
A 9	0	12
A 15	0	10:30
A 4	0	8:30

The greatest length of time spent in copulo was by A 1, 1 day 5 hours and 15 minutes. The shortest time spent in copulo was by A 4, 8 hours and 30 minutes. The average time spent in copulo for the eleven cases (excluding A 4 which was accidentally severed) was 21 hours and 20 5/11 minutes.

In every case the pairing was done during the night, the following morning finding them in copulo, in which condition they would remain throughout the day, separating some time during the following evening. Both male and female were active from the time when the wings had spread until they had mated. Wherever possible they were given to mate very soon after hatching to avoid an expenditure of excessive amount of vitality and injuring themselves through their activity, which perhaps might have caused earlier death.

As I have already shown, the males, after leaving the females, lived from 6 to 12 days, and retained their original activity for perhaps one or two days. Then for sometime they would grow less active, remain almost stationary on the wire or twigs in the cage, and would only become somewhat active when handled. Soon they became too aged to even cling to the wire. We would then find them lying on the bottom of the cage, only moving when irritated. Soon the wings assumed a vertical position and the insects remained for the most part motionless, resting on one side of their abdomen and on one wing. When irritated they could just barely move the wings, and presently would appear dead. My test for ascertaining whether the organism was still alive was to gently move the wings back into their normal position and see if they still had the power to assume the vertical position. Thus, we see the slow senescence and death of the male.

In the females we find the insects ovipositing on the same day, or at the latest, one day after the termination of copulation. After three days of ovipositing we usually find the female dead, death, no doubt, being due to exhaustion from the task of egg laying, for, in the greater majority of cases, we find that, could its life have been prolonged, a fair proportion of eggs could have been deposited. The species is monagamous, all attempts to mate one male with more than one female or one female with more than one male being futile.

(*b*) *The number of eggs deposited by fertilized females.*

Notes derived from observations in eleven instances.

KNOWN AS	NUMBER OF EGGS
A 10, A 10a	796
A 1	317
A 9	287
A 8	260
A 15	231
A 12	229
A 4	217
A 3	213
A 11	187
A 5	159

The greatest number of eggs were deposited by A 10 and A 10a, which were placed in one cage. 796 eggs were deposited by the two females. Perhaps one or both were abnormal, as the greatest number of eggs deposited by any one female was 317. The smallest number of eggs were deposited by A 5, 159. The average number of eggs deposited by eleven females was 263 3/11.

J. J. Davis,[2] who has made observations on the number of eggs deposited by the Cecropia moth, finds that, in a count of twenty lots, the greatest number deposited by any one female was 366 eggs, the smallest 119 eggs, and the average for the twenty lots, 243.9 eggs, which is a smaller average by almost 20 than my observations give.

(*c*) *The number of eggs deposited by unfertilized females.*

Notes derived from observations in four cases.

KNOWN AS	NUMBER OF EGGS
B 5	113
B 1	135
B 1a, B 2a	380

The average number of eggs deposited by four unfertilized females was 157.

[2] Entomological News. 368. D 1906.

(*d*) *Comparison of the number of eggs deposited by fertilized and unfertilized females.*

The average number of eggs deposited by the fertilized females was 263 3/11. The average number of eggs deposited by the unfertilized females was 159.

The average number of eggs deposited by fertilized females was greater than the average number of eggs deposited by the unfertilized females by 104 3/11.

The figures show that the fertilized females lay the greater number of eggs.

(*e*) *The number of eggs remaining in the body of the fertilized females when overtaken by death.*

Notes derived from observations in twelve instances.

KNOWN AS	NUMBER OF EGGS
A 14	125
A 5	112
A 8	98
A 4	91
A 3	61
A 12	55
A 1	45
A 10a	14
A 9	4
A 10	0
A 11	0
A 15	0

The greatest number of eggs retained at death was 125. In three instances no eggs were retained at death. The average number of eggs retained for the twelve females at death was 50 5/12.

(*f*) *The number of eggs remaining in the body of the unfertilized females when overtaken by death.*

Notes derived from observations in four instances.

KNOWN AS	NUMBER OF EGGS
B 5	201
B 1	175
B 1a	4
B 2a	0

The largest number of eggs retained by unfertilized females was B 5, 201. No eggs were retained by B 2a.

The average number of eggs retained by unfertilized females was 95.

(*g*) *Comparison of the number of eggs remaining in the body of the fertilized female with those remaining in the unfertilized female.*

The greatest number of eggs remaining in the body of any one fertilized female was 125. The greatest number of eggs remaining in the body of any unfertilized female was 201. The unfertilized female retained 76 more eggs than the fertilized. The least number of eggs retained by a fertilized female was zero in three instances, as well as in the case of one unfertilized female. The average number of eggs retained by fertilized females was 50 5/12. The average number of eggs retained by unfertilized females was 95. The average number of eggs retained by unfertilized females was greater than the average number of eggs retained by fertilized females by 44 7/12.

(*h*) *The entire number of eggs contained in the body of female at hatching computed by the number of eggs deposited plus the number of eggs retained.*

Observations computed in fifteen cases.

KNOWN AS	NUMBER OF EGGS
A 10, A 10a	810
B 1a, B 2a	384
A 1	362
A 8	358
B 5	314
B 1	310
A 4	308
A 9	291
A 12	284
A 3	274
A 5	271
A 15	231
A 11	187

The greatest number of eggs carried by any one female was 362. The smallest number carried by any one female was 187. The average number carried was 292 4/15.

(*i*) *The number of days spent in ovipositing and the number of eggs deposited each day.*

Notes from observations on four fertilized females.

KNOWN AS	DAYS	EGGS DEPOSITED
A 1	3	1. 210 2. 80 3. 27
A 3	3	1. 158 2. 38 3. 17
A 4	4	1. 117 2. 53 3. 43 4. 4
A 5	3	1. 58 2. 80 3. 21

In three out of four instances the eggs were deposited in three days; in the fourth instance oviposition consumed four days, but on the fourth day only a very few eggs were deposited. In three cases out of four we find the greatest number of eggs deposited on the first day, in the fourth case on the second day. In every instance the smallest number were deposited on the last day.

IV. The Relation of the Duration of Life, the Relation of the Time Spent in Copulo, and the Relation of the Ages of Parents at the Time of Copulation to the Number of Eggs Retained at Death.

(*a*) *The relation of the duration of life of unfertilized females to the number of eggs retained at death.*

Notes derived from observations in four instances.

KNOWN AS	DURATION OF LIFE	NUMBER OF EGGS RETAINED
B 5	7 days 30 min.	201
B 1	8 days	175
B 1a	8 days	4
B 2a	9 days	0

The above figures apparently show that there is a relation between a long life and perfect oviposition, and a short life and imperfect oviposition. We shall see later, however, in the fertilized females, where observations were made on a greater number of moths, that there is no relation between a long life and perfect oviposition, and a short life and imperfect oviposition. Were observations made on a larger number of unfertilized females, the results, no doubt, would lead to similar conclusions.

(*b*) *The relation of the duration of life of fertilized female to the number of eggs retained at death.*

Notes derived from observations in seven instances.

KNOWN AS	DURATION OF LIFE		NUMBER OF
	DAYS	HOURS	EGGS RETAINED
A 8	9	19:30	98
A 9	9	4:30	4
A 10a	8	16:30	14
A 14	7	21:50	125
A 15	7	18	0
A 12	7	7	55
A 10	6	16	0

The figures show that there is absolutely no relation between a long life and perfect oviposition and a short life and imperfect oviposition. Here we see imperfect oviposition in a long life, perfect oviposition in a short life, and *vice versa.*

(*c*) *The relation of time spent in copulo to the number of eggs retained.*

Notes made from observations in twelve instances.

KNOWN AS	TIME SPENT		NUMBER OF
	DAYS	HOURS	EGGS RETAINED.
A 1	1	5:15	45
A 8	1	0:30	98
A 5	1	0	112
A 11	1	0	0
A 10	0	23:30	0
A 10a	0	23:30	14
A 3	0	23:30	61
A 14	0	22:30	125
A 12	0	17:30	55
A 9	0	12	4
A 15	0	10:30	0
A 4	0	8:30	91

The above figures show that there is no relation between a longer or shorter period of copulation and perfect or imperfect oviposition. In some cases we see a short copulating period with perfect oviposition, a long copulating period with imperfect oviposition, and *vice versa.*

(*d*) *The relation of the difference in the ages of the parents at the time of copulation to the number of eggs retained at death.*

KNOWN AS	DIFFERENCE IN AGE DAYS	HOURS	NUMBER OF EGGS RETAINED
A 8	♀ 5	5:30 older than ♂	98
A 12	♀ 1	15:30 older than ♂	55
A 14	♀ 0	20 older than ♂	125
A 15	♀ 0	0:20 older than ♂	0
A 10	♀ 2	0:30 younger than ♂	0
A 9	♀ 2	1 younger than ♂	4
A 10a	♀ 2	0:30 younger than ♂	14

The figures show that there is a direct relation between the ages of the parents at the time of copulation and the number of eggs retained at death. In A 15 we have the most perfect oviposition, there being only a difference of 20 minutes in the ages of the male and female. In A 10, A 9, and A 10a, we have perfect or almost perfect oviposition. In each of these cases it is shown that the female was more than two days younger than the male at the time of impregnation. In A 8, A 12, and A 14, we have very imperfect oviposition, the number of eggs retained at death being 98, 55, and 125 respectively. In each case we find the female older than the male.

The fact that there is a relation between perfect oviposition and the younger age of the female, and between imperfect oviposition and the older age of the female can be accounted for in this way. Each individual is destined to live for a certain length of time, females from 6 to almost 10 days. Where the male is of equal age or older than the female we have perfect or almost perfect oviposition. To insure the deposition of all the eggs, the male, so to speak, must be in readiness, waiting for the female to hatch. In the cases where no males were at hand when the females had hatched and the females were compelled to await impregnation for a certain number of their days, which were spent in activity with consequent injury and perhaps loss of vitality, they were overtaken by death, regardless of whether or not the propagation of the species had been assured to the fullest extent. The duration of life does not seem to be regulated by the needs of the species, but is controlled by some unknown internal force.

V. Summary.

1. The 68 good cocoons hatched 43 males and 25 females.[3]

2. The species is monagamous.

3. The Cecropia moths take no food or water.

4. The shortest entire duration of life of male was 8 days 14 hours and 40 minutes; the longest was 11 days 5 hours and 30 minutes. The average for six cases was 10 days 1 hour and 26 2/3 minutes.

5. The longest duration of life of male from copulation until death was 13 days 1 hour and 30 minutes; the shortest was 7 days and 30 minutes. The average duration was 9 days 17 hours and 39 minutes.

6. The greatest duration of life of male from termination of copulation until death, which can be no other than useless life, was 12 days 1 hour and 30 minutes. The shortest useless life was 6 days and 1 hour. The average duration for the ten instances was 9 days and 42 minutes.

7. The greatest length of time that any male survived its mate was 8 days and 11 hours; the shortest survival was 12 hours and 30 minutes. The average length of time that the ten males survived their mates was 3 days 18 hours and 38 minutes.

8. The longest duration of entire fertilized female life was 9 days 19 hours and 30 minutes. The shortest was

[3] The number of males was also greater in a collection at Washington University. Thirty-five individuals had hatched in the spring of 1909, twenty-two being males and thirteen females.

6 days and 16 hours. The average entire duration of life of fertilized females for the seven instances was 8 days 4 hours and 28 4/7 minutes.

9. The shortest lived male outlived the shortest lived female 1 day 22 hours and 40 minutes. The longest lived male outlived the longest lived female by 1 day and 10 hours. The average duration of life of male was greater than the average duration of life of female by 1 day 20 hours and 58 2/21 minutes.

10. Regardless of age, we find in every case the male surviving its mate.

11. The shortest duration of life of unfertilized female was 7 days and 30 minutes. The longest duration of such life was 9 days. The average duration was 8 days 7 1/2 minutes.

12. The longest lived fertilized female outlived the longest lived unfertilized female by 19 hours and 30 minutes. The shortest lived unfertilized female outlived the shortest lived fertilized female by 8 hours and 30 minutes. The average duration of entire life of fertilized female was greater than the average duration of entire life of unfertilized female by 4 hours and 21 1/14 minutes.

13. The greatest duration of life of female from copulation until death was 8 days and 30 minutes. The shortest was 4 days. The average duration of life of female from copulation until death was 5 days 23 hours and 25 5/6 minutes.

14. The number of days which elapsed in the life of the fertilized female from hatching to the time when the first eggs were deposited in the one observation was 3 days.

15. The average length of time which elapsed in the life of the unfertilized female from hatching until the first eggs were deposited for the two cases observed was 3 days and 12 hours.

16. My notes on the lapse of time between hatching and egg laying are too insufficient to make any conclusions as to whether the unfertilized female holds off oviposition in the "hope" of mating.

17. In all the cases observed the eggs were deposited on the same day, or not more than one day after, the pair had severed.

18. In all but one case the time which intervened between the last egg laying and death was 1 day or less than one day. The females, so to speak, were overtaken by death in the act of ovipositing.

19. In the one case referred to above the time which intervened between the last egg laying and death was 3 days. After death this body contained 91 eggs. This individual was accidentally separated while in copulo only 8 hours and 30 minutes. Perhaps this is the direct cause of a 3 days' duration of life without oviposition.

20. The greatest length of time that any pair remained in copulo was 1 day 5 hours and 30 minutes. The shortest was 8 hours and 30 minutes. The average time spent in copulo for the eleven cases observed was 21 hours and 20 5/11 minutes.

21. The greatest number of eggs deposited by any one fertilized female was 317. The smallest number was 159. The average number for the eleven cases was 263 3/11.

22. The greatest number of eggs deposited by two unfertilized females was 380; the smallest 113. The average number for the four cases was 157.

23. The average number of eggs deposited by the fertilized female was greater than the average number of eggs deposited by the unfertilized female by 104 3/11.

24. The greatest number of eggs remaining in the body of the fertilized female after death was 125, and in three

cases none. The average number of eggs retained for the twelve females was 50 5/12.

25. The greatest number of eggs remaining in the body of the unfertilized female after death was 201; the smallest number 0. The average number for the four females was 95 eggs.

26. The average number of eggs retained by the unfertilized female was greater than the average number retained by the fertilized female by 44 7/12.

27. The greatest entire number of eggs carried at hatching by any female was 362; the smallest number 187. The average for the fifteen females was 292 4/15.

28. Three days were for the most part spent in ovipositing. In almost all cases the greatest number of eggs were deposited on the first day, and in all cases the least number were deposited on the last day.

29. In the unfertilized female there is an apparent relation between perfect oviposition and a long duration of life, and between imperfect oviposition and a short life. Notes were made only on four specimens, an insufficient number for any definite conclusions.

30. In the fertilized females, where notes were made on seven individuals, we see no relation between a long life and perfect oviposition, and a short life and imperfect oviposition.

31. There is no relation between the length of time spent in copulo and perfect or imperfect oviposition.

32. We find a relation between the difference in the ages of the parents at the time of copulation and perfect or imperfect oviposition. Where the males and females are of equal age or where the females are younger, there is perfect or almost perfect oviposition. In all cases where the females are older, death overtakes them while still possessing a large number of eggs.

VI. General Considerations and Conclusions.

(*a*) *General Considerations.*

Only in a very few instances does Weismann give us any facts as to the duration of life of the male and female of any moth, and in those few instances the species is allied to the Cecropia moth. Since the moths are somewhat analogous, a comparison of Weismann's facts with notes upon the Cecropia moth will not be out of order in a paper of this kind.

In his essay on Life and Death[4] Weismann says: "Lepidoptera, such as the emperor-moths and lappet-moths, lay their eggs one after another and then die. We may certainly say that these insects die of exhaustion; their vital strength is used up in the last effort of laying eggs, and in the case of the males, in the act of copulation. Reproduction is here certainly the most apparent cause of death, but a more remote and deeper cause is to be found in the limitation of vital strength to the length and the necessary duties of the reproductive period. They live in a torpid condition for days or weeks until fertilization is accomplished."

The emperor-moth as well as the Cecropia moth belong to the family Saturniidae. Neither species in the imago state takes nourishment, still there seems to be some difference in the duration of life of the emperor-moth when compared with that of the Cecropia moth.

The female Cecropia moth does not die after egg laying, and the males in the act of copulation, as Weismann tells us of the emperor moth; but the female Cecropias die, in the greater number of cases, before all the eggs are deposited, while the males live, on an average of 9 days and 42 minutes, after separating from the females.

The female Cecropias do not live in a torpid condition for days or weeks until fertilization is accomplished, but

[4] Essays upon Heredity. English translation. 159. 1891. (2d Ed.)

oviposit whether or not mating has taken place, and their life is of no longer duration than that of their fertilized sisters. In the three cases observed egg laying occurred within 3 or 4 days after hatching. Perhaps Weismann's emperor moth could live for days or weeks in a torpid condition, awaiting impregnation, on the accumulated reserve nutriment. But in the Cecropias we found both males and females so active that all efforts were made to mate them early in life. This was done to avoid damaging their wings and also to avoid an excessive expenditure of vitality, which probably would have shortened their lives.

In his essay on the Duration of Life[5] Weismann points to the case of *Aglia tau,* in which the duration of male and female life is unequal. He says: "The males certainly live for a period of from eight to fourteen days, while the female moth seldom lives for more than three or four days." This, he seems to think, is an adaptation for the good of the species, for he says the males "fly swiftly in the forests, seeking for the less abundant females."

Weismann evidently means that the males fly swiftly through the forests after impregnating the females, although he may possibly mean that they do so before mating. If the former is true, we must assume that the species is polygamous, and, if the latter, that it is monagamous.

Both *Aglia tau* and *Samia cecropia* belong to the family Saturniidae (Claus). The greater duration of life of the male, that we found among the Cecropia moth, is somewhat analogous to that of *Aglia tau,* but how this difference can prove of benefit, at least in the Cecropias, I have no way of telling. Were the species polygamous, perhaps the longer life of the male would be of value to the race, were it not for the fact that the life of the male, after leaving the female, is one of inactivity and

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[5] Essays on Heredity. English translation. 18. 1891. (2d Ed.)

slow decline. The Cecropia moth has about enough vitality to fertilize one female; after that its longer or shorter life is of no consequence to the species.

Seeing the similarity between the duration of life and the functionless proboscis in *Aglia tau* and *Samia cecropia,* are we not justified in supposing that *Aglia tau* is also monagamous, and that the longer duration of life of the male of *Aglia tau* is one of slow decline and that physically it is unfit to fly actively about after impregnation?

If we suppose Weismann to mean that *Aglia tau* flies swiftly through the forests before mating, we must conclude that the species is monagamous. If the species is monagamous, and if the females reject old or middle-aged males, as they do in the cecropia, and considering the physical condition of a moth that has flown through the forests without nourishment for from eight to fourteen days, we can well see how necessary it is for mating to take place while the males are quite young. If it is necessary for the male to mate when very young, in what way can a useless life of the male from 8 to 14 days benefit the race?

Weismann states that his notes on the life of *Aglia tau* are not from direct observation, but are estimated from the time when these insects were seen on the wing. It might be possible that further observations on *Aglia tau* would show that the duration of its life and its habits are somewhat similar to that of *Samia cecropia.*

(*b*) *Conclusions.*

Finding the duration of life of the female to be insufficient to propagate the race to its fullest extent, and, in contrast to this, an excessive duration of life in the male, which in a species that is monagamous can be nothing but useless, we must conclude that the duration of life at this stage of evolution cannot be an adaptation for the good of the species.

Perhaps the male lives longer because it can accumulate larger stores of reserve nutriment in the larval stage. The female, having a large mass of ova to produce, has perhaps little time or room to lay up as large a store of reserve nourishment, and in many cases it may be possible that the supply is insufficient to completely carry it through the reproductive period, while in the male it may be so great as to carry it far beyond. Again, if the reserve nutriment be equal in both sexes, the earlier death of the female may be due to the expenditure of a greater amount of vitality in the efforts of egg laying.

We have seen that those females, which had a male almost in waiting, so to speak, when they hatched, were overtaken by death when all the eggs had been deposited; we also found that death, after a time, likewise overtook those less fortunate females, who mated late in life and were cut short in their ovipositing regardless of whether the propagation of the species was assured to the fullest extent. For just this reason one is apt to think that out of 68 cocoons 43 were males so that they might be on hand to properly fertilize the females early in life and thus insure perfect oviposition.

Thus we are led to suppose that the greater number of males is an adaptation for the good of the species, and that perhaps this came about through natural selection. But if natural selection produced a greater number of males it also endowed them with a longer duration of life, which is as useless to the individual as to the species.

If natural selection is so great a factor in economically producing adaptation, would it not have been easier, and perhaps better, to prolong the life of the female just a few days or perhaps a few hours to insure perfect oviposition, than to produce a greater number of males and uselessly prolong their lives to insure impregnating the females at an early age? Could it not be possible that the phenomena here observed are the incipient stages of higher adaptation, or that at this stage of the Cecropia moth we have a phylogenetic vestige of the time when the long life of the male was of advantage to the species? Perhaps before the mouth parts degenerated, the species took food and was long lived, and may have been polygamous and the proportion of the sexes equal.

Possibly the female died of exhaustion in ovipositing, while the male was able to fly about actively, finding and impregnating many females, which, being heavily laden with ova, were inactive and could not conveniently fly about to seek the males. Can it possibly be that the longer duration of life of the male, as we now see it in the Cecropia moth is a vestige of the time when such longevity was of benefit to the species?

TABLE I. COPULATING PAIRS.

Pair known as	Date of Hatching of Female	Date of Hatching of Male	Time when First Seen in Copulo	Time when Pair was First Observed Separated	Time Spent in Copulo	Date when First Eggs were Deposited	Number of Eggs Deposited					Number of Eggs Retained After Death	Entire Number of Eggs Carried by ♀
							1st Day	2nd Day	3rd Day	4th Day	Total		
A 1	....	....	5/16 7 A. M.	5/17 8:15 A. M.	1 da. 5:15 hrs.	5/17	5/17 210	5/19 80	5/20 27	None	317	45	362
A 3	....	....	5/19 6:30 A. M.	5/20 6 A. M.	23:30 hrs.	5/20	5/20 158	5/22 38	5/23 17	None	213	61	274
A 4	....	....	5/18 6 A. M.	5/18 2:30 P. M.	8:30 hrs.	5/19	5/19 117	5/20 53	5/21 43	5/22 4	217	91	308
A 5	....	....	5/20 6 A. M.	5/21 6 A. M.	1 da.	5/22	5/22 58	5/23 80	5/24 21	None	159	112	271
A 8	5/29 10:30A.M.	6/3 4 P. M.	6/4 6 A. M.	6/5 6:30 A. M.	1 da. 0:30 hrs.	......	....	....	....	......	260	98	358
A 9	6/6 7:30 A. M.	6/4 6:30 A. M.	6/9 6 A. M.	6/9 6 P. M.	12 hrs.	......	....	....	....	......	287	4	291
A 10	6/9 bet. 12 noon and 5 P. M.	6/7 2 P. M.	6/10 6:30 A. M.	6/11 6 A. M.	23:30 hrs.	......	....	....	....	....	796	0	810
A 10a	6/9 bet. 12 noon and 5 P. M.	6/7 2 P. M.	6/10 6:30 A. M.	6/11 6 A. M.	23:30 hrs.	......	....	....	....	....		14	
A 11	....	....	6/11 6:30 A. M.	6/12 6:30 A. M.	1 da.	......	....	....	....	......	187	0	187
A 12	Bet. 12 noon 6/9 and 2 P. M. 6/10	6/11 3:30 P. M.	6/12 7 A. M.	6/13 2:30 A. M.	17:30 hrs.	......	....	....	....	......	229	55	284
A 14	6/11 2 P. M.	6/12 10 A. M.	6/13 8:30 A. M.	6/14 7 A. M.	22:30 hrs.	......	....	....	....	......	?	125	?
A 15	6/12 4:30 P. M.	6/12 4:50 P. M.	6/14 6:30 A. M.	6/14 5 P. M.	10:30 hrs.	6/15	6/15 81	....	6/20 150*	None	231	0	231

* Additional were found.

TABLE I. COPULATING PAIRS — *Continued.*

Pair known as	Date of Death of Female	Date of Death of Male	Duration of life of ♀ from copulation until death	Duration of life of ♂ from copulation until death	Duration of life of ♀ from hatching until death	Duration of life of ♂ from hatching until death	Length of time ♂ survived its ♀	Life of ♂ from termination of copulation until death	REMARKS
A 1	5/21 4 P. M.	5/21 5:30 P. M.	5 da. 9 hrs.	5 da. 10:30 hrs.	....	....	1:30 hrs.	4 da. 9:15 hrs.	Death of ♂ accidental.
A 3	5/23 7 P. M.	6/1 6 A. M.	4 da. 12:30 hrs.	12 da. 23:30 hrs.	....	....	8 da. 11:00 hrs.	12 da.	
A 4	5/25 6:30 A. M.	5/28 6:30 A. M.	7 da. 0:30 hrs.	10 da. 0:30 hrs.	....	....	3 da.	9 da. 16 hrs.	Pair accidentally separated while in copulo.
A 5	5/25 4 P. M.	6/2 7:30 A. M.	5 da. 10 hrs.	13 da. 1:30 hrs.	....	....	7 da. 15:30 hrs.	12 da. 1:30 hrs.	
A 8	6/8 6 A. M.	6/14 3:30 P. M.	4 da.	10 da. 9:30 hrs.	9 da. 19:30 hrs.	10 da. 23:30 hrs.	6 da. 9:30 hrs.	9 da. 9 hrs.	
A 9	6/15 12 N.	....	6 da. 6 hrs.	....	9 da. 4:30 hrs.	....	....	....	♂ escaped.
A 10	6/16 6:30 A. M.	6/17 7 A. M.	6 da.	7 da. 0:30 hrs.	6 da. 16 hrs.	9 da. 17 hrs.	1 da. 0:30 hrs.	6 da. 1 hr.	7 ♂'s had hatched 6/7 P. M. 2 were selected. Both pairs placed in one cage. Estimated date of ♀ birth 6/9, 2:30 P. M.
A 10a	6/18 7 A. M.	6/18 7:30 P. M.	8 da. 0:30 hrs.	8 da. 13 hrs.	8 da. 16:30 hrs.	11 da. 5:30 hrs.	12:30 hrs.	7 da. 1:30 hrs.	
A 11	6/18 1:30 P. M.	6/21 7:30 A. M.	7 da. 7 hrs.	10 da. 1 hrs.	....	....	2 da. 18 hrs.	9 da. 1 hr.	
A 12	6/17 7 A. M.	6/21 7:30 A. M.	5 da.	9 da. 0:30 hrs.	7 da. 7 hrs.	9 da. 16 hrs.	4 da. 0:30 hrs.	9 da. 5 hrs.	Time figured on ♀ hatching as 6/10, 12 midnight.
A 14	6/19 12:10 P.M.	6/22 2 P. M.	6 da. 15:40 hrs.	9 da. 5:30 hrs.	7 da. 21:50 hrs.	10 da. 4 hrs.	3 da. 1:50 hrs.	9 da. 5:30 hrs.	The eggs of this pair for the greater part were lost.
A 15	6/20 10:30A.M.	6/21 7:30 A. M.	6 da. 4 hrs.	7 da. 1 hrs.	7 da. 18 hrs.	8 da. 14:40 hrs.	21 hrs.	6 da. 14:30 hrs.	

TABLE II. UNFERTILIZED FEMALES.

Known as	Date of Hatching	Date when First Eggs were Deposited	Number of Eggs Deposited					Number of Eggs Retained after Death	Entire number of Eggs Carried	Date of Death	Duration of Life from Hatching Until Death	REMARKS
			1st Day	2d Day	3rd Day	4th Day	Total					
B 5	5/28 2:30 P. M.	5/31	5/31 19	....	....	last eggs laid 6/4	113	201	314	6/4 3 P. M.	7 da. 0:30 hrs.	
B 1	5/20 2:30 P. M.	5/24	5/24 8	....	....	last eggs laid 5/28	135	175	310	5/28 2:30 P. M.	8 da.	
B 1a	5/21	....	Up to 5/29 the 2 ♀'s deposited 278 eggs	....	....	....	380	4	384	5/29 9:30 P. M.	8 da.	B 1a and B 2a were placed in one cage.
B 2a	5/25	....		....	....	last eggs laid 5/31		0		6/3 7:30 A. M.	9 da.	

Issued February 26, 1910.

HAIL INJURY ON FOREST TREES.*

Frank J. Phillips.

Among the minor injuries to which forest trees are exposed that of hail storms is one of the most interesting. The total amount of primary damage resulting from such storms is always localized sharply and while this damage may be temporarily great so far as the locality is concerned, it is not ordinarily severe for a whole region or for a whole state even for a series of years. Within the limits of individual storms, forest growth as a whole is more immune from serious effects than almost any other crop with the possible exception of the short, non-cultivated grasses. Whole crops of fruit and vegetables are often entirely ruined while forest trees usually escape with varying amounts of defoliation, laceration of the bark and cambium, and the occasional destruction of young trees or sprouts. Many of the European texts consider this injury limitedly and one authority[1] on hail reports storms which were severe enough to remove branches two inches in diameter.

No other region in the United States presents as good a field for such an investigation as does the middle west. A large number of hail storms occur in adjoining states but the states of the Plains may be rightly called the hail storm center. Missouri and Nebraska have been selected as good examples for this region. In both these states hail is a typical late spring and summer phenomenon, although such storms do occur in March, October and November in Missouri. Hail has been reported during the winter months, but this is probably pellets of snow or soft hail without crystalline structure, the same as the "Graupeln" of Germany.

In Missouri[2] during April and May, particularly the latter month, hail accompanies almost every thunder-

* Presented by title to the Academy of Science of St. Louis, December 20, 1909.

[1] On Hail. R. Russell. 1893.

[2] Information supplied by George Reeder, Section Director, U. S. Weather Bureau.

storm that is of marked energy. In the majority of instances the duration of the fall is for one or two minutes, while the stones are few in number and range from one-fourth to one-half inch in diameter though they may be an inch or more in diameter. The hail belt is generally a narrow strip running from east to west or from the southwest to the northeast, but has been reported running in other directions. The extent of the belt usually ranges from two to four hundred feet in breadth to a half mile or more long, skipping a large section to fall again farther along. Once or twice during a decade a storm may be very severe, covering territory several miles wide and ten to fifteen or more miles in length.

For the fifteen years 1895-1909 the average number of hail storms was as follows: March, 2; April, 8; May, 12; June, 8; July, 4; August, 4; September, 3; October, 2. Many of these were very slight and caused no damage. It appears that hail storms are more frequent and severe in the northwestern part of the state. Probably the most severe hailstorm that has occurred within the history of the state was that of September 5, 1898.[3]

The following table will give a general idea as to the prevalency of such storms and the possibility of injury to forest trees:

Stations in Nebraska.	No. of Years of Observation.	NUMBER OF DAYS ON WHICH HAIL FELL.[4]						Total.
		April	May	June	July	Aug.	Sept.	
Ashland	26	13	16	7	6	1	1	44
Beaver City	20	4	4	16	3	1	1	29
Fairbury	27	7	8	8	3	7	2	35
Fremont	32	8	8	9	7	1	0	33
Genoa	21	14	19	15	9	7	6	70
Harvard	22	22	15	9	11	5	2	64
Hay Springs	23	4	8	11	10	9	1	43
Kimball	22	2	16	27	17	4	2	68
Lincoln	24	19	11	11	6	10	4	61
Minden	32	29	24	22	12	8	7	102
Oakdale	21	7	17	12	3	8	6	53
Ravenna	32	10	14	12	9	4	2	51
Weeping Water	32	7	28	13	7	8	4	67

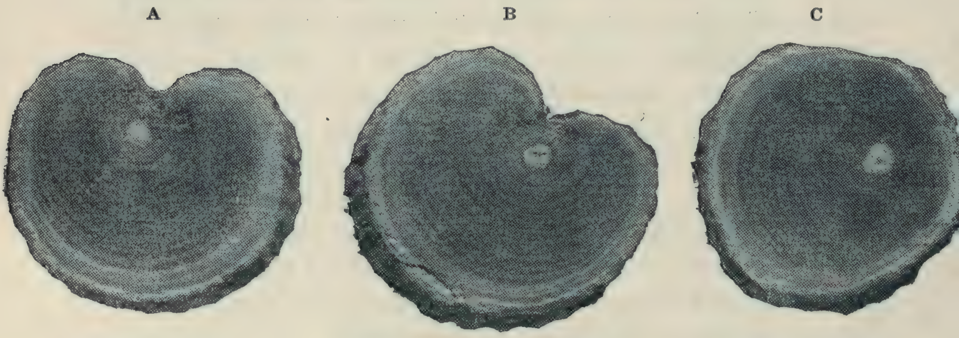
[3] Described in Monthly Report, Missouri Section, October, 1898.
[4] Information supplied by Prof. Geo. Loveland, Section Director, U. S. Weather Bureau.

This is the total number of days that hail was reported for each month from April to September inclusive. A few hail storms were reported in March and October, but they were few and scattering. Most of the storms here reported were entirely harmless or did but little damage. These stations are considered the most reliable in the state.

Excellent opportunity for studying this kind of injury was afforded by a hailstorm which occurred at Hutchinson, Kansas, on the last day of May, 1908. The storm started about 5 a. m., and lasted for 20 to 30 minutes, doing damage both north and south of the city. The hail clouds came from the northwest against the wind which was blowing from the southeast. This probably accounted at least partially for the duration of the storm and explains why the defoliation of forest trees occurred on the south and east sides although the clouds came from the opposite direction. The hail stones ranged from the size of a hazelnut to that of a hickory nut and formed a layer of 1 to 4 inches in depth. The stones on the outskirts of the storm were reported to be of a larger size but were fewer in number, and the injury to all forms of vegetation was less than in the center of the storm.

Hardy catalpa suffered worse than any other forest tree. Except in rare cases whole stands were entirely defoliated and the bark badly torn on exposed branches. On trees 6 to 10 years old many wounds were measured which were continuous for 12 to 15 inches, and occasionally these wounds were an inch or more in breadth. Especially bad effects were noted in one year old coppice stands. Such sprouts are very succulent, never possess side branches and have large, tender leaves. In such stands it frequently happened that many sprouts were broken from the stump, while others had the bark completely girdled or shredded for their entire length. In coppice shoots older than one year as well as in seedling stands the current season's growth was almost invariably killed back while in many cases the shoots were killed back into the last season's growth. However, the bark was only slightly injured on growth 3 years old or over and this injury occurred almost invariably between the flakes or ridges of bark. It has frequently been reported that only moderately severe hailstorms cause a serious malformation and restriction of growth when catalpa pods are developing. Such malformation consists of badly curved pods, many of which fail to develop. Moderate hailstorms after the pods are fully developed rarely do serious damage.

Sycamore suffered co-ordinately with the catalpa in regard to leaf defoliation and very nearly as bad results to the young twigs. The effect was so severe that not a



HAIL INJURY TO CATALPA.

single sycamore was seen which had not made an entirely new seasonal growth and often the growth was killed back so that the adventitious buds developed from the middle of last season's growth. Unlike the catalpa, however, the bark on the sycamore shoots 2 years old was not severely injured, but the force of the hail caused slight wounds on the largest trunks. A microscopic examination showed that few of these wounds had affected the cambium badly except in twigs and small branches.

Russian mulberry suffered badly from defoliation and injury to new growth. In the usual cases two-thirds to three-fourths of each tree was defoliated while many specimens standing in the open were entirely defoliated. Injury to the bark was nearly as severe as it was to the catalpa with the exception that the bark wounds on catalpa were much more irregular because of the fibrous nature of the bark.

The deepest bark wounds on any species were found on the cottonwood and box elder. This was due to the soft, smooth nature of the bark which extends over comparatively large branches, while in such trees as catalpa the bark matures rapidly. It was not infrequent to see branches of cottonwood 3 to 4 inches in diameter with wounds an inch broad and several inches long. Cottonwood was about one-half defoliated; the characteristic injury consisting of riddled leaves which consequently lost their function and were shed by the tree. A peculiar character of the injury to the limbs consisted of wounds bridged over by dead cortical strands of fibrous bark. It is thought that the force of the hail was sufficient to injure the cambium without entirely destroying the bark. The possibility of fungus action was considered but since no trace of fungi was found in such areas it was thought improbable that the injury was due to such a cause.

Honey locust suffered from defoliation but had only slight injury to the wood. Black walnut was in most cases entirely defoliated. The bark was wounded slightly more than honey locust but not so much as box elder or cottonwood. Silver maple had slight injury both to the leaves and the bark. Green ash leaves were less injured than black walnut while the bark was injured about the same. Russian olive leaves were scarcely affected and the bark showed injury only in rare cases. Bur oak had no appreciable injury to the bark and only a few leaves were partially lacerated.

Box elder suffered more from defoliation than did cottonwood, but on the other hand more leaves were shed and fewer lacerated. The wounds on the young wood were as severe as on cottonwood. American elm suffered moderately from defoliation and laceration, but had only rare injury to the bark. English elm showed still less effect on leaves and wood than American elm. White willow suffered worse than sand-bar willow in both bark and leaf injury. Osage orange showed the least effect of any of the broad leaved trees.

Conifers as a class were much less affected than were the broad leaved trees. Scotch pine suffered most, but even in the worst cases lost only a few leaves and showed few wounds on the bark. Austrian pine was still less affected than Scotch pine and red cedar showed no injury.

The relative resistance of the broad leaved species in this storm is shown in the following table in which the worst affected species are placed at the head of the table.

DEFOLIATION.	INJURY TO TWIGS.
Catalpa (*Catalpa*).	Catalpa.
Sycamore (*Platanus*).	Russian Mulberry.
Russian Mulberry (*Morus*).	Box Elder.
Cottonwood (*Populus*).	Cottonwood.
Box Elder (*Negundo*).	White Willow.
Black Walnut (*Juglans*).	Sandbar Willow.
Green Ash (*Fraxinus*).	Sycamore.
Silver Maple (*Acer*).	Green Ash.
Honey Locust (*Gleditschia*).	Silver Maple.
White Willow (*Salix*).	Black Walnut.
Sandbar Willow (*Salix*).	Honey Locust.
American Elm (*Ulmus*).	American Elm.
English Elm (*Ulmus*).	English Elm.
Osage Orange (*Maclura*).	Osage Orange.

All species suffered most severely from defoliation on the sides from which the storm came, while the worst injury to twigs and branches occurred in the tops of the trees and usually on such exposed branches as were most nearly at right angles to the hail. This occasionally caused the opposite side of the tree from which the storm came to have more wound injury to bark than the side from which the storm came. In four Carolina poplars which were examined it seemed that less bark injury occurred than in common cottonwood, and it is thought that the sharper angle of branching had much to do with this. Unfortunately time did not permit a search for a sufficient number of these trees to determine this point.

Trees with flexible branches suffered less than those with stiff branches. Species with small twigs or with hard wood suffered less than those with large twigs and succulent wood. Large, succulent leaves were much worse affected than linear leaves, cut leaves, or leathery leaves. Coppice was more seriously affected, because of the more succulent growth and also because it retains smooth bark for a much longer period, than seedling growth. An especially noteworthy feature of the injury was noticed in the growth of the new leaves where entire defoliation had taken place. In every case the first leaves developed at the ends of the growing shoots, when the shoots were not badly wounded. If the shoots were broken or severely lacerated, the first leaf developed from an adventitious or a dormant bud back of the injury. Such leaves were usually at least one week in advance of all other leaves. Lateral leaves further down the shoots continued to appear from 3 to 4 weeks after the first leaves, thus causing a very irregular and prolonged leaf development. The retention of thick, leathery leaves such as occur on osage orange aids materially in protecting the shoots. In Europe[5] the removal of the forest is said to increase the frequency of hail.

The injury to forest trees caused by hail is especially likely to induce secondary injuries from forest fungi and insects. In cases of severe injury to shade trees it would be well to trim off the branches most severely affected and to watch carefully for insect or fungus infestation. As a result of two years' observation there seems little doubt that hail injury increases the infestation of hardy catalpa by dry rot (*Polystictus versicolor* Fr.). Hardy catalpa does not recuperate readily from hail injury and most of the plantations, windbreaks and shelterbelts in the state show the effect of some hail storm of the past. In such plantings it is a common occurrence to find wounds ten to twenty years old which have not healed over and such badly wounded branches often show a great deal of fungus action. Some of the wounds show a secondary injury by insects, but so far this is limited. Most of these wounded trees are also characterized by water sprouts

[5] Houston, E. J. Outlines of Forestry. 147. 1893.

which on trees 30 to 45 feet tall may number 200 to 300 to the tree.

Attention should also be paid to the management of catalpa coppice during the first year. It has been customary to leave two or three sprouts to each stool for the first year because of the danger from wind. In case of hail an immediate inspection of the coppice should be made and if the injury has occurred early in the growing season all badly injured growth should be removed. Occasionally it will be necessary to cut all the sprouts, but in most cases from 1 to 3 healthy sprouts will remain. At the end of the first growing season, the plantation should again be thinned leaving one sprout to the stool. The reason for cutting off sprouts badly injured by hail immediately after the storm is obvious. If such sprouts were allowed to remain the growth would be inferior and the stool would be weakened. If injury occurs in the middle of or late in the growing season it is best to leave one sprout to the stool or to leave all remedial work until the end of the season because of the danger from winter killing.

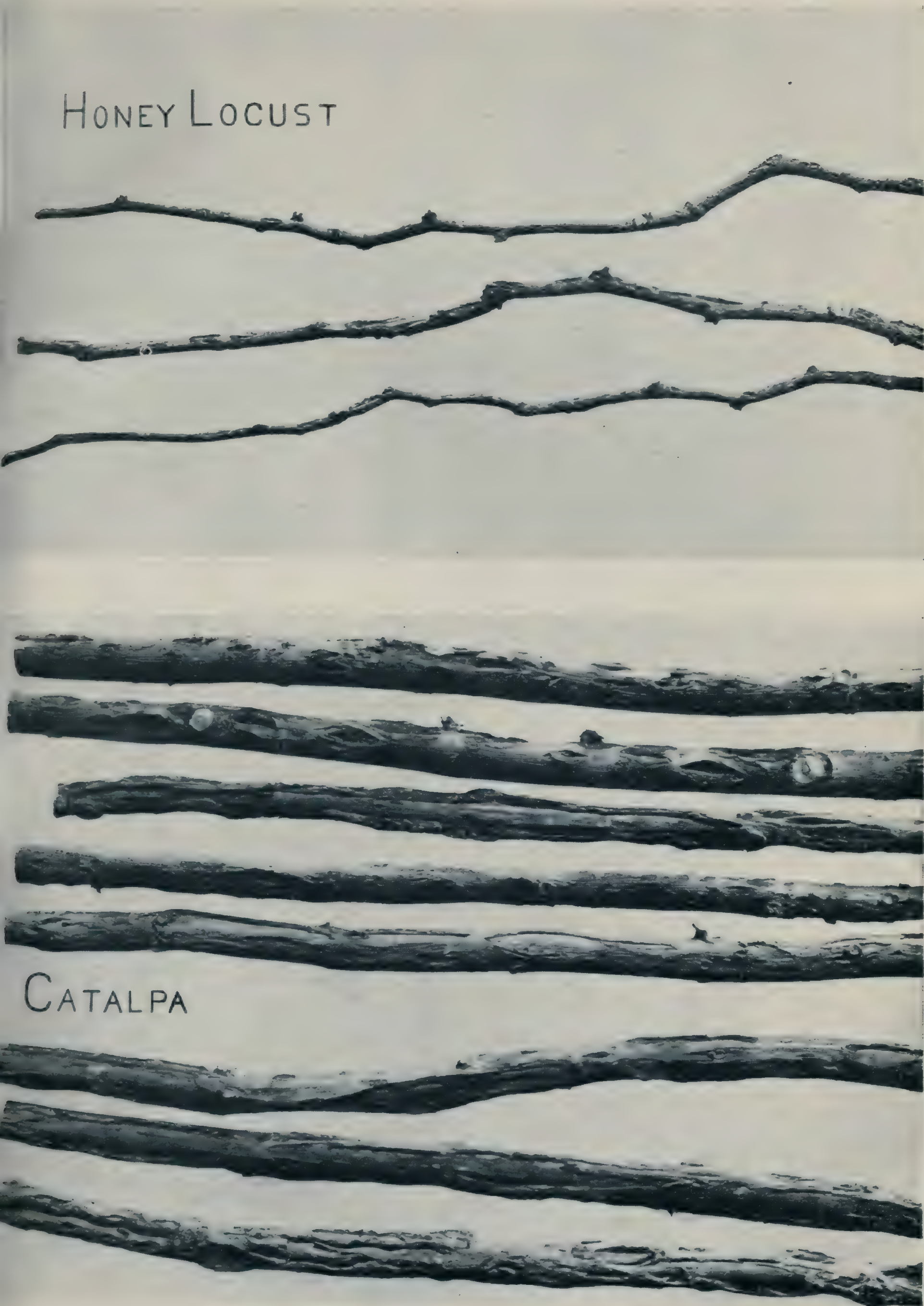
Hail injury naturally reduces the annual wood increment and in such a storm as the one which occurred at Hutchinson it causes the formation of false annual rings in the species worst affected. Natural pruning of the branches continues for many years after a hail storm has passed; such pruning occurs first on weakened, interior branches and branches deeply wounded, but the pruning continues and has been noted on branches which had been injured 19 years previously. Favorable climatic conditions immediately after the storm assist tree growth in recuperation while a prolonged drouth would greatly increase the damage.

EXPLANATION OF ILLUSTRATIONS.

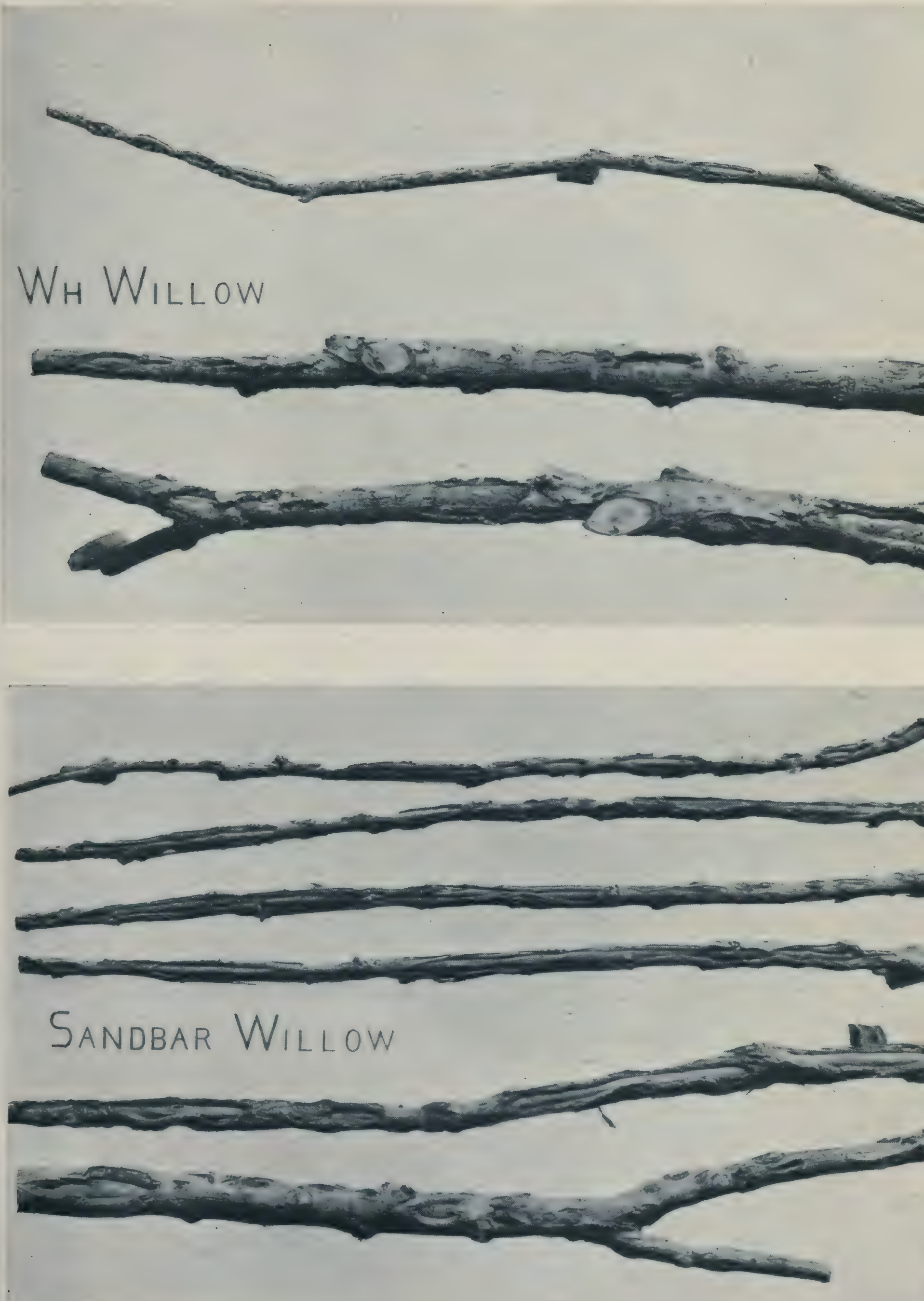
Text-figure. Hail injury to hardy catalpa, experienced ten years before the photographs were made. B shows a false ring. C is fourteen inches below an open wound, but still shows heart-rot. Reduced.

Plates XI–XVII.— Hail injury to twigs of various forest trees. One-half natural size.

Issued March 10, 1910.



HAIL INJURY.



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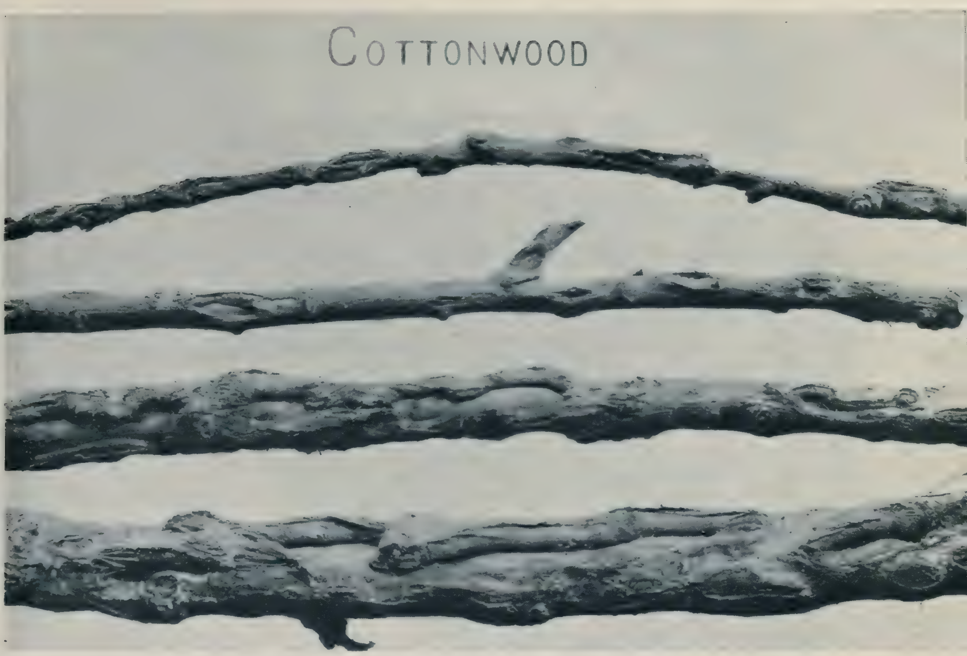
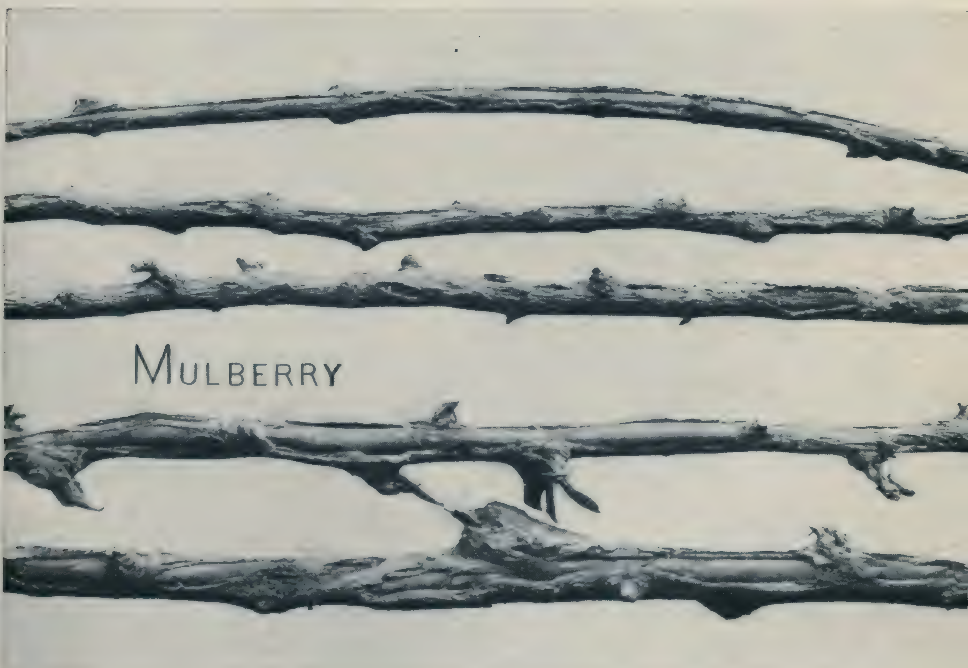
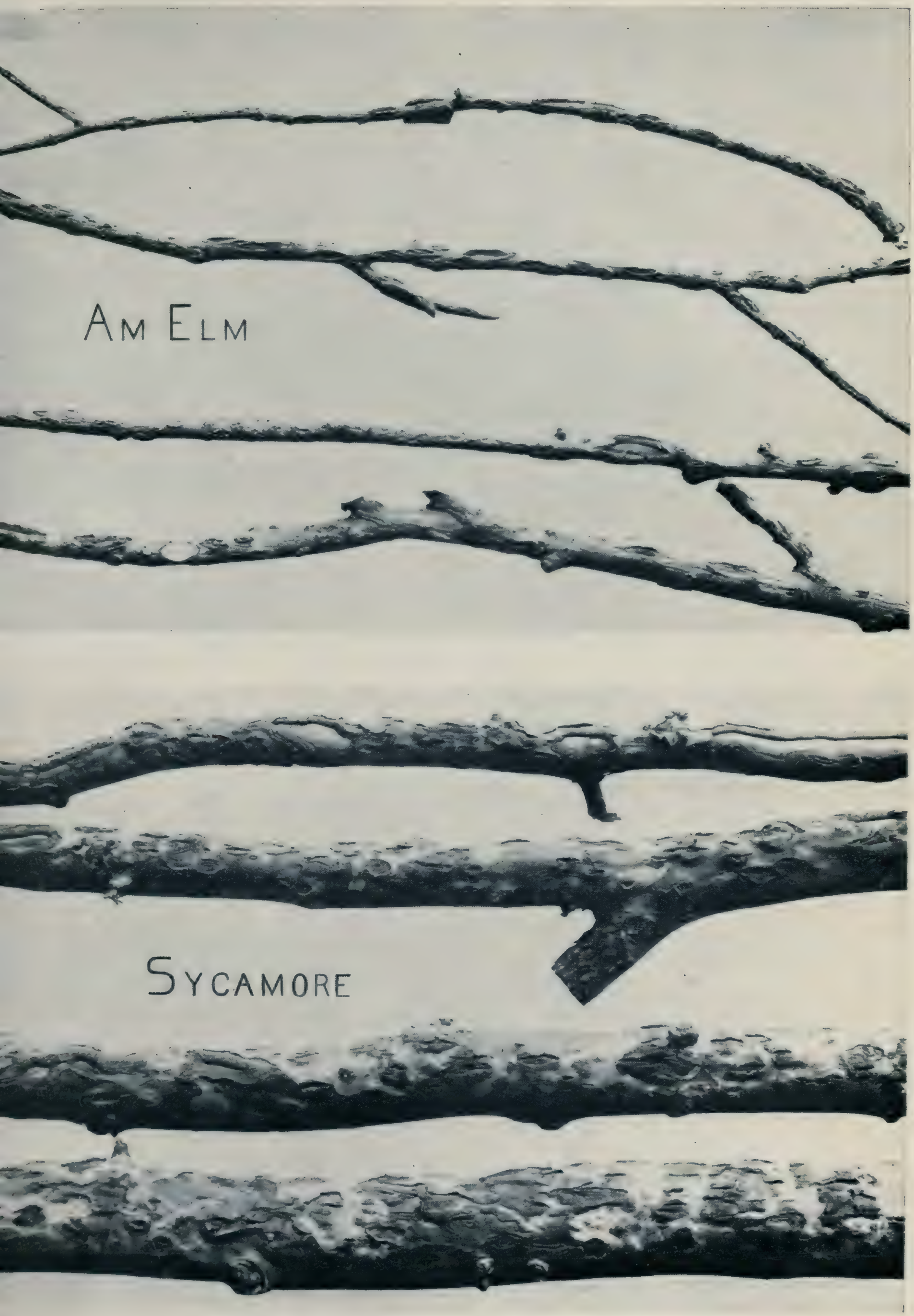




HAIL INJURY.



HAIL INJURY.

HAIL INJURY.

HAIL INJURY.

HARDY CATALPAS, AFTER A LAPSE OF TEN YEARS

HAIL INJURY, FOLLOWED BY INSECT ATTACKS.

HARDY CATALPAS, AFTER A LAPSE OF TEN YEARS.

ON THE NATURE OF THE ELECTRIC DISCHARGE THE ONE-FLUID AND THE TWO-FLUID THEORIES.[1]

FRANCIS E. NIPHER.

The dissymmetry in the discharge effects at the positive and negative terminals of an electric machine is now ascribed to the difference in the size of the carriers of the electric discharge. In my former paper in these Transactions evidence has been presented, which shows that this dissymmetry is due to the fact that the negative electrons are being forced out under "pressure" at the negative terminal, and that they are being drawn in at the positive terminal under conditions which may be likened to those on the exhaust side of a pump. Characteristic forms of discharge lines usually attributed to positive and negative discharge are shown in Plates XVIII and XIX, Figs. A and B.

Such plates were obtained by means of the arrangement shown in Fig. 1.

The lines leading from the terminals of an influence machine are separately grounded in the yard outside of the building. In each line there is a spark-gap of several centimeters at the machine terminal. Each line has another gap, the two ends of which terminate in pin-heads which make a spring contact with copper plates P and P^1. The copper plates rest on sheets of glass. The pin-head nearest the machine in the positive line, and the one nearest the ground in the negative line are in Fig. 1 shown as resting on the film of a photographic plate. The other pin-heads rest on the copper sheets. In each case there will be an inflow of Franklin's fluid from the copper plate to the pin-head. This inflow is in

[1] Continued from No. 1, Vol. XIX. Presented before The Academy of Science of St. Louis, May 2nd, 1910.

part a disruptive spark discharge. This is accompanied by a streaming in of the negative fluid from various directions over the film. See Plate XVIII, Fig. B, and Plate XIX, Fig. A. In the negative line the copper plate is in the case shown in Fig. 1 energized by a compression

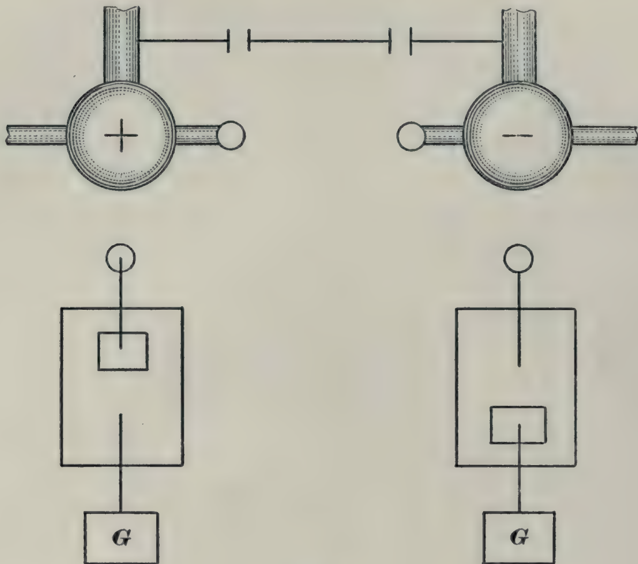


FIG. 1.

action from the machine terminal. The discharge from the film is urged towards and into the grounded line. The flow lines resemble a system of rivers and tributary streams.

In the positive line the terminal resting on the film is in a condition which may be described as an exhaust condition. The electric fluid is then drawn into the pin-head terminal from the film. The stream lines in this case certainly originate at the pin-head terminal, and elongate in a direction opposite to that of the flow. Possibly this may be true of the plate in the negative line also. The results seem to be alike in character. The action is, however, different, and it may be that there is a difference in degree. There is in both cases a condenser effect. In Plate XVIII, Fig. A, and Plate XIX, Fig. B, are shown two plates where in each gap of Fig. 1, the plates were exposed at the opposite terminal. Here we have over each film a negative outflow from the pin-head. In the negative line the outflow is from the pin-head, which is in communication with the machine. In the positive line it is an outflow from the grounded pin-head. This outflow is induced by the copper plate below, which is in an exhaust condition. Franklin's fluid has been drawn out of it. These discharge lines are also alike in character. These results might have been expected, if the ground connections in Fig. 1 were broken, and the lines were connected to form a circuit between the machine terminals. This result is similar to that described in the former paper[2] for the Crookes tube.

It can hardly be claimed that these four photographic plates contain in themselves evidence that they are produced by au outflow at one terminal of each gap, and by an inflow at the other terminals. Such plates have long ago been produced at the gap terminals of an electric circuit, and they have not suggested such an explanation. But when it is known that the so-called positive discharge is an inflow of negative electricity, the plates themselves seem to be suggestive of such a condition.

If both terminals in either of the gaps in the discharge lines of Fig. 1 be placed on the film of a photographic plate, the terminals of the two forms of discharge lines will unite with each other as should be expected if one is an outflow and the other an inflow. In such an exposure, a sheet of glass may be placed between the metal plate and the photographic plate. In the exposure of the four photographic plates thus far described, the spark gaps at the machine were between large knobs. No appreciable brush discharges which could affect the film preceded the disruptive discharge.

The exposure table was screened from external sources of light due to sparks at the machine. It was also wholly surrounded by a metal screen of wire netting, which was

[2] These Trans. XIX, 1, p. 7.

grounded on an independent ground. The diagonal brushes of the influence machine were also grounded independently of all other ground contacts.

Conditions Which Precede Disruptive Discharge.

In making an examination of the conditions which precede a disruptive discharge, the arrangement shown in Fig. 1 was somewhat modified. The metal plate was removed. The photographic plate was lifted above the glass top of the table, and supported at its edges only by insulating supports. The pin-head terminals were moved nearer together and rested on the same film, which had dimensions $3\frac{1}{4}$x$4\frac{1}{4}$ inches. The spark gap at the machine was reduced to 3 or 4 mm. The plates of the machine were revolved very slowly. Several small sparks at the machine having followed each other in quick succession, a spark would pass across the film between the pin-head terminals. In a series of plates to be described, the exposure was in the negative line. The positive terminal was grounded, on an independent ground.

Fig. A of Plate XX shows the effect of a single small spark at the machine. The negative inflow at the pin-head terminal marked G, which was connected with the ground is very slight. In B and C, the exposure was slightly increased. This may be done by increasing the number of minute sparks at the machine, or by slightly increasing the length of this spark. Fig. A and Fig. B of Plate XXI show the result of a slight increase of the spark length. The ionization of the air due to the inflow of negative electricity to the grounded pin-head has in Fig. A extended to the small fogged area around the pin-head, which is receiving the negative discharges from the machine. This is the negative glow. We have here the same phenomenon that was pointed out in the former paper. It is apparently with difficulty that the negative discharge can be forced out of the negative terminal, but it can easily be drawn in from the film to the positive terminal. The results here shown were obtained when the plates were exposed in open air in the darkened room containing the influence machine. No change in the result was obtained when the table with its overhanging curtains on which the plates were exposed, was wholly surrounded by a cage of galvanized wire screen which was then grounded.

The lines of inflow on this series of plates are in appearance like the outer extremities of the lines of inflow in Fig. B, Plate XVIII, and Fig. A, Plate XIX.

When the exposure has reached the stage represented in Fig. A, Plate XXI, a spark is on the point of passing. In securing such a plate dozens of plates may be spoiled by the passage of a spark. Such a result is shown in Figs. B and C, Plate XXI. In the latter figure, the disruptive discharge evidently did not begin at the grounded pin-head. That terminal was surrounded by a film of ionized air, which was thus sufficiently possessed of the property of conduction, to prevent the formation of the rarefied hole or channel through which the disruptive discharge passed. The end of this hole is about 4 mm. from the grounded pin-head. The volley of negative electrons which passed through this discharge channel from the negative terminal, was apparently fired at the grounded pin-head across this small interval of ionized air. The result is seen in the fogging of that part of the plate around the grounded terminal. The volley was apparently a diverging one. Its fogging effect extended more than a centimeter beyond the grounded terminal at which the volley was directed. The pin-head protected that portion of the film which was behind it as seen from the muzzle of the discharge channel. Fig. A, Plate XXII, shows a somewhat larger region of ionized air into which the discharge from the air channel was diffused. In Fig. B two sparks passed, the first of which apparently produced the ionizing effect. The second discharge passed through more than three centimeters of ionized air on its way to the grounded terminal and the fogging effect extended nearly an equal distance beyond, as is shown by the shadow cast by the pin-head.

In obtaining such ionization of the air around the grounded anode terminal, the plates of the machine should be turned with extreme slowness. There should be a gap of a couple of mm. at the machine terminal, and the rotation should cease for a moment, if it is thought that a spark may pass across the plate. After half a minute the velocity of rotation may be increased and the spark allowed to pass over the film. This method of procedure will give time for the ionization to be brought about, and will occasionally give desired results.

In Fig. C of Plate XXII the pin soldered to the end of the terminal wire was so bent, that the rounded head made contact at the central point of its rounded head with the photographic film. The form of the shadow shows that the cause for the fogging effect around this pin-head lies in a very thin layer of air at the film.

Fig. C of Plate XXII also shows that the origin of the agency which produces the fogging effect is at the muzzle of the discharge channel about midway between the terminals. Fig. D is a print from Fig. C. Hundreds of plates have been used in securing a comparatively few specimens which show the dispersion of the disruptive discharge at some point between the metallic terminals. In no case has such a dispersion area of ionized air extended to the negative pin-head. These ionization effects always have their origin at the grounded pin-head, although the presence of the negative pin-head is of course necessary in order to make the grounded pin-head effective.

Fig. A of Plate XXIII shows one of two exposures which have been obtained, in which the disruptive part of the discharge is a very small part of the distance between the pin-heads.

In both cases there is evidence that there was a discharge towards the negative terminal such as might be produced by an issuance of positively (or, perhaps, negatively) charged particles from the negative end of the spark channel. There is slight evidence of such discharge in other plates, which show the negative discharge towards the grounded terminal in a more strongly marked way. It certainly might be expected that some such effect might exist in case of a disruptive discharge.

Fig. B of Plate XXIII was exposed in the positive line in precisely the same way that former plates were exposed in the negative line. Here the negative discharge comes from the ground. The ionization is produced at the positive pin-head terminal, which is connected with the positive terminal of the machine.

In Fig. C of Plate XXIII the pin-head terminals were connected with the + and — terminals of the machine. The spark-gaps at the machine were not more than 3 or 4 mm. A single spark was passed through these gaps. This figure shows what is clearly shown in other plates, how insignificant is the ionizing effect at the negative terminal, as compared with that which produces the negative inflow at the positive terminal. In this plate these ionization effects are due to the exhaust effects at the positive terminal and to the presence of the negative terminal, which produces such effects at the opposite terminal, even when it is grounded. The effect is to be finally traced to the forced rotation of the glass plates of the machine in the presence of the inductor cards on the stationary plates

In this figure it will be observed that one of the stream lines which proceeds to the positive terminal curves around the small black area at the negative terminal. Its source is on the opposite side of the negative terminal from the positive terminal. Its curved form is due to the negative outflow from the negative terminal.

In this figure as well as in Fig. A of Plate XXI the discharge lines have a form which suggests lines of force from static charges of opposite sign. It is, however, to be observed that the conditions in these fields of force are dynamic in character. There is an outflow of gaseous molecules from both terminals, as will be explained later. The meeting and mingling of these oppositely directed "electric winds," produced the disturbed condition that is to be observed between the terminals and just outside of the dark circular area around the negative terminal. These lines do not terminate in the negative pin-head terminal in the same manner that they originate in the positive terminal. They appear distorted near the negative terminal, as if by a blast from that terminal. The significance of this will appear later. It may, however, be here stated that the conditions in this region, just outside of the negative glow, are like those in the Faraday dark space in the vacuum tube, although the mean free path of the molecules is of course very much less.

Canal Rays.

The results heretofore discussed in this paper and in the preceding one, suggested the idea that an insulated plate of metal placed between spark terminals of the influence machine should arrest the ionization of the air column between them and prevent the passage of sparks. This was tested by the arrangement shown in Fig. 2.

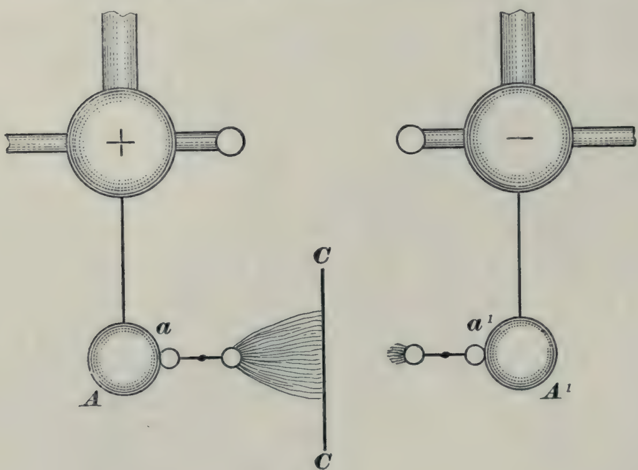


FIG. 2.

A and A' are large knobs of about 10 cm. diameter, having adjustable floating spark terminals *a* and *a'*. The large knobs are metalically connected with the larger knobs forming the terminals of the machine. Small spark gaps may be made at a and a^1, either by adjustment of the positions of A and A^1, or the floating terminals a and a^1.

If the adjustment is such that loud sparks are passing between the terminals, the effect of placing the insulated metal sheet CC midway between the terminals is to completely prevent the sparks from passing. A luminous brush "discharge" passes from the positive terminal to the plate. A luminous glow is formed at the negative terminal. This glow is of a character which indicates that an active discharge is passing from the negative terminal. But between this negative glow and the metal sheet the space is absolutely dark. The positive luminescence and the negative glow are produced only when a minute spark gap exists at a or a^1.

A photograph of these positive and negative discharge effects is shown in Fig. A. Plate XXIV. This photograph was made by means of a large copying camera, with an exposure of 15 minutes.

The distance between the knobs was about 13 cm.

When the metal plate was hung on long silk cords it set in stable equilibrium at a distance of 3 or 4 cm. from the negative terminal. In this position sparks passed through the plate as readily as they would pass when it was removed. The dark space still existed between the plate and the negative glow. If the plate is moved over to the positive terminal the dark space follows, as the positive column follows when the motion is in the opposite direction.

A small windmill having vanes of thin mica mounted in a hub of hard rubber, and turning on pivots of vulcanized fiber will revolve when placed in either gap. In the positive column, the air is thus shown to be moving towards the plate, and from the positive terminal. In the dark space the air is moving in the opposite direction. In the positive column the rotation was about like that which could be produced by walking with the wind mill in still air with a velocity of 1.5 meters per second. In the dark space the speed was somewhat less.

A hole of about 5 mm. diameter was made in the copper plate on the line through the two knobs. Loud sparks then passed. On the negative side of the plate they passed to the hole, keeping along the luminous positive ray which passed through the hole. On the positive side the sparks danced about in a fantastic way within the luminous column. A photograph of 80 spark discharges is shown in Fig. B, Plate XXIV. This photograph was obtained by replacing the large lens of the copying camera, by a small pin-hole in a sheet of tin-foil. It is evident that the spark discharge followed the column of air from which the negative electrons had been drained into the positive terminal.

The Leyden jars were removed from the machine, in order to avoid spark discharges. The brush discharges were photographed by means of the camera with lens, Fig. C, Plate XXIV. Here the positive column is seen to extend through the opening in the metal screen. It extends to the negative glow. A feeble negative inflow to the edge of the copper plate (a positive brush "discharge") is also to be seen. A comparison of this figure with the former one is very instructive. It shows that the cathode discharge is promoted by extending a channel of conducting air to the cathode. Nevertheless a discharge is continually passing through the dark space, when no opening exists in the metal screen. This transfer across the dark space is then evidently by convection. The air molecules are overloaded with the negative particles at the negative terminal, in the region of the negative glow. After passing through the dark space the negative particles are delivered to the metal plate, from which they pass to molecules in the positive column which have been deprived of negative particles through drainage to the positive terminal.

Fig. A of Plate XXV shows a shadow made by a glass tube when placed in the positive column, its end facing the camera. The air in this shadow is not in a condition to conduct the discharge from the metal plate. The tube cuts off the means for draining into the positive terminal, the electrical particles contained in the molecules within the shadow, or between the tube and plate. The positive column shown in Figs. A and C, Plate XXIV, and all the figures of Plate XXV at any instant show to the eye the same details which are shown in Fig. A, Plate XXI. A time exposure in a camera shows, of course, no such detail of the discharge.

It appears that the insulated metal plate CC of Fig. 2 serves to separate the luminous positive column from the Faraday dark space, to such an extent that they may become apparent in discharges through air at ordinary pressure. When the metal plate is removed, the molecules at the boundary of these two regions mingle with each other. Electrically they are friendly, and they are being urged in opposite directions, by the compression and rarefaction terminals of the machine.

The Critical Spark-Length. The Faraday Dark-Space.

The metal plate CC of Fig. 2 was removed. A minute spark-gap was made at a^1. The contact at a was made as complete as possible, so that no luminous point is seen at this contact. The discharge then swept through the entire spark gap of about 15 cm. The photograph of this luminous column as taken by the camera is shown in Fig. B, Plate XXV. The exposure was about five minutes. The mica wind-mill shows a feeble wind from the positive terminal. If the gap at a^1 is made somewhat larger, the discharge is then filled throughout with small disruptive sparks, and the windmill will not operate. If the gap a^1 is made still longer, as seen in Fig. D, Plate XXV, a strong positive wind causes the windmill to rotate so rapidly that its vanes are invisible. This wind sweeps through the entire gap. The discharge is not then disruptive in character. If the gap at a^1 is closed and that at a is opened, the luminous streamers forming the positive column are beaten back by a blast of air from the negative terminal. The mica windmill shows that the negative wind now sweeps the entire gap. Fig. C, Plate XXV, is a camera photograph of the discharge. The slightest change in the length of the spark-gaps a and a^1, produces marked changes in the form and character of the discharge through the long gap. Such changes are attended by variation in the pitch of musical tones which accompany the discharge. Oscillations certainly play an important part in the phenomena. These results seem to justify the suggestion made in the former paper that the striations in the vacuum tube are produced in somewhat the same manner as the waves in an organ pipe.

The discharge at a^1 shown in Fig. D of Plate XXV, before referred to, is one of great interest. In this figure the position and size of the knobs is indicated by the circular arcs drawn in ink. This discharge shows the Faraday dark space, which is a region of convection of air molecules, which have been overloaded with Franklin's fluid, in the region of the negative glow. The negative glow is also shown in the figure. If the large knob be moved nearer to the small positive terminal, the dark space is made shorter. The negative convection apparently penetrates the positive luminous column. The end of the positive column begins to fray out into streamers. When the large knob reaches the end of the positive column, disruptive discharges begin. They are joined together at the positive terminal. If the gap is reduced to the length of the dark-space, the luminous positive discharge streamers are meanwhile separated from each other from knob to knob. Apparently negative convection and negative conduction by transfer from molecule to molecule (positive discharge) are taking place side by side. Dark spaces and positive columns exist side by side. They jostle each other in a somewhat tumultuous way. This is the critical spark length.

If the conditions represented in Fig. D exist, the discharge not being disruptive, it will become so if an insulated copper plate be placed between the knobs, at the end of the positive column. Moving the copper plate a fraction of a mm. towards the positive terminal, wholly cuts off the discharge. Such a minute change in position will result in a change from the noisy crackle of a multitude of small sparks, to silence and darkness. The same statement may be made concerning the motion of the large knob A^1, if the plate be removed and the large knob be placed at the end of the positive column. In this case, however, the disruptive discharge does not begin until the large knob has reached the positive column. A slight movement of the knob away from the positive terminal then causes the disruptive discharge to cease. When the copper plate is placed at the end of the positive column and is then moved towards the anode, the "resistance" of the gap appears to be increased. When moved towards the cathode it is diminished, and the positive column, from which Franklin's fluid has been drained into the anode, is made longer. It appears to follow the plate.

The copper plate does not obstruct the discharge if moved into the dark space. The positive column follows it, and acts as a conductor.

If the copper plate be placed in contact with the cathode knob, the negative glow passes to the corners and edges of the plate, where it ceases to be effective or visible. If placed in contact with the anode knob, the drainage column (positive brush discharge) into the anode then appears at the corners and edges of the plate. It then also ceases to be effective.

If the preceding explanation is valid it probably explains the behaviour of the Hittorf tube referred to by J. J. Thomson.[3] In the shorter branch of the tube, the dark convection discharge across the Faraday dark space involves a transfer of super-charged gas molecules from cathode to anode. In the longer branch, the electricity is passing by transfer from molecule to molecule, from cathode to anode. The molecules of gas are, however, moving in the opposite direction. The flow of gas in the two branches thus forms a continuous circulation around the circuit of the two branches.

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[3] Conduction of Electricity through Gases, 2d ed., p. 443.

The phenomena which have been discussed in this and the former paper have suggested the idea, that the amount of electricity that can be pumped out of a body in normal condition and at zero potential is not necessarily equal to the amount that can be forced into or upon it. This statement may perhaps correspond to the statement that when a boiler is full of water, more water can be pumped out of it, than can be forced into it.

A large attracted disk electrometer was constructed of sheet copper. The guard-plate which had a diameter of nearly two meters was hung from the ceiling on four silk cords, and faced a grounded plate of equal diameter. The attracted disk had a diameter of about 20 cm., and was hung on silk cords from a long and light balance beam of wood turning on two needle points. The apparatus was surrounded by a grounded screen of galvanized wire netting. The scale-pan carrying the weights was just outside of the screen. When the negative terminal of the influence machine was grounded, and the positive terminal was connected with the attracted disk, the attraction was about 20 per cent. greater than when the reverse connections were made. The results of this paper and of the previous one seem to make it doubtful whether this is to be accounted for as due to unsymmetric leakage through the ionized air between the large plates. It seems probable that this difference in the conditions existing in the two cases tends to diminish the observed effect. Apparatus of greater precision is being prepared for a further examination of this effect.

Again assume two equal spheres to be charged to potentials $+V$ and $-V$. Surround them by concentric spherical shells which are insulated. If shell and sphere are in each case put into contact, we have been accustomed to say that the charges on the two spheres go to the shells. If the one-fluid theory is to be adopted, we must suppose that Franklin's fluid flows from the shell to the positively charged sphere which it surrounds. May we not properly expect a dissymmetry in these two cases?

Is the positive electrification of a body simply a surface effect?

The phenomena described in this and the preceding paper seem to indicate that the main function of the positive ions, in spark discharge, is to serve as stepping stones of a somewhat unstable character. The anode wire is found to be very effective in converting the air molecules into a condition which makes the air a conductor of the discharge. Such an anode wire is absent in the arrangement of discharge circuit shown in Plate II of the former paper. (No. 1 of Vol. XIX.) The results in the present paper suggest that there may be a convection discharge from the negative glow along that negatively charged wire. This convection discharge is into a Faraday dark space, with no positive column beyond. In the device of Plate III of the former paper, the positive column is supplied through the agency of the grounded point below the photographic plate.

In the discharge between the wire and the grounded point below the photographic plate, represented in Plates III and V of the former paper, the photographic plate takes the place of the metal plate in the cases discussed in the present paper. In Plate III, the film is in the negative glow, and facing the cathode. In Plate V it is in the positive or luminous column, and facing the anode.

In closing, a suggestion which may have practical importance may be made. It seems probable that the danger of puncture of X-ray tubes may be materially diminished by grounding the cathode through a wet string resistance. This would result in draining Franklin's fluid through the tube, instead of forcing it through under pressure.

EXPLANATION OF THE PLATES.

Plate XVIII.— Fig. A. Electrical discharge from pin-head terminal. Negative outflow in negative line. Fig. B. Negative inflow to pin-head in negative line.

Plate XIX.— Fig. A. Positive line. Positive outflow. (Negative inflow). Fig. B. Positive line. Positive inflow. (Negative outflow). These four figures are emphasized by condenser effects.

Plate XX.— Fig. A. One minute spark. Negative line. Fig. B. Slightly longer spark. Fig. C. Two sparks. The sparks were in a small gap at the machine.

Plate XXI.— Fig. A. One spark. Increased length. Fig. B. Five or six sparks and then increase of speed of machine and disruptive spark. Fig. C. Dispersion of spark discharge into ionized air around grounded terminal. Shadow of pin-head terminal.

Plate XXII.— Fig. A. The same. Fig. B. The same. Two discharges in quick succession. Fig. C. The same. One spark. Fig. D. Photographic reversal of last Fig.

Plate XXIII.— Fig. A. Shadow effects at both pin-heads. Explosive discharge channel very short. Fig. B. Effects like preceding but in positive line. Fig. C. Pin-head terminals connected to + and — terminals of machine. Small gap at machine. Spark about to pass between pin-heads. Compare Fig. A, Plate XXI.

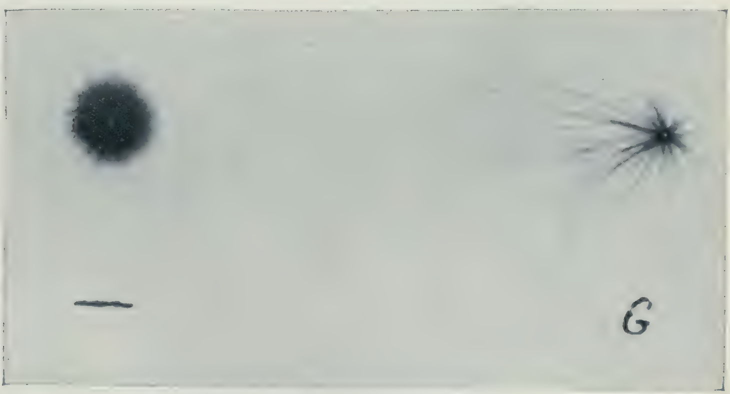
Plate XXIV.— Fig. A. Camera photograph of brush discharges. Insulated copper plate between terminals. Spark will not pass. Fig. B. Same as last with drill-hole in copper plate. Eighty spark discharges. Pin-hole photograph. Fig. C. Camera photograph of canal ray. Same as last with no Leyden jars in machine. Brush discharges.

Plate XXV.— Fig. A. Shadow by glass tube in positive column. Camera photograph. Fig. B. Brush discharge in which mica windmill shows feeble positive "electrical wind" or none. Camera photo. Fig. C. Same where marked negative wind is shown. Fig. D. Brush discharge at a^1 Fig. 2 showing Faraday dark space and positive column. Camera photograph. This spark gap was 3.2 cm. in length.

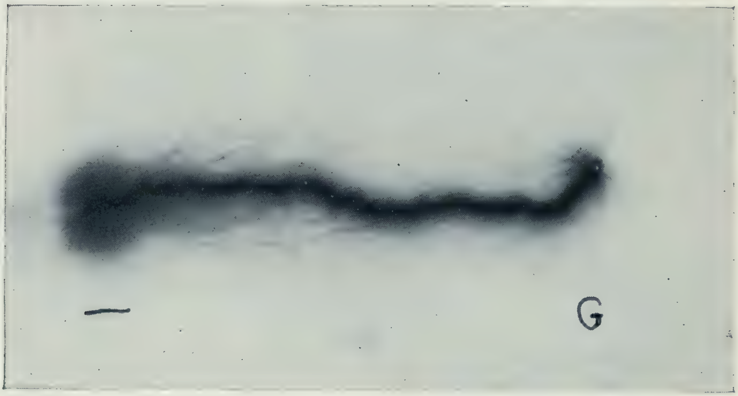
Issued June 2, 1910.

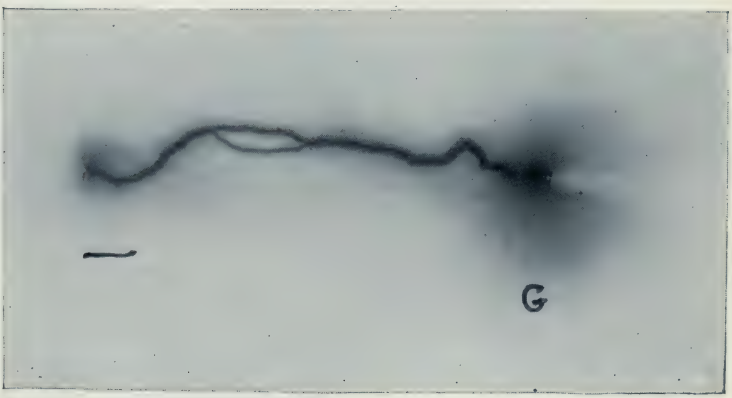
FIGS. A AND B.

FIGS. A AND B.

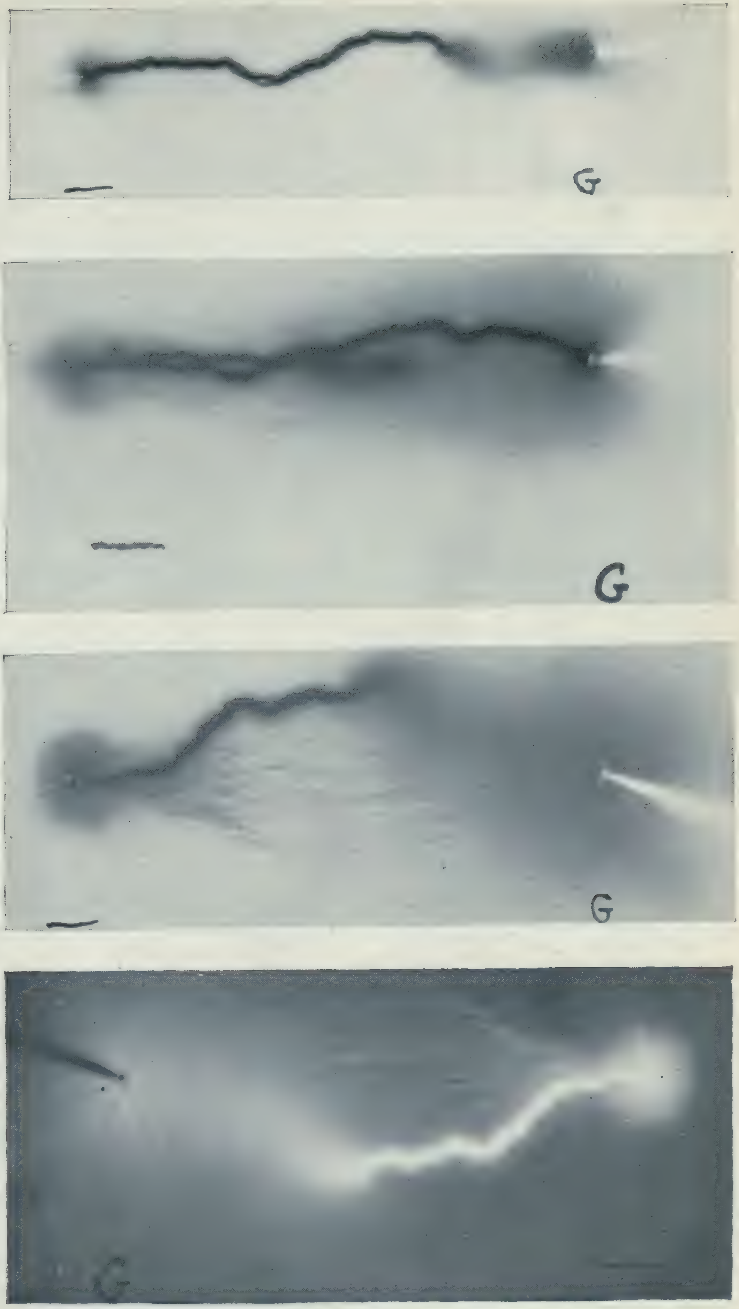


FIGS. A, B AND C.

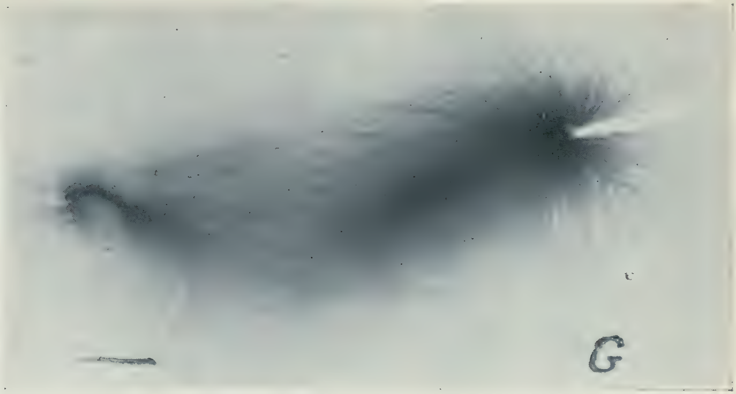


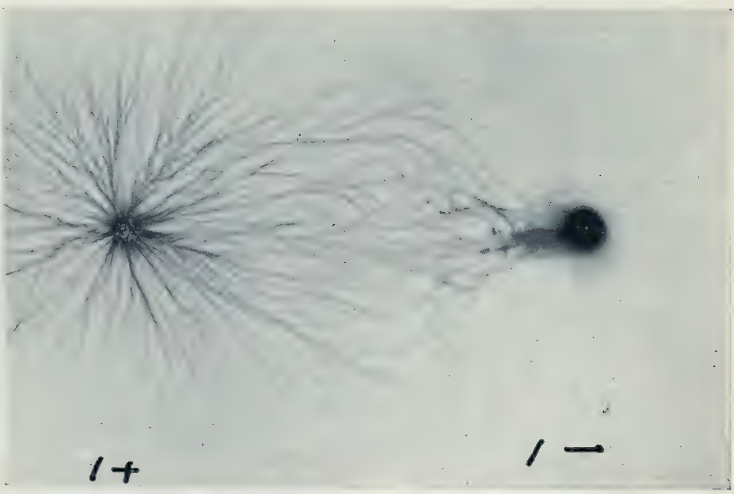


FIGS. A, B AND C.

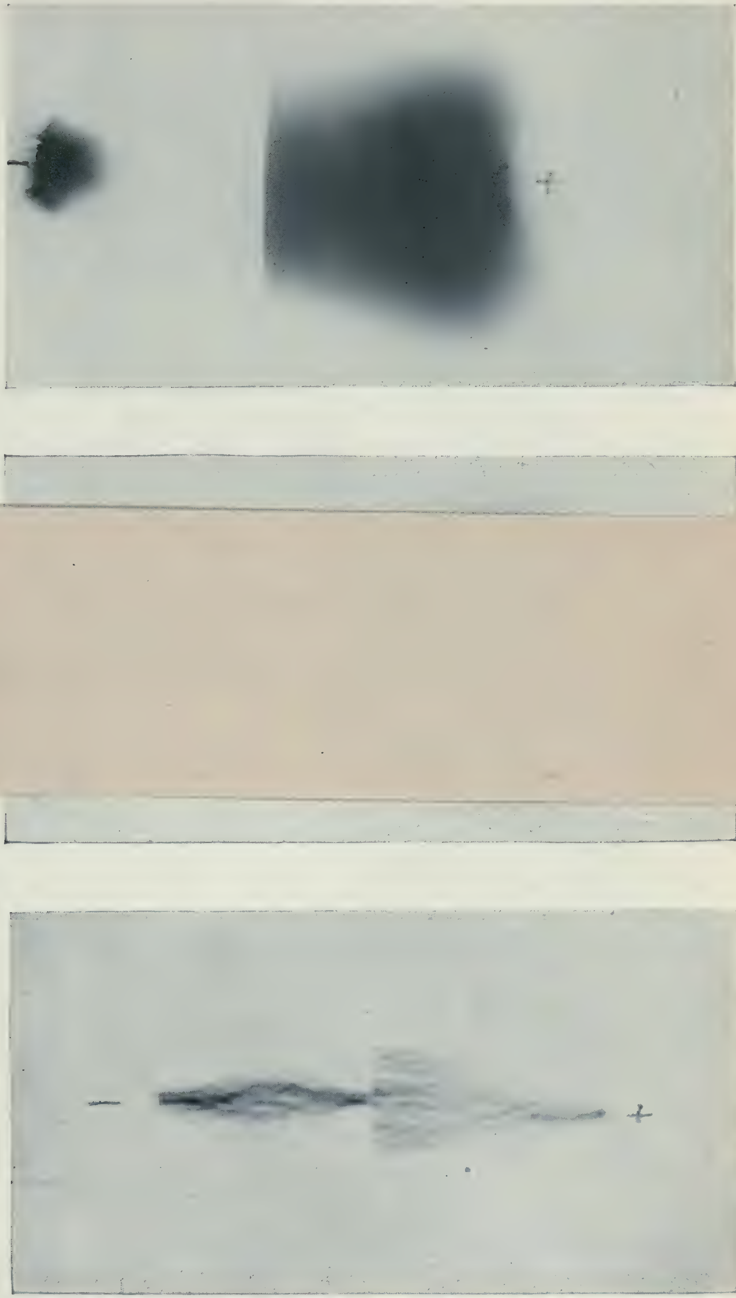


FIGS. A, B, C AND D.





FIGS. A, B AND C.

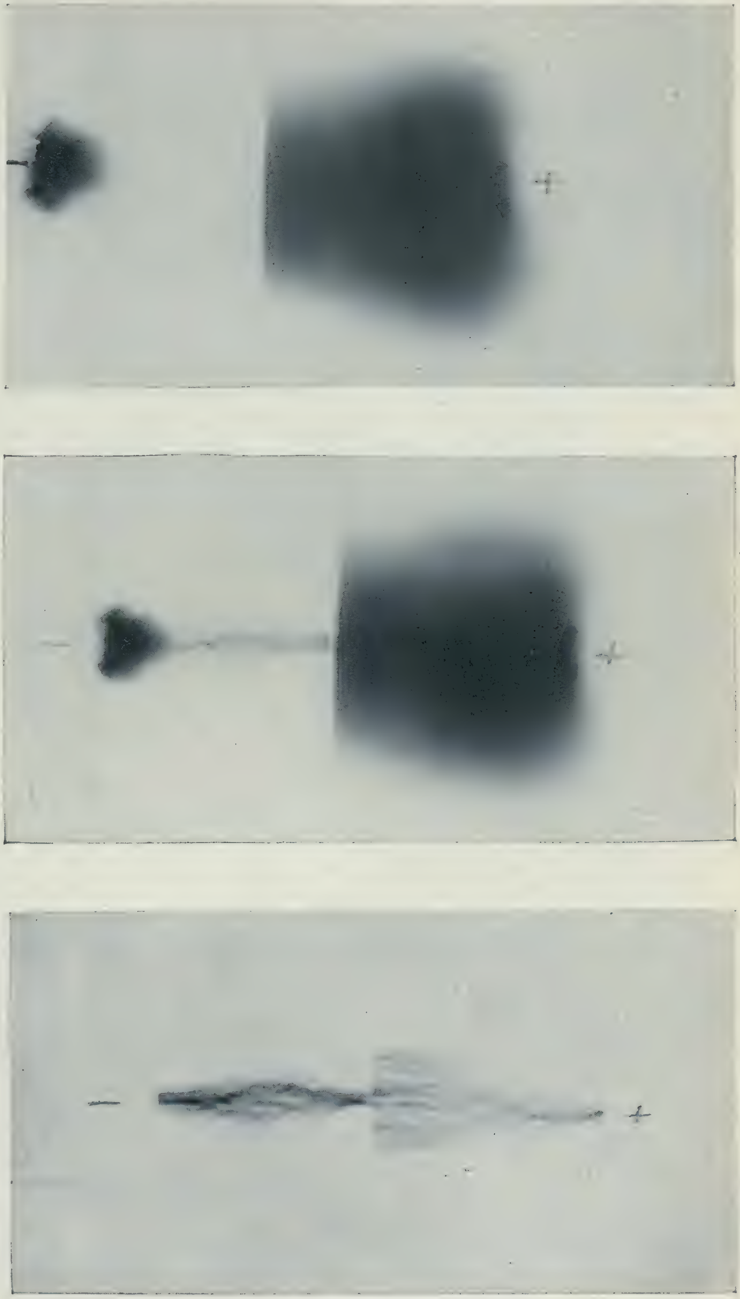


FIGS. A, B AND C.

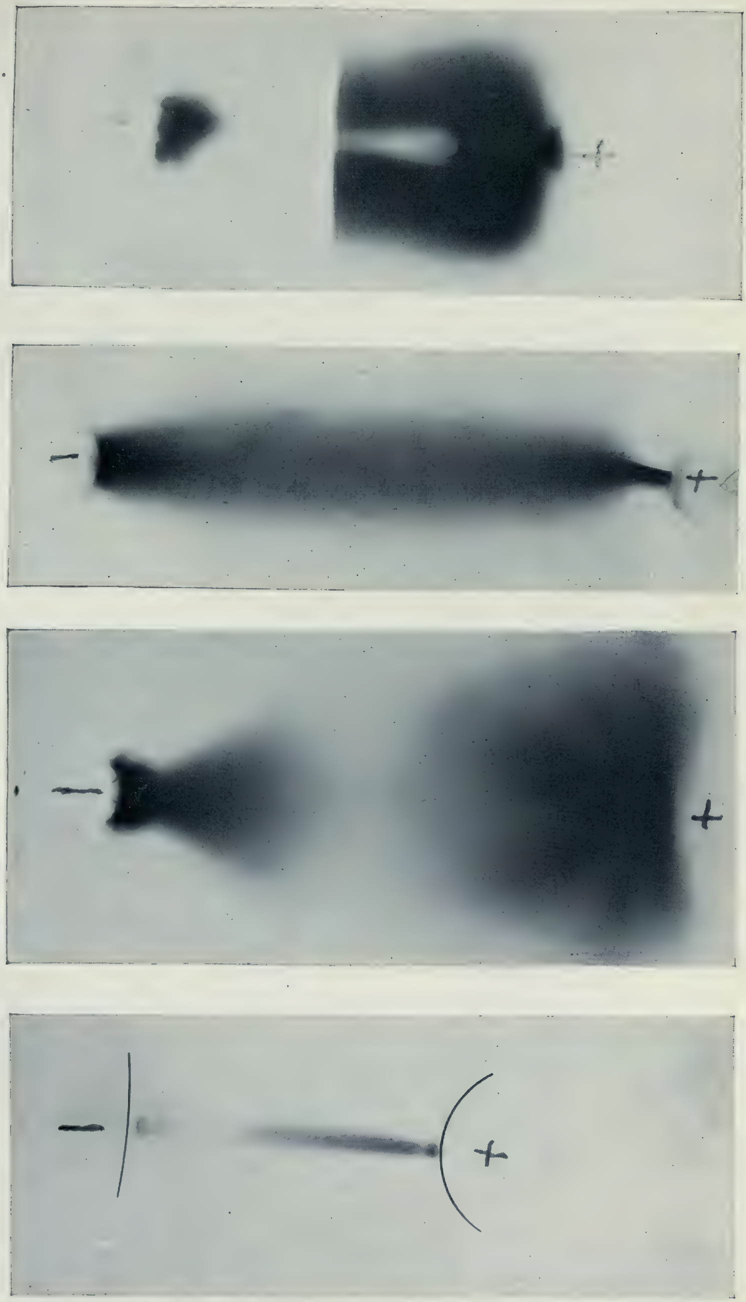
to face Plate 24.

CORRECTION No. 4, VOL. XIX.

In Plate XXIV, Figs. B. and C should have been transposed.



FIGS. A, B AND C.



FIGS. A, B, C AND D.

NOTES ON THE ROBBER FROG (LITHODYTES LATRANS COPE).*

John K. Strecker, Jr.

The Robber Frog, *Lithodytes latrans,* is one of the most peculiar and little known of the frog-like amphibians inhabiting the State of Texas. Discovered by Mr. G. W. Marnock, near Helotes, Bexar County, in 1878, and described in the same year by Cope,[1] it is still a rare species in collections. In 1899, the present writer discovered its presence at Waco, nearly 200 miles north of the type locality, in a rather different faunal region.

Lithodytes latrans has in all probability an extensive range, but, on account of its peculiarly secretive and nocturnal habits, has been overlooked by the most eminent herpetologists who have visited Texas. Its distribution is entirely dependent on the presence of the exposures of white limestone which enclose many of the streams of the central and southern sections of the State.

It is a land animal, hiding in caves and fissures during the daytime, and, excepting during the brief breeding period, venturing abroad only at night. Breeding in water-filled pockets and hollows in the rocks and in the rocky beds of small streams, it does not appear to be perfectly at home in the water at any time and specimens observed by me made no attempt to conceal themselves by diving but swam clumsily across small pools and sought to escape by leaping up the bank on the opposite side. A breeding pair remain in copula close in to the bank. The masses of water-soaked leaves which line the edges of the pools and hollows serve them for the purpose of floating their fertilized eggs.

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* Presented by title to The Academy of Science of St. Louis, May 2, 1910.

[1] American Naturalist, 1878 : 186.

LIFE COLORATION.

Examples of *Lithodytes* from Waco are not as brightly colored as those from the type locality, nor are the markings of the upper surfaces as well defined. Miss Dickerson[2] mentions Helotes specimens in which the superior surfaces were tinged with salmon-pink. As a rule, San Antonio and Waco examples of the same species, both in reptiles and amphibians, have widely different colors. Specimens of *Holbrookia texana* Troschel, and *Sceloporus consobrinus* B. & G., from the San Antonio district display shades of red not exhibited by examples from Austin northward.

The following description was written in the field:

(Baylor University Collection No. 5281, male, Waco, Texas, March 5, 1910.) Skin very smooth. Superior surfaces brownish gray with a few large brown spots having pale greenish centers. (These spots were very distinct in the living animal, but are now much faded, their outlines being barely perceptible. The animal was accidentally suffocated in the collecting can.) Outer and inner surfaces of limbs, bright yellowish green, this color extending along the side of the body to a point midway between the fore- and hind-limbs and forming conspicuous patches. Below pale grayish dotted with white on the chest and throat as in pale Eastern examples of *Engystoma carolinense* Holbrook. Throat pale yellowish, a blackish line along the edge of the under lip. Bars on upper surfaces of the limbs present, but rather indistinct. Spots along side of body and head very conspicuous, blackish brown in color. Spot in front of arm insertion pale in color but distinct. Spaces below dark spots under eyes and along upper lip, white. Iris bronze. Vocal pouch well developed.

This specimen is only about half grown and the limbs are comparatively shorter than in larger examples. Total length, head and body, 1-13/16 in. The coloration, how-

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[2] The Frog Book 163. 1906.

ever, is the same as that of adult examples. Attains a length of 3½ inches. An example collected April 13, 1910, had the ground color of the upper surfaces a beautiful pearl gray.

Habitat Associations.

The Robber Frog has been observed by the writer in two similar localities in the vicinity of Waco:—

(1) Flat Rock Creek, McLennan County (Hewitt Section, altitude 625 to 655 feet), an intermittent stream flowing through a stretch of prairie land. Banks of soft shaly white limestone, filled with cavities and fissures. Large fragments have been broken loose from the bluffs from time to time and strew the bed of the stream. Several trips have been made to this place and in each case the same species of reptiles and amphibians have been obtained. The most characteristic reptile is an iguanian lizard—*Holbrookia texana* Troschel—which is equally abundant on the bluffs and among the rocks below them. Numerous examples of Long's Garter snake, *Eutaenia proxima* Say, and the diamond-marked water snake, *Tropidonotus rhombifer* Hallowell, haunt the neighborhood of the deeper water holes, where they find abundant food—Leopard Frogs, Cricket Frogs, and small fishes. Two species of Toads, *Bufo valliceps* Weig. and *Bufo americanus* Le Conte (large dark type), scorpions, *Buthus,* and large ground spiders are found in fissures in the banks and in hollows under the larger rocks. Whip Snakes, *Zamenis flagellum* Shaw, of the pale prairie type resort here in numbers for the purpose of feeding on the lizards and the large grasshopper, *Schistocera americana,* which forms their principal food. The following species of mollusks are abundant: *Polygyra roemeri* Pfr., *Polygyra texasiana* Mor., *Bulimulus dealbatus mooreanus* Pfr. The rocky bluffs are low, averaging less than a dozen feet.

(2) Nameless Gully, three miles north of Waco, heading near Walker's Crossing on the Bosque River. Banks of soft shaly limestone, interspersed with stretches of

yellow clay. At the highest point, the bluffs are only about 20 feet, but average about 15 feet for a distance of about a quarter of a mile. The gully is dry during the greater portion of the year. A few small water pockets are fed by tiny springs but the moisture evaporates so rapidly that a running stream is seldom formed. The majority of the hollows in the bed are filled with rain water. A few of them are as much as a foot in depth, but the average is only three or four inches. The bluffs are constantly shaling off and the bed of the gully is strewn with small shattered masses of limestone. The hill on the east side is covered with a heavy growth of Rock Cedar, *Juniperus sabinoides* Nees, and the one on the west side with numerous trees, shrubs, and vines of many species.

FAUNA.

MAMMALIA.

[3] Peromyscus maniculatus pallescens Allen.

REPTILIA.

[4] Holbrookia texana Troschel.
[5] Eumeces quinquelineatus Linn.
[5] Leiolepisma laterale Say.
[4] Cnemidophorus gularis B. & G.
[3] Eutaenia proxima Say.
[3] Storeria dekayi Hollbrook.

AMPHIBIA.

[3] Bufo ameircanus Le Conte.
[3] Bufo valliceps Weig.
[3] Acris gryllus crepitans Baird.
[3] Rana pipiens Schreber.
[3] Lithodytes latrans Cope.

MOLLUSCA.

Helicina orbiculata tropica Jan.
Praticolella berlandieriana Mor.
Polygyra mooreana W. G. B.
Polygyra texasiana Mor. (Banded form)
Polygyra roemeri Pfr.
Bulimulus dealbatus liquabilis Rve.
Bifidaria sp.
Vitrea indentata umbilicata Sing.
[6] Omphalina friabilis W. G. B.
[6] Agriolimax agrestis Linn.
Pyriamidula alternata Say.

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[3] These species were found only in the gully.

[4] East Hill, living among rocks and around the bases of the cedars.

[5] West Hill only; among leaves and around stumps and fallen trees.

[6] Not recorded in the writer's report on the Mollusca of McLennan County (Nautilus XXII: 63–67. 1908), and since found only at this place. The slug was identified by Bryant Walker. It is not uncommon and is found under fallen branches and pieces of dead bark. Very few living examples of *Omphalina* were discovered, but hundreds of weather-worn shells are imbedded in clay and strewn along the rocks on both sides of the gully.

Living examples of the above mollusks were found only on the west slope. Altitude about the same as that of the other station.

Notes on Breeding Habits.

This species breeds unusually early in the year. Marnock informed Cope[7] that the eggs were hatched in winter. Here in central Texas the breeding season is later than it is in Bexar County and the eggs are deposited early in February. If the eggs were deposited before the 9th of that month in the present year, they were subjected to some of the hardest freezes we have had in years. On the 9th and 10th the ground was covered with two inches of snow. A few days later the weather was warm and clear and melted snow filled the hollows in many of the gulches that are usually dry at this season.

On March 5th, a number of tadpoles were found in small pools in the gully three miles north of town. They were in two stages, the larger ones having the hind limbs well developed. In form these larvae were short and round bodied, with slender, but rather short, tails. In a specimen 36 mm. in total length, the distance from muzzle to anus was 14 mm. In a smaller example, the tail was only 4 mm. longer than head and body.

Color above deep brown, appearing blackish in water. Beneath silvery white. Under a glass the superior surfaces present a peculiarly mottled appearance, much as though several tints of brown paint had been thrown together without being thoroughly mixed. Sides reticulated with blackish brown lines. To the naked eye, the lateral line sense organs appear as continuous yellow stripes on the sides. From above the head presents a much narrower outline than is found in tadpoles of the families *Hylidae* and *Ranidae*. The upper lip has two rows of teeth, the lower three.

These little "polly-wogs" are very active and on being disturbed conceal themselves among leaves in the bottoms

[7] Bull. U. S. Nat. Mus. 17. 1880.

and on the sides of the pools. The larger ones are unusually wary and it is a difficult matter to capture them even with a dip net. I was unsuccessful in an attempt to transfer several of them to the aquarium in our laboratory, for although all precautions were taken, they died a short time after their capture. The tadpoles were found in three lots and were of three different sizes.

Those of lot 1 (three in number) were in a rather deep and well shaded water pocket, under an overhanging rock. Dimensions of pocket, 6x4 feet. Depth at deepest point, about a foot. When first observed the tadpoles were in the shallow portion, but on being alarmed swam to the bottom. All three appeared to be of about the same size.

In lot 2 were ten specimens, each about two-thirds the size of those in the first lot. In a water pocket six inches in depth.

Lot 3, twenty or more specimens, the majority of which were small (stage 1), were in water in a section of the gulch where tiny springs issue from the bases of the bluffs. The water was barely running and the portion of the stream in which the tadpoles were found was about 25 feet in length and from 6 to 24 inches in width, with a depth of only a few inches. Rocky bottom, well covered with dead leaves.

Judging from these exhibits the number of eggs deposited by this species must be remarkably small, for those of the smaller Anurans such as *Chorophilus triseriatus* and *Acris gryllus* usually number 500 or more. As no fish were found in the pools and none of the Ophidians were as yet active, the question of the number being reduced by animal foes is entirely eliminated. The eggs or tadpoles could not have been scattered by being washed down stream as there were no accumulations of water higher up in the bed of the gully. By the 19th of March the larger tadpoles had become fully developed frogs and left the water with their short tails still in evidence. They were slightly over a third as large as full grown adults. The complete metamorphosis must not take over six weeks, if we are to judge by the length of time required for other frogs to transform after the first appearance of the hind limbs. Two specimens collected in March were only about an inch and a half in length. This indicates that it requires from 2½ to 3 years for this species to become full grown.

General Notes.

Up to the 12th of March, *Lithodytes* was the only active amphibian noted. Even *Acris* was sluggish and the few examples observed were stirred out from piles of dead leaves and rock fragments in the bed of the gully. The only toads discovered were two semi-torpid examples of *Bufo americanus* which were found in burrows under a rotten log.

In 1899 I captured a single half-grown *Lithodytes* in a gutter on one of the principal streets of Waco, just after a heavy shower. On April 13, 1910, an adult was captured on an elm flat, nearly a mile from any bluffs. Two specimens of *Bufo punctatus* B. & G., a toad which also inhabits rocky gulches, were found under similar conditions in 1908. I have no theory to account for the presence of these animals so far from their natural haunts.

Our Robber Frogs may never breed in the heart of winter, yet their breeding dates are far in advance of those of other *Anura* inhabiting the vicinity of Waco.

The following is a list of our tailless amphibians, with breeding and other data:—

ANURA OF WACO.

SPECIES.	BREEDING DATES.	BREEDING LOCALITIES.	REMARKS.
Hyla versicolor Le Conte (Var.)	April 3, 1899.	Permanent ponds.	Species
	April 3, 1910.	Permanent ponds.	rare.
	April 21, 1910.	Small pool in gravel pit.	Large tadpoles.
Hyla cinerea Daudin	April 15, 1904.	Permanent lagoon 15 miles south of city.	

Chorophilus triseriatus Wied.	April 2, 1910.	Water-filled ditches on mesquite flats.	Males only.
	April 12, 1896.	Grassy marsh two miles east of city.	
	May 20, 1897.	Temporary prairie ponds breeding in company with *Bufo debilis* Gir. and *Engystoma texense* Girard.	Spring rains later than usual.
Acris g. crepitans Baird	April 10 to May 30.	Ponds and small streams.	
Engystoma texense Girard	April 15 to June 1.	Prairie ponds, pools in damp gulches, roadside ditches.	
Bufo americanus Le Conte	March 19 to May 30.	Brazos river, Waco creek, ponds.	
Bufo valliceps Wieg.	April 10 to May 30.	Pools in damp gulches, small creeks. The males are usually heard a night or two before the females seek the breeding places. The former greatly exceed the latter in numbers.	
Bufo debilis Girard	April 30, 1900.	Prairie ponds.	
	May 12, 1906.	Roadside ditches along mesquite covered flats.	
	May 20, 1897.	Prairie ponds.	
Bufo compactilis Wieg.	May 1 to May 30.	Temporary ponds and ditches. Breeding habits resemble those of *Scaphiopus* to a considerable extent. Metamorphosis of tadpole unusually rapid.	
Bufo punctatus B. & G.	May 12, 1907.	One specimen captured in a temporary pond but may not have been breeding.	
	April 15, 1909.	Near Glen Rose, Somervell Co., Texas, I found this species breeding in water-filled hollows in a rocky gulch.	

Scaphiopus couchii B. & G.	April 10 to May 30. As late as July in dry years.	Permanent ponds, temporary pools, water-filled hollows in city yards.
Scaphiopus sp.[8]	April 13, 1910.	Temporary pool.
Rana catesbeiana Shaw	April 1 to May 10.	Waco creek, permanent marshes and ponds.
Rana pipiens Schreber	April 11 to May 15.	Marshes, ponds, small creeks.
Rana sphenocephala Cope	No date for Waco.	
	April 14–15, 1909.	Deep holes in Paluxy creek, Somervell County, Texas.

It must be taken into consideration that many of our species breed in temporary pools and that the time of their going into the water depends entirely on the amount of rainfall we get in early spring. Earlier dates for some of the species have been recorded from more northern localities, but this discrepancy in dates and latitude is something that I am unable to account for. Some frogs can stand a comparatively low temperature, but moisture is most essential to them under all conditions. In the north in early spring the ponds and water-courses are filled to overflowing as a result of the winter sleets and snows, but in Texas we usually get the greatest amount of rainfall early in the autumn and in the months of April and May. In the plains country in Western Texas (Hale and Garza Counties), *Bufo cognatus* Say and the Tiger Salamander *Ambystoma tigrinum* Green rarely go into the water before July.

The adult *Lithodytes latrans* presents a rather unusual appearance for a frog, on account of its proportions and its peculiar method of elevating the body. Younger specimens have much shorter limbs and do not look so odd. At times the species is sluggish and rather easily captured, but as a rule retreats into caves and fissures at the slightest alarm. Its voice is a short dog-like bark

[8] A new species related to the solitary spadefoot (*S. holbrookii* Harlan) to be described later.

ending in a metallic ring. It is usually uttered at night or during heavy showers; rarely in the morning, in its breeding haunts. The stomach of one example contained the elytra of a ground beetle and the remains of many spiders and ants. Much yet remains to be learned regarding the habits and eccentricities of this strange creature, but it is hoped that the present paper will prove of interest to those engaged in working out the life histories of this most interesting order of animals.

Issued, June 14, 1910.

ON THE HISTOLOGY OF THE EYE OF TYPHLOTRITON SPELAEUS, FROM MARBLE CAVE, MO.*

Adolf Alt.

When through the kindness of Mr. J. Hurter of this city an opportunity was offered to me to make the histological examination of the eyes of a number of specimens of *Typhlotriton spelaeus* of Marble Cave, Mo., I was at first not in possession of any previous literature on the subject, nor did it seem possible to get hold of it, since a personal letter to Dr. Carl H. Eigenmann remained unanswered. Through the kindness of Professor A. C. Eycleshymer of the St. Louis University I have of late received a number of reprints on this subject. Aside from one paper written together with another author, as far as I can find, it is Carl H. Eigenmann's own work which alone treats on the structure of the eyes of this so-called blind salamander.

What appears to have been the first description by this author is a paper published in the twenty-first volume of the Transactions of the American Microscopical Society, 1900, under the title "The eyes of the blind vertebrates of North America, II. The eyes of *Typhlomolge Rathbuni,* Stejneger." In this paper he says, after a short description of the eyes of *Typhlomolge,* "The eye of *Typhlotriton* is, in many respects, much more degenerate than that of its European caverniculous relative, *Proteus.*" When reading this it seemed somewhat strange to me that the larger part of a paper on the eyes of *Typhlomolge Rathbuni* should be taken up by a description of the eyes of *Typhlotriton,* but there it was in print and could not be doubted.

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* Read and illustrated with numerous lantern slides before The Academy of Science of St. Louis, March 21, 1910.

After a somewhat lengthy description of the different membranes of the eye of *Typhlotriton,* in which I find also the statement that no bloodvessels enter the eye, he summarizes as follows:

"1. The eye lies just beneath the skin. The skin is but little thinner over the eye than elsewhere and shows no structural characters different from those of the neighboring regions.

2. The eye muscles have vanished.

3. The lens has vanished and its place has in part become filled by an ingrowth of choroidal tissue containing pigment.

4. The vitreal body is very small, if present at all. The vitreal cavity is a funnel-shaped space.

5. The pigment layer of the retina is a pavement epithelium with indistinct cell boundaries, and with occasional pigmented processes extending into or through the nuclear layers.

6. Rods and cones are not formed.

7. The outer reticular layer has disappeared.

8. The inner and outer nuclear layers form one layer, cells indistinguishable from each other.

9. The inner reticular layer, as usually with degenerate eyes, is relatively well developed.

10. The ganglionic layer is well represented and connected with the brain by the well developed optic nerve, etc."

When reading this, after having myself examined a number of specimens of *Typhlotriton* eyes, I could not understand how such a description was possible. Surely, in my specimens of *Typhlotriton,* the crystalline lens, for instance, which Eigenmann said had vanished, was one of the most prominent features, and there were numerous other discrepancies.

A little later I came into possession of a second paper written by Carl H. Eigenmann together with W. A. Denny, entitled: "The eyes of the blind vertebrates of North America. III. The structure and ontogenetic degeneration of the eyes of the Missouri Cave Salamander, etc.'' Biological Bulletin, **2**: 1. 1900.

In this paper the eyes of *Typhlotriton spelaeus* from Rock House Cave and from Marble Cave, Mo., are described very exhaustively. Again it appeared strange that in this paper I could nowhere find any reference whatever to the former paper, although the two descriptions differ so widely, as will be seen from the following summary with which this second paper ends:

''*Typhlotriton* is an incipient blind salamander living in the caves of southwestern Missouri. It detects its food by the sense of touch without the use of its eyes. It is stereotropic. The eyes show the early stages in the steps of degeneration from those of salamanders living in the open to those of the *Typhlomolge* from the caves of Texas. The lids are in process of obliteration, the upper overlapping the lower so that the eye is always covered in the adult. The sclera possesses a cartilaginous band in the larval stage but not in the adult. The disappearance of the cartilage is probably an incident of metamorphosis, not of the degeneration the eye is undergoing. The lens is normal. The retina is normal in the larva with a proportionately thicker ganglionic layer than in the related epigaean forms. Marked ontogenetic degenerations take place during and shortly after the metamorphosis. a. The outer reticular layer disappears. b. The rods and cones lose their complexity of structure, such as differentiation into inner and outer segments and finally are lost altogether.''

In this paper the author also states ''that the six eye muscles are present.''

After I had read the present paper before the Academy of Science, I was made acquainted through the kindness of Miss M. Klem with a large and beautifully illustrated volume, entitled ''The Cave Vertebrates of America. A study in degenerative Evolution,'' by Carl H. Eigenmann. Published by the Carnegie Institution of Washington, D. C., June, 1909.

In this volume my former suspicion that in the above mentioned paper on the eyes of *Typhlomolge Rathbuni* Stejneger the word *Typhlotriton,* wherever it appears, should in reality read *Typhlomolge,* seems to be proven correct. At least in the part of this paper referred to, as it is reprinted in the large volume, this change from *Typhlotriton* to *Typhlomolge* is made. This chapter is followed by one which is an exact reproduction of the above mentioned paper on the eye of the Missouri cave salamander by Eigenmann and Denny. This in turn is followed by "Conclusions as to the eye of *Typhlotriton spelaeus,*" which are the exact reproduction of the conclusions given as a summary after the description of, what I now think, should have been the eyes of *Typhlomolge Rathbuni,* although it was always called *Typhlotriton.* (See page 83.) After these conclusions, in reality referring to the eye of *Typhlomolge,* comes finally a "Summary in regard to *Typhlotriton,*" which is the exact reproduction of the summary following the original paper of Eigenmann and Denny. (See page 84.)

What is a student to make of such contradictions, when, he reads, for instance, on page 40, "The lens has vanished, etc.," and on page 41, "The lens is normal," and so on, apparently referring to one and the same species?

In an address delivered as president of the Indiana Academy of Science (Proceedings 1899) by C. H. Eigenmann, entitled "Degeneration in the eyes of the cold-blooded vertebrates of the North American caves," this author again says about the eyes of *Typhlotriton* "the dioptric arrangements are all normal; the retina is normal in the young, but the rods and cones disappear with the change from the larval to the adult condition."

Of the six specimens of *Typhlotriton spelaeus* from Marble Cave, Mo., which I had for examination, the smallest—a larva—was 90 mm. long, and the largest measured 115 mm. Of the two smallest ones one still had gills and no eyelids, the other no longer showed a sign of gills, but, also, had no eyelids. (See Figs. 1 and

2.) The next two in size had eyelids and a small palpebral fissure, the upper eyelid, however, overlapped the lower one. (See Figs. 3, 6 and 11.) In the two largest specimens I could not find the smallest palpebral opening. It seems that no light whatever could enter their eyes except after having passed through the semi-transparent lids covering them. (See Figs. 5, 8 and 12.)

Unfortunately the preservation of the material for examination was not such as we are accustomed to with the material taken from man. One specimen was still alive when I got it. Yet, even in this animal's eyes, into which the preserving and hardening fluids evidently did not enter in a sufficient quantity, certain post mortem changes took place. Another difficulty lay in the fact that the celloidin in which I embedded the decalcified heads for cutting did not penetrate into the interior of the eyes in such a way as to fill the cavities and give the whole a uniform firmness. In consequence the eyes were more or less shrunken and the tissues did not always lie in their natural positions and relations to each other. Some parts, like the uveal tract, were always more or less disintegrated. In quite a number of sections the crystalline lens fell out during the handling and staining. I cut some of the heads vertically to the surface and some parallel to the surface, hoping to get in this way a more complete picture of the real conditions.

In the two specimens which had as yet no eyelids (Figs. 1 and 2) the outer skin seems simply to pass over the eyes. But it shows decided structural changes in this ocular part, so as to be easily recognized as the cornea. While the epithelium of the skin in the neighborhood of the eye consists chiefly of cylindrical and goblet-shaped cells, it is suddenly changed into a stratified epithelium where it covers the eye. While in the four eyes without lids I can find no section in which the whole of this corneal epithelium is intact, on account of the lack of protection, yet larger portions, and especially the peripheral parts, were in a larger number of the sections well enough preserved to show that there are usually three layers of epithelial cells. The cells of the basal layer are more or less cuboid, the next layer consists of flatter cells, and in the outer layer they are still more flattened. In the eyes of the adult specimens where the corneal surface was well protected the corneal epithelium is preserved intact and shows the same arrangement.

The corneal tissue proper shows a lamellated structure with fixed corneal cells. I have not been able to find any anterior uniform layer corresponding to Bowman's layer, nor a posterior membrane corresponding to that of Descemet in the human eye. On account of the extreme shallowness of the anterior chamber in most of my sections, in consequence of which the anterior surface of the iris and the anterior pole of the crystalline lens seem fairly agglutinated to the posterior surface of the cornea, it was only with difficulty that I could convince myself that the posterior surface of the cornea is lined with a layer of endothelial cells. These cells appear large and flat and have a large oval nucleus. They resemble so much the capsular epithelial cells of the adjacent crystalline lens that this, also, helps to render it more difficult to differentiate them.

The sclerotic is quite thin and shows nothing particular aside from a small amount of cartilage tissue which I find not only in the larvae, but also in some of my adult specimens.

As stated above, the very darkly pigmented uveal tract is in all of my sections more or less mutilated and disintegrated, and quite frequently the choroid is split in two unequal parts, the inner one adhering to the retina. It was, therefore, impossible to study the structural conditions with anything like accuracy and completeness. In none of my sections have I found a trace of a blood-vessel in this membrane, which in the human eye is the vascular coat. The ciliary body appears simply like a few folds and corrugations of darkly pigmented tissue in which I can find no trace of any muscular fibers. It is, also, impossible to demonstrate any muscular tissue in the iris.

The cells of the pigment epithelium are comparatively well preserved in a good many of my sections, although their continuity is frequently interrupted. They are large flat cuboid cells, the protoplasma of which is filled with fuscin needles. Their nucleus is quite large. In most sections they adhere to the outer surface of the retina, which must be distinctly stated as it is of importance for the understanding of the outer structures of the retina.

According to Eigenmann there is a very marked difference between the retina in the larval state and that in the adult.

My specimens show no such marked difference, in fact they appear very much the same in both states. It may, of course, be possible that at an earlier age than that which my larval specimens had attained, the retina of the larva is really as nearly perfectly developed as Eigenmann states.

In all the sections next to the crystalline lens the retina is really the most conspicuous part of the eye. Even where it is well preserved and lies approximately in its normal position its great thickness is obvious. When viewed from within outward under a higher power the first striking fact is an absence of a plainly visible nerve fibre layer. Eigenmann does not mention this layer at all. I have not been able to see any nerve fibres no matter what stain I used. Possibly they had become disintegrated. Surely their absence would seem particularly strange with such a well developed layer of ganglionic cells. The ganglionic cell layer, according to Eigenmann, is composed of five or six rows of cells in the larva, and of two to five rows of cells in the adult. The thickness of this, as of all the layers of the retina depends, of course, on the part of the retina from which the section is taken and on the plane in which the section lies. I have sections of the larval eye in which the ganglionic layer seems to be composed of three more or less well defined rows of cells, and, on the other hand, sections of the adult eye in which six or seven rows of cells may be counted.

Outside of the ganglionic layer the inner plexiform (reticular) layer forms in all the sections, whether they are from the eyes of the larvae or of the adult, a comparatively broad band. No details can be made out in my sections in this layer; it appears as a uniformly stained homogeneous tissue. Outside of this layer lies apparently a single very broad nuclear layer, where in the human retina we have the two nuclear layers, separated by the external plexiform layer. This thick nuclear layer shows, sometimes very indistinctly, sometimes more plainly, a separation between the large inner mass of nuclei and the two outermost layers, that is, what in the human eye would correspond to the layer of rods and cones and their nuclei. From the foregoing it is seen that while in my specimens there is neither in the eyes of the larva nor in those of the adult a distinct outer plexiform layer, still there is a sign of some separation between the large inner and these two outermost nuclear layers. The outermost layer, corresponding to the rods and cones, consists of cells which are arranged pallisade-like and markedly differ in their shape and nature from the others. While in the larval eyes they often appear broader at the base and thinner at their outer end (see Fig. 14), in the adult eyes their shape is more rounded at the outer end. It is impossible to distinguish between rods and cones, the cells appearing all of the same ovoid shape. (See Figs. 15, 16, 17.)

According to Eigenmann the so-called outer segments of the rods and cones are lost in the adult eye. While in most of my specimens the space between the rods and cones and the pigment epithelium is filled with a mass of detritus which contains numerous streaks and heaps of fuscin needles and which takes up a slight stain with eosin, there are sufficient places in which distinct processes can be traced from the rods and cones toward the pigment epithelium which take up eosin and are doubtlessly such outer segments. (See Figs. 14, 15, 16, 17.) It seems, therefore, to me that, while no differentiation can be made between rods and cones, the outermost layer of the larval as well as the adult retina of *Typhlotriton* represents what in the human eye are the rods and cones with their outer segments.

In order to find out whether epigaean relatives of *Typhlotriton* have a very different arrangement of the retina, I, also, studied the eyes of a specimen of *Desmognathus fuscus* from Mobile, Alabama, kindly furnished me by Mr. J. Hurter. The arrangement of the different retinal layers in this salamander corresponds almost exactly with that of *Typhlotriton,* especially the cells representing the rods and cones are very much the same. Except that where in *Typhlotriton* I found only an indistinct separation of the outer two layers from the nuclear layer, in *Desmognathus* I could with Mallory's stain here and there demonstrate a blue line in this locality. It seems, therefore, that the peculiar appearance of the cells in the layer of rods and cones does not alone belong to *Typhlotriton.* The retinae of another salamander, *Diemyctilus viridescens,* from Cliff Cave, Missouri, have very different rods and cones, which are easily recognized as such.

A distinct nerve fibre layer, however, I have been just as unable to find in the retina of *Desmognathus* and *Diemyctilus* as in that of *Typhlotriton.* Either these fibres have become disintegrated during the hardening process, or, instead of forming a separate layer as in man, they may, perhaps, run between the ganglionic cells in such a manner as to be more or less hidden and not easily distinguished.

Like Eigenmann I have not found any network of bloodvessels in the retina proper, yet in a number of sections there is one large bloodvessel lying in the retina—but I have found it in cross sections only—near where the optic disc should be. It seems to be venous in character.

As I have never been able to see a nerve fibre layer in the retina, I have, also, been unable to see exactly how the nerve fibres pass out of the eye. In some sections a line passes through the posterior pole of the retina to the nerve. (See Figs. 9 and 10.) The latter simply forms a process which is very darkly pigmented and which beginning at the outer surface of the retina passes through choroid and sclerotic and into the tissue centrally from the eyeball in a direction toward the cranial cavity and brain. I have no transverse sections which allow of a better understanding very close to the eye, but I have numerous transverse sections of the nerve farther away centrally. Here the nerve in most specimens is seen to be accompanied or surrounded by darkly pigmented cells—in one no such pigment cells are found. The optic nerve itself is small and consists of very few fibres only. (See Fig. 18.) From their nuclei I can only count about from 6 to 12. It appears from a number of sections that each optic nerve separately enters the cerebral hemisphere on its side, at least in a number of sections this seems to be the only explanation. In these I find a strand of fibres with spindle shaped nuclei going from the back of the eye towards the brain and entering it through an opening in the cranial bones. The only link wanting is the direct connection of this strand of fibres with the retina, probably due to a curve which the nerve makes just behind the eyeball.

Eigenmann says: "In both adult and young the optic nerve enters as a single strand and passes entirely through the layers. A heavy mass of pigment is found following the optic nerve to within a short distance of the brain."

The crystalline lens is very large and in most sections, as far as I can see, it is perfectly spherical, although Puetter (Graefe-Saemisch. 2^1: 192. [2nd ed.]) says: "The lens of amphibia is not really spherical, as this is usually stated. The anterior surface is less curved than the posterior one." It fills in my sections almost the whole space between the cornea and posterior surface of the iris, and the retina, except at its posterior pole where the retina has a funnel-like depression (corresponding to the optic papilla in man) in front of the optic nerve. It consists of broad epithelial fibres with large oval nuclei. While in man the capsular epithelium reaches only a little ways back of the aequator of the lens, in *Typhlotriton* it lines the whole of the lens capsule. (See Fig. 8.)

Whether there is any tissue, like the vitreous body of man, in the eye of *Typhlotriton* I have not been able to decide. There is in many of my sections a small amount of amorphous tissue, stained slightly by eosin, situated in the funnel back of the lens; but it is impossible to state whether this is derived from vitreous body or from disintegrated nerve fibres coming from the retina. (See Figs. 1, 2, 9 and 10.)

What I have stated thus far refers to the eyes of both larvae and adults. As already mentioned, I can find no material difference between the two states. If there is one it must be in larvae considerably smaller than the two which I had for examination.

The only real difference I can find is that the adults have eyelids and a conjunctival sac. (See Figs. 3 to 8.) Two of my adult specimens have a small palpebral fissure which is centrally located. Towards what might be termed the outer and inner canthus the eyelids are united. In these specimens the upper lid overlaps the lower one in the palpebral fissure to quite an extent. (See Figs. 3, 6, 11.) Both lids contain the same small amount of subcutaneous pigment. To both sides of the palpebral fissure the union of the two eyelids is for a certain distance an epithelial union only (see Fig. 13), but still further outward this gives place to firm tissue union. The palpebral opening can be of little use as far as the admission of pictures from the outer world goes, especially since there does not even seem to be any muscular tissue in the upper lid which might serve as a levator. Yet, the eyelids are evidently transparent enough to transmit a considerable amount of light. Mr. Hurter tells me that he found at least one specimen of *Typhlotriton* crawling on a rock outside of and quite a distance removed from the entrance of Marble Cave. This seems to show that the animal is not blind in the full sense of the word, or at least that some individuals do not always live in the darkness of the cave.

Eigenmann says: "The six normal eye muscles were present in *Typhlotriton.* The musculi recti form a sheath about the optic nerve in its distal part and spread out from it near the eye." It is hard to understand what is meant by this description. There is, as far as I can see, much muscular tissue in the neighborhood of the eye, but it has not been my good fortune to see one, much less the six normal muscles insert themselves into the sclerotic. In fact the only muscular tissue which seems to merge into the sclerotic reaches backward from the posterior pole of the eye enveloping the optic nerve. It seems to form a rather thick and broad band which is attached to the sphenoid bone. It would seem that this muscle might act as a retractor oculi. (See Figs. 9 and 10.)

EXPLANATION OF THE PLATES.

Plate XXVI.—Fig. 1. Vertical section through the eye of the larva of *Typhlotriton* which still had gills. No evidence of lid formation. Cornea covered with epithelium which is flattened and differs materially from that on the surrounding skin. The retina does not lie in the normal position since the eye is shrunken, but shows the different layers well. A separation between the two outermost layers of cells and the remainder of the retina is quite noticeable. Fig. 2. Vertical section through the eye of a *Typhlotriton*, probably just about reaching the adult state. This specimen showed no gills, yet, no eyelids have as yet been formed. Perhaps, the protruding fold seen on the left side of the cornea is the beginning of the lower eyelid. In this figure, too, although not as well as in figure 1, a separation of the two outermost layers of the cells of the retina from the broad nuclear layer is visible.

Plate XXVII.—Fig. 3. Vertical section through the head of an adult *Typhlotriton.* The plane of this section is evidently somewhat oblique. In consequence the left eye shows the eyelids where the small palpebral fissure is open, while on the right side this is closed by firm tissue union of the two lids. On the left the upper eyelid overlaps the lower one in such a manner as to make the palpebral fissure apparently useless for vision. There is quite a large conjunctival sac. Below are remnants of the food of the salamander. Fig. 4. Vertical section of the head of an adult *Typhlotriton.*

Plate XXVIII.—Fig. 5. Vertical section somewhat further back than figure 4. In this specimen no overlapping of the upper lids over the lower one has taken place and there is no palpebral fissure, the lids being united at their margins. The conjunctival sac is plainly visible between the lids and eyeball. Incidentally these sections show the lower jaw and glandular tongue of this salamander. Fig. 6. Vertical section through the eye of an adult *Typhlotriton* showing under a higher power the manner in which the upper eyelid overlaps the lower one. The cornea and its epithelial covering are well preserved. The whole eye is evidently pretty firmly united with the surrounding tissue and therefore probably immovable. No external eye muscles are visible.

Plate XXIX.—Figs. 7 and 8. Enlarged from figures 4 and 5, showing the union of the eyelids at their margin and the absence of even a microscopical palpebral fissure. Figure 8 shows the capsular epithelium of the lens on its posterior surface. No eye muscles are visible.

Plate XXX.—Fig. 9. A nearly horizontal section through the eye of an adult *Typhlotriton.* The crystalline lens lies against iris and cornea; the contents of a possible anterior chamber have disappeared. The thick retina forms a broad band behind the lens from which it is separated only posteriorly by a funnel shaped depression in it corresponding to the human optic papilla. The inner reticular layer is seen as a white line. There is, also, an indistinct whitish line seen to pass through the thickness of the retina at the posterior pole and apparently to connect with the optic nerve. The latter leaves the eye in a curve and appears darkly pigmented. An indistinct broken line may be seen to separate the two outermost layers of cells from the remainder of the retina. To the right of the optic nerve some muscular tissue is seen to insert itself into the sclerotic. Fig. 10. Another horizontal section through the same eye as figure 9. The darkly pigmented optic nerve can be traced somewhat farther back nasally. The muscular tissue inserting itself into the posterior part of the sclerotic is seen in this section to the right and left of the optic nerve. The small funnel shaped space between the posterior pole of the lens and the retina in both of these figures is filled with an amorphous material.

Plate XXXI.—Fig. 11. Enlarged from figure 3. Shows the two lids in the middle of the palpebral fissure and the manner in which the upper one overlaps the lower. To the right is the corneal epithelium cut obliquely. Fig. 12. Enlarged from figures 5 and 8. Although in this eye the lids appear throughout united with each other at their margins, so that there is no palpebral fissure in this *one* section from the center under a high power it seems as if the union was not yet quite accomplished. The conjunctival sac is still quite large. To the right the corneal epithelium is seen in oblique section.

Plate XXXII.—Fig. 13. Vertical section through the lids of an adult *Typhlotriton* a little beyond the open palpebral fissure. It shows that the union between the eyelids in this part is as yet only an epithelial one. To the right the corneal epithelium. Fig. 14. Section through the retina of a larva of *Typhlotriton.* To the left and upward sclerotic, in the lower angle part of the cartilage tissue found in the sclerotic. To the right in the retinal tissue the transverse section of a large, probably venous bloodvessel. No layer of nerve fibres can be made out on the inner (upward) surface of the retina. The ganglionic layer appears to consist of six or eight rows of cells. The white space separating the ganglionic layer (downward) from the broad nuclear layer is the inner plexiform layer. In this section the separation between the nuclear layer and its two outermost layers of cells is not so marked as in others, but the outer cells corresponding to rods and cones can be well seen. They appear as conical or oval bodies. The space between these layers and the pigment epithelium is filled with detritus containing many fuscin needles.

Plate XXXIII. Figs. 15 and 16. Sections through the retina of adult eyes. They show that there is very little difference between the retina of my specimens from the larval or the adult state. Really the only difference I can find is that the outermost layer (rods and cones) seems to consist in the main of oval cells. From these cells small processes may be seen in many places to reach into the space between retina and pigment epithelium, which I take to be the outer segments of the typhlotriton's rods and cones, although most of them are evidently disintegrated and form the detritus which fills this space.

Plate XXXIV. Fig. 17. Section through the retina of an adult eye. Fig. 18. Shows a transverse section of an optic nerve not very far from the eyeball. The large black mass is the choroid cut at a tangent. The nerve which lies below it is accompanied by a large number of darkly pigmented cells and surrounded by muscular tissue. Below is the palate with its cylindrical epithelium.

Issued October 12, 1910.

FIG. 1.

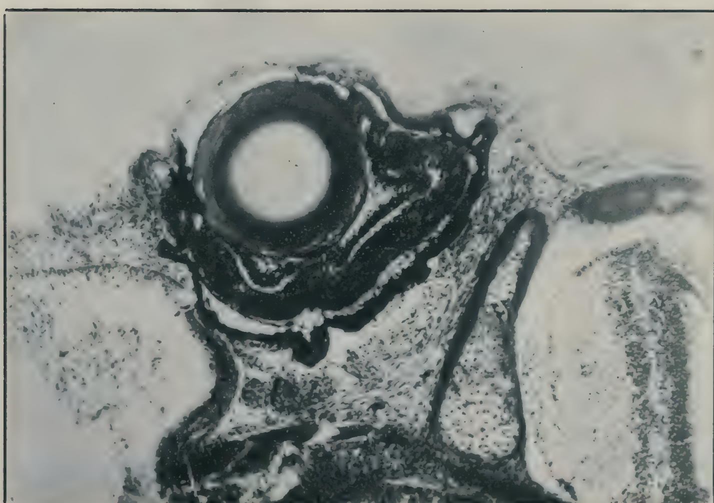

FIG. 2.

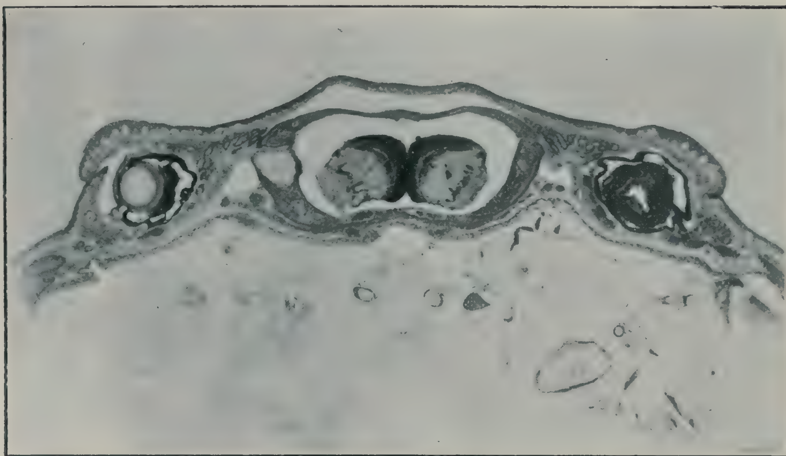

FIG. 3.

FIG. 4.

FIG. 5.

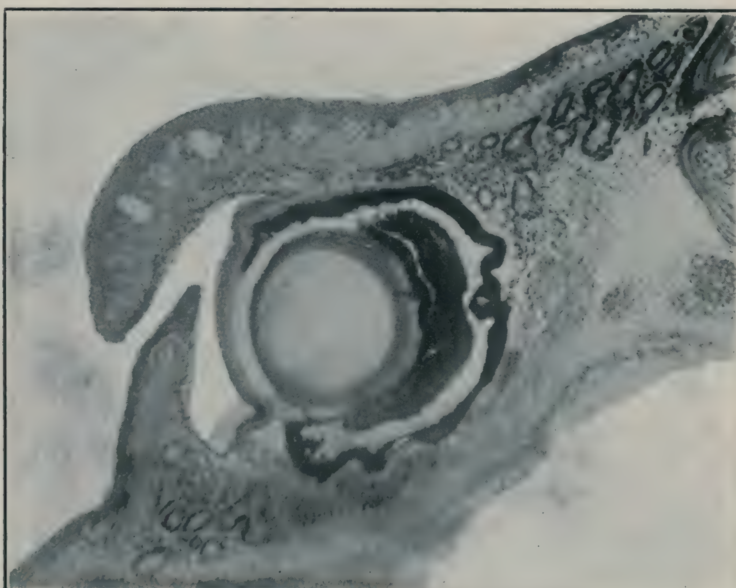

FIG. 6.

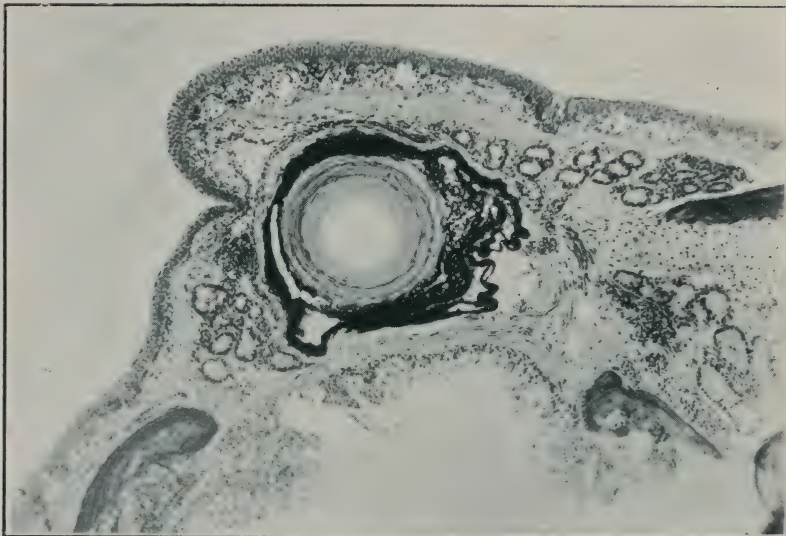

FIG. 7.

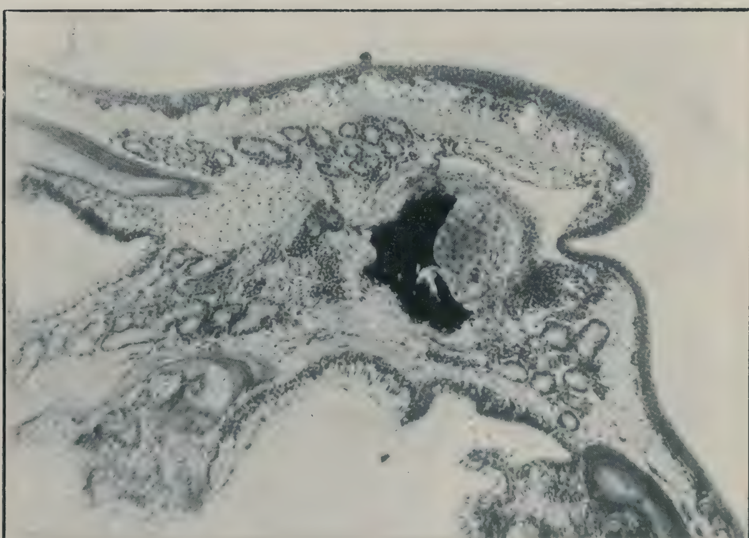

FIG. 8.

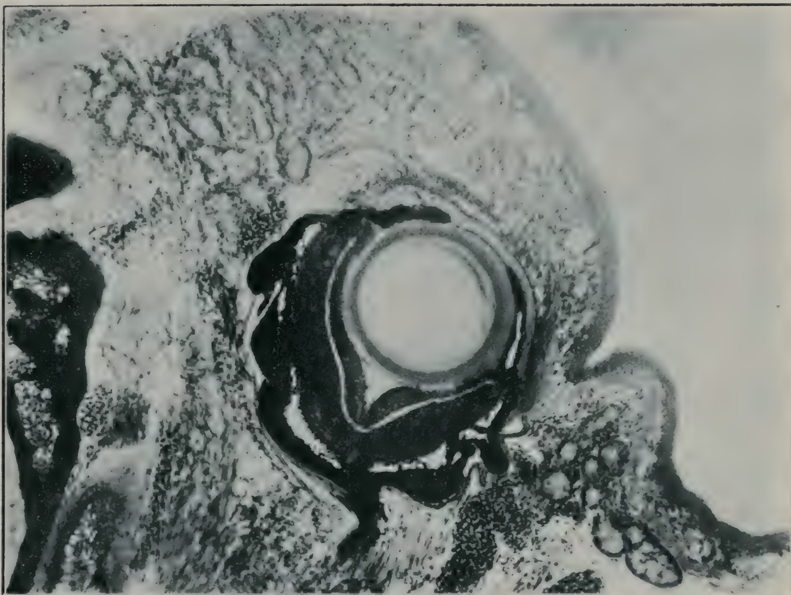

FIG. 9.

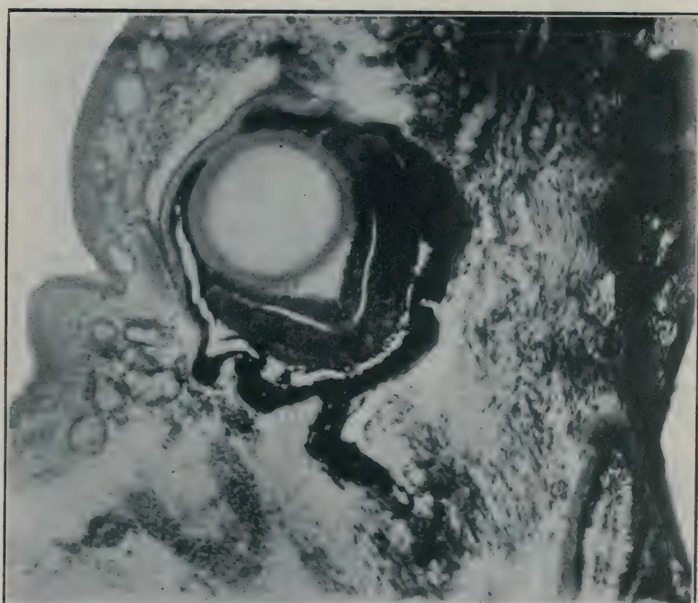

FIG. 10.

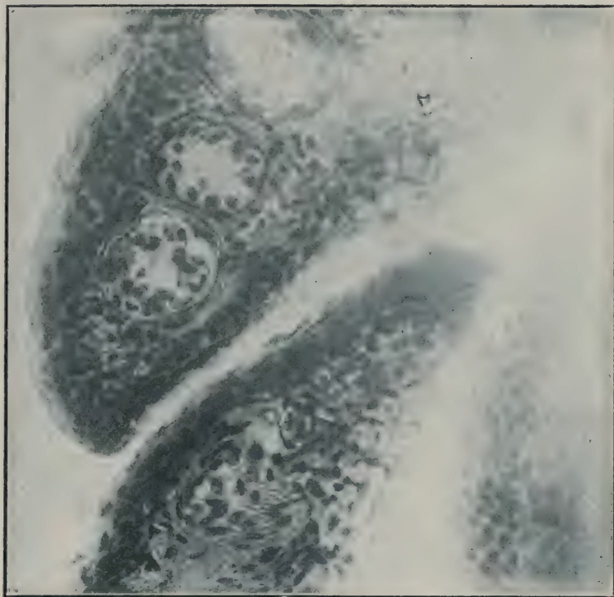

FIG. 11.

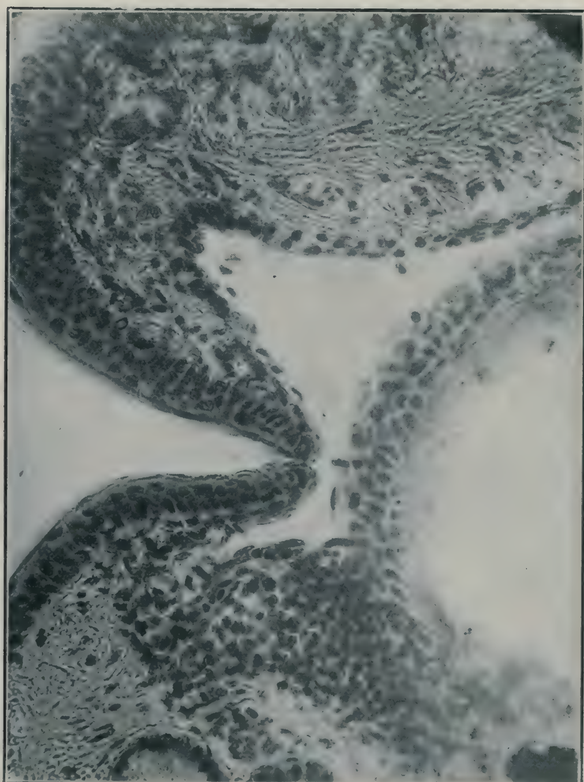

FIG. 12.

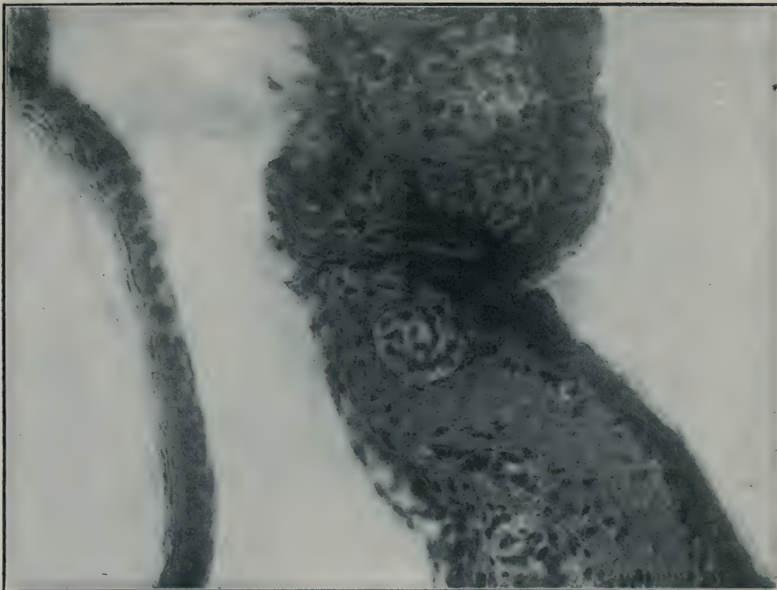

FIG. 13.

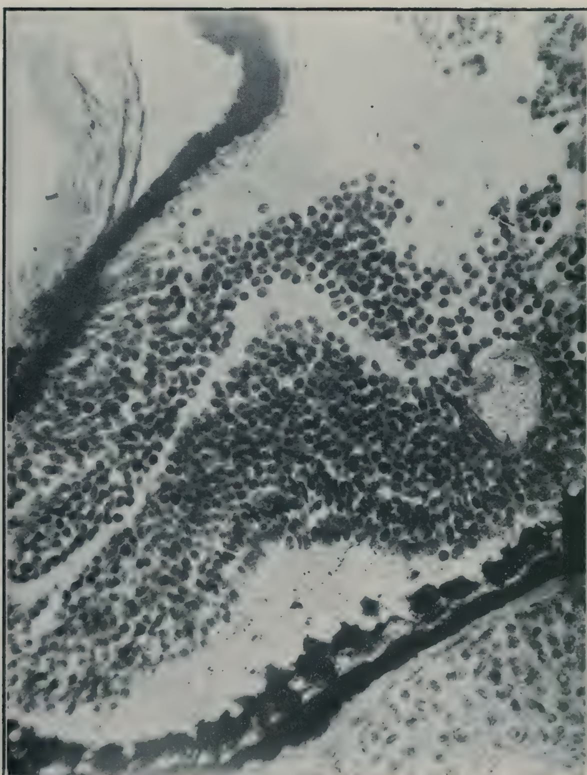

FIG. 14.

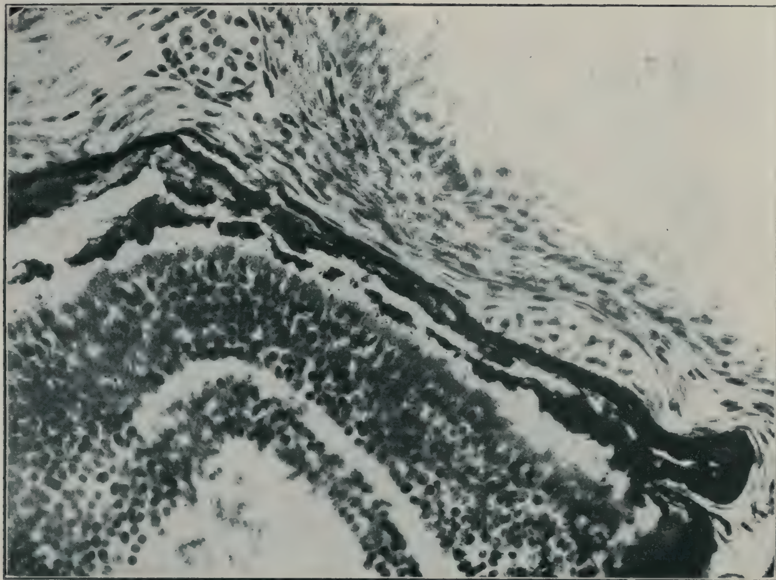

FIG. 15.

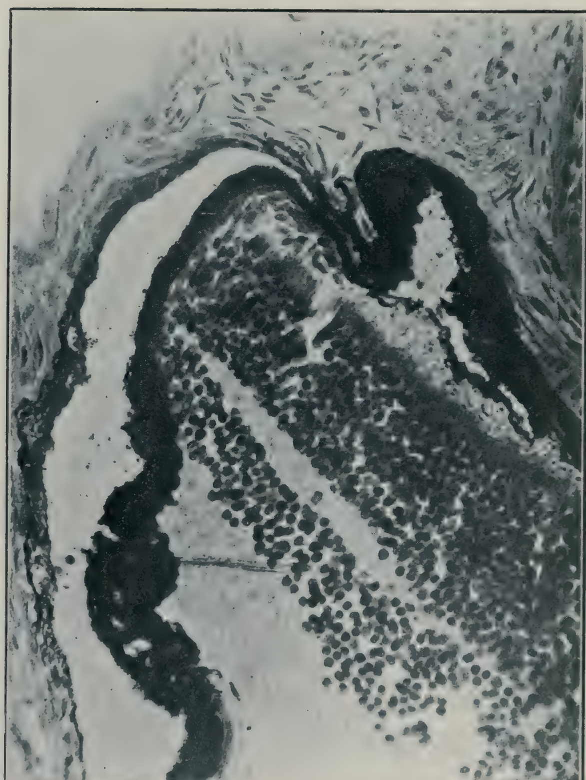

FIG. 16.

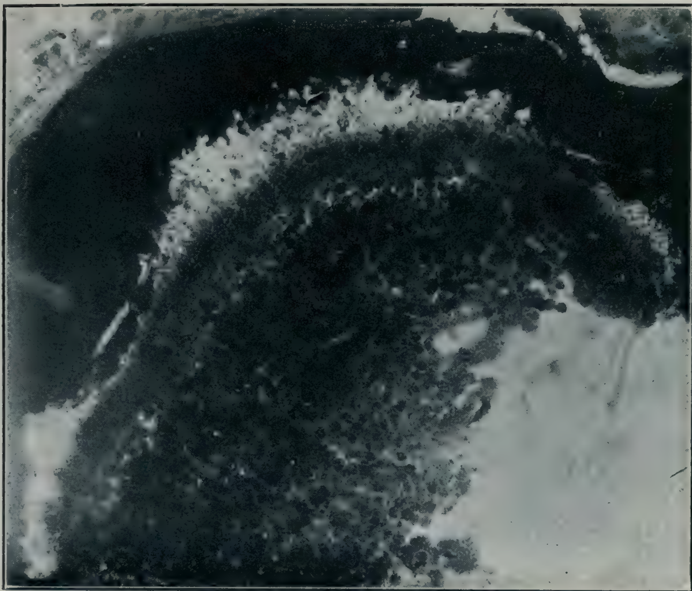

Fig. 17.

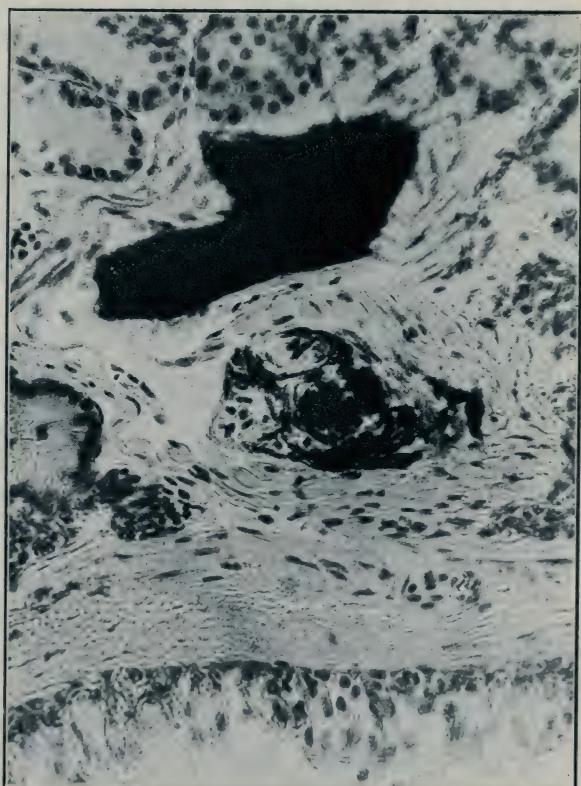

Fig. 18.

FLORA OF THE GRAND FALLS CHERT BARRENS.*

Ernest J. Palmer.

Several years ago while botanizing near Joplin, Missouri, I came upon an interesting locality in the valley of Turkey Creek where several plants were growing that I had not noted or collected previously in the vicinity, and subsequent visits to the same spot have been rewarded by the discovery of a number of other uncommon species.

At this point, on the north side of the creek, just west of the Girard branch of the Frisco Railway, along the Joplin-Belleville wagon road, the erosion of the stream has laid bare a massive bed of chert or flint, the rugged but generally horizontal surface of which forms the floor of the valley over an area of several acres. The thin layer of rich soil gathered in the local depressions of the rock, subjected to sharply contrasted conditions in regard to moisture at different seasons of the year, serves to support a flora in many respects peculiar and interesting.

Some time later, having extended my explorations to Shoal Creek in the northern part of Newton County, I was surprised to find much more extensive outcrops of the same chert formation, upon which a number of the peculiar plants collected at the Turkey Creek locality, several miles north in Jasper County, were growing under practically identical conditions. This was in the vicinity of Reding's Mill, about four miles south of Joplin. On both sides of the stream, near the bridge that spans it at that point, the chert is well exposed and good examples of the barrens may be seen. During the past few years I have made several trips to this region, exploring the barrens on both sides of the creek as far

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* Presented by title to The Academy of Science of St. Louis, November 21, 1910.

down as the Grand Falls, some two or three miles below. On two or three of these excursions Mr. B. F. Bush has accompanied me; and I am indebted to him for the determination of a number of the species.

The picturesque scenery along this part of the creek attracts many picnic parties and campers from Joplin and other nearby towns. The locality has been known to geologists since Swallow first described it in the old Missouri Reports of 1855. In connection with the work of the Geological Survey Professor Broadhead also made a small collection of plants in the vicinity of Grand Falls. The botany of the barrens formed by the chert exposures, scarcely less interesting than the geology of the region that has been studied by both the United States and State Surveys, presents several features worthy of investigation and description. To the enthusiastic collector the locality is one of special interest on account of the presence of a number of plants that are rare or unknown elsewhere in this part of the country. The peculiar ecological conditions under which the plants grow, and which undoubtedly make it possible for them to maintain themselves against the encroachments of the common dominant species that surround them, while at the same time limiting their range strictly to the area occupied by this particular geological formation, also offer an interesting field for study.

In the present paper only a brief sketch can be given of the singular physiographic features of the region and the resulting peculiarities of the local flora. The locality is one that would well repay a closer study with a more complete list of plants than that appended, which is based on the results of several hasty collecting trips at various times in the year, although scarcely covering the entire season. However it is intended to include all of the higher plants noted that seem peculiar to the region as well as a number common to the dry woods and prairies surrounding the barrens.

The geological formation that gives rise to the Shoal

Creek barrens is a massive silicious bed near the base of the Keokuk stage of the Mississippian series or Lower Carboniferous rocks. Throughout Southwest Missouri and adjacent territory occupied by strata of this age chert is everywhere abundant, usually in the form of nodules, lenses or layers interbedded with limestone. The Grand Falls Chert layer, as this formation is called from the falls on Shoal Creek where it is typically exposed, is remarkable if not unique for its great extent and thickness. The surface exposures, with the exception of the small area referred to above on Turkey Creek, north of Joplin, are confined to the valley of Shoal Creek and several of its small tributaries in the northern part of Newton County, Missouri. The area has been carefully studied and mapped by the United States Geological Survey, and the formation is described in the Geological Atlas of the Joplin District, published in 1907. The exposed area perhaps aggregates about two square miles, beyond which the chert disappears under higher strata and is of wide extent as revealed by hundreds of shafts and drill holes that have penetrated it in search of lead and zinc ores, of which it often carries valuable lodes. To the northward in Jasper County it is known to the miners as the "sheet ground," and is the basis of a very extensive mining industry. In the vicinity of Webb City the chert is found at an average depth of about one hundred and fifty feet below the surface, and its thickness ranges from thirty to forty feet. Elsewhere it is said to attain a maximum thickness of over eighty feet.

Shoal Creek, along which the principal exposures of Grand Falls Chert occur, is a swift flowing stream of considerable volume, that might well be denominated a small river. It has its rise in the highlands of Barry County, flowing in a winding but generally northwesterly direction until it joins Spring River several miles beyond the Kansas line. For the greater part of its course it traverses a rugged hilly country, through which it has carved a valley of varying width and depth, the adjacent hills sometimes rising to a height of two or three hundred feet above the flood plains.

Where the course of the stream has led through the usual limestone formations of the region portions of the valley are from half a mile to a mile in width. However when the level of the Grand Falls Chert was reached the process of erosion was sharply checked, and a series of shallows and rapids were formed, as the water, etching its way slowly through the hard strata, leaped from ledge to ledge. This change in the topography of the valley is well shown on the map, where the contour lines are crowded close to the stream in the vicinity of Reding's Mill. Three miles below the rapids culminate in the Grand Falls, where the stream makes a drop of twenty-four feet. For most of the intervening distance the creek has cut through the upper layers of the chert, which is exposed on one or both sides in perpendicular or overhanging cliffs, twenty to forty feet in height. Extending for some distance back from the tops of these cliffs the rock has been washed bare or is covered only with a sparse mantle of soil, thus forming the barrens.

So hard and dense is the rock that the ordinary forces of surface erosion: rain, wind and frost, have little effect upon it. Looking at the gnarled and rugged faces of the cliffs or at the smoothly polished promontories of the surface, one might well believe that the storms of ages would beat upon them to little purpose. Indeed few works of nature impress the mind more forcibly with a sense of their strength and indestructibility than these massive beds of the Grand Falls Chert.

The stream, however, aided by the sharp gravel and boulders derived from the beds themselves, is slowly but incessantly cutting its way through them, and in places undermining the cliffs. The process of disintegration is facilitated by the fact that the rock is deeply fractured at intervals by fissures, either vertical or at various angles, that eventually allow undermined portions of the cliffs to shear off into the stream. Here and there great castlelike masses thus detached lie isolated at the foot of the cliff or well out in the stream itself, bearing mute testimony to the slow ravages of time. The general and extensive fracturing of the beds, due to the brittle nature of the rock, has doubtless been caused by stress and displacement, resulting either from a general upward movement of the region or a local settling in consequence of solution of the underlying limestone. Both causes have been operative at times more or less remote, and the latter at least is still going on to some extent.

Where a fissure has determined the line of cleavage the face of the cliff is often smooth and bare, not even a lichen finding foothold on its barren surface. However, owing to the peculiar gnarled and brecciated nature of the rock, the cliff faces are usually very irregular, affording many hollows, crevices and shelves, where soil borne by the wind or transported by rainwater from the hills above or by the alluvium laden waters of the stream in times of flood, finds ready lodgment. Here soon a few hardy mosses, grasses and other herbaceous plants establish themselves, adding vegetable mold to the deposit from year to year, and thus affording sustenance to other immigrants, until in time the face of the cliff is adorned with a diversified flora wherever a little shade and moisture exist.

In such situations are found several ferns, some of them not known elsewhere in the region. These are *Dryopteris marginalis, Asplenium Trichomanes* and *Cheilanthes lanosa,* although the last also extends up into the barrens and flourishes wherever a ledge or irregularity of surface affords a little protection. *Asplenium parvulum, Woodsia obtusa* and several other ferns also abound, and *Melica nitens* and *Arabis laevigata* are quite characteristic, with many other plants common to the barrens and surrounding woods.

Where the horizontal surface of the chert is smooth and level a condition of absolute barrenness prevails. This is however the case only over very small spots, as in general the surface is very rough and irregular, splintered and jagged, or rising into innumerable small hummocks and bosses and sinking into basin-like depressions, seldom exceeding a few inches or at most a foot or two in vertical measurement, but sufficient to cause the accumulation of a thin layer of soil and to retain an abundance of water during the rainy season. In addition to this, at several places, terraces or ledges a few feet in height afford still further protection to soil and plants.

The close fine textured chert being quite impermeable to water, except where flawed or fractured, pools gather in the basin-like depressions, where the water is retained until, as the season advances and rains become less frequent, it is gradually evaporated by the sun; after which the region becomes temporarily a parched desert again. To this unequal distribution of moisture in different parts and at different seasons of the year may doubtless in large measure be attributed the peculiarities of the flora.

In spring and early summer, with a superabundance of water in the local depressions, a number of brackish water and moisture-loving plants spring up. Amongst these are *Eleocharis ovata, Fimbrystylis laxa, Stenophyllus capillaris, Cyperus aristatus, C. acuminatus, Juncus marginatus, Allium mutabile* and *Cynosciadium pinnatum.*

Just beyond the margins of these temporary pools, in thin rich soil, at first saturated but soon dry, or where the rock is nearly exposed, such succulent species as *Sedum Nuttallianum, S. pulchellum, Portulaca pilosa, Talinum calycinum* and *T. parviflorum* flourish. In somewhat drier situations, but where the accumulation of soil is greater and moisture is consequently conserved to some extent for a considerable portion of the season, the number of species is much larger. Typical amongst them are *Saxifraga texana, Selenia aurea, Rumex hastatulus, Crotonopsis linearis, Lathyrus pusillus, Chaerophyllum texanum, Ptilimnium Nuttallii, Spermolepis echinata, Hypericum pseudomaculatum, Linaria canadensis, Phacelia* *dubia, Coreopsis lanceolata, C. tinctoria* and *Polygonum tenue.* Growing with these are also many plants of wider distribution, evidently invaders from the dry woods and prairies beyond. In number of species these far exceed the "aborigines," although of the latter such plants as *Selenia aurea, Crotonopsis linearis* and *Coreopsis tinctoria* sometimes prevail over limited areas almost to the exclusion of all others.

Over the most exposed portions of the surface, where the rock is almost destitute of soil and very little sustenance is afforded such hardy pioneers of vegetable colonization as *Selaginella rupestris,* reindeer moss and a number of other lichens and mosses manage to maintain themselves. Here, no doubt, the cryptogamist would find an interesting field for study.

As might be expected nearly all of the characteristic plants of the more typical portions of the barrens are annuals, with a few fleshy-rooted perennials, such as *Opuntia macrorhiza* and the Talinums, especially adapted to sustaining long periods of drouth. The life period of many of the plants is shorter and the individuals are much smaller than of the same species under normal conditions. The perpetuation of some of them apparently is dependent upon their ability to mature their seeds or spores while the supply of moisture holds out. With the hot sun beating down on the unshaded rock, the germination of the seed deposited in the thin rich soil, and the subsequent development of the plants is hastened with almost tropical rapidity.

In a normally dry season the number of plants that can be collected after mid-summer is very small. Of the annuals a few grasses, such as *Aristida basiramea* and *Eragrostis capillaris,* and such narrow leafed plants as *Polygonum tenue, Crotonopsis linearis* and *Isanthus brachiatus* survive until late in the season. After the autumn rains set in some of these seem to take on a new lease of life, with *Selaginella rupestris* and the fleshy rooted perennials.

Narrow and linear leafed plants are strikingly predominant in these barrens, broad and large leafed species being indeed entirely absent from the typical portions. This is of course plainly a case of adaptation to environment, such species being better able to resist the scorching sun and drouth to which they are subjected. Another noticeable peculiarity, perhaps not so easily explained, is the predominance of yellow-flowered plants. Possibly this is more apparent than real, however, from the fact that most of the common species with conspicuous flowers have petals of this color. Early in the spring the bright yellow blossoms of *Selenia aurea* give a truly golden tint to the surface. A little later it assumes a somewhat paler hue, as the lemon-colored flowers of *Sedum Nuttallianum* come into evidence over a large part of the area. As the season advances the slender scapes of *Coreopsis lanceolata* and the taller branching stems of C. *tinctoria* bear a wealth of richly tinted blossoms, conspicuous from afar, like the gold of some fabled Ophir or Eldorado.

Most of the plants peculiar to the barrens are strictly limited in their range, seldom being found more than a few feet beyond the chert outcrop; and it is only over very limited areas that they are able to maintain undisputed possession and keep back the hordes of the more hardy races that press upon them from all sides, invading their territory wherever a little greater accumulation of soil exists, as a breach in the rocky barrier that defends them.

The amount of soil varies greatly in different parts of the barrens, patches of absolutely naked rock, where no form of vegetation can maintain itself, alternating with small areas upon which a deposit of soil and gravel several inches or even feet in thickness sustains a growth of shrubs and stunted trees, in addition to the herbaceous species.

The ligneous plants are limited chiefly to a series of low knolls or mounds, that constitute a very striking and peculiar feature of the region, and one that stands in need of further explanation. On both sides of the creek, wherever the chert is exposed and even over the small area on Turkey Creek in Jasper County, these peculiar mounds may be observed. They are perhaps most typically developed along Silver Creek, a small stream that flows into Shoal Creek from the north, near Reding's Mill. A large number may be seen along this stream, just west of the Joplin wagon road, and between this point and the mouth of "Tanyard Hollow" hundreds could doubtless be counted.

These elevations are usually from ten to thirty feet in diameter, roughly circular in outline and rise in the center to a height of from two to three feet above the general level. The plants occupying these knolls are, as might be expected, chiefly those of the dry woods, which monopolize these more favorable spots nearly to the exclusion of the barren species. Amongst trees and shrubs *Quercus stellata, Q. marylandica, Diospyros virginiana, Fraxinus americana, Amelanchier canadensis, Rubus villosus, Rosa setigera, Vaccinium arboreum* and *V. vacillans* are common.

A general similarity in size and form and something like uniformity of distribution at several points strongly suggests the theory that the mounds are of artificial origin. With this idea, no doubt, persons digging for relics have dug trenches in several of them at different points. However, so far as known, nothing has been found in any of them to repay the investigation or to bear out the theory. The material forming the mounds, as encountered in these excavations, is a mixture of soil, clay and chert fragments, showing no evidence of human agency in its arrangement, but on the contrary having every appearance of being a natural deposit of residuary material. Indian relics are found at a number of places in the nearby alluvial valley; but one could scarcely believe that the rocky barrens would be likely to have appealed to the aboriginal settlers as a favorable site either for a village or a necropolis. Moreover a careful search has failed to discover any trace of implements or of wrought flints on the surface of the barrens. The most obvious and natural explanation would be that the knolls are merely the result of surface erosion, remnants of the soil mantle that once covered the entire area; but when seen in the field this hypothesis can scarcely be entertained as a satisfactory one, in view of the peculiar appearance of the mounds, as mentioned above. Rejecting these explanations as unsatisfactory, a third possible one suggests itself: May not these low mounds have been constructed by some animal long since extinct, that once found a congenial habitat in the rocky barrens along the banks of these clear, swift flowing streams? However their origin may be accounted for, their frequency and uniform size render them a singular and striking feature of the region.

The range of most of the peculiar species of plants is, as has been stated, co-extensive with the chert outcrop; and it is a curious fact that nearly all of those found at the Shoal Creek localities should reappear with the outcropping of the Grand Falls chert north of Turkey Creek. Although only about six miles distant this area is entirely isolated from the main outcrops, and no trace of most of the barrens plants can be found in the intervening or surrounding country. A few of the species, such as *Selenia aurea, Cyperus inflexus, Specularia leptocarpa, Portulaca pilosa, Talinum calycinum* and *Linaria canadensis,* are also found occasionally in sandy soil or in limestone barrens throughout Jasper and Newton Counties.

The occurrence in the barrens of a number of plants of such restricted range suggests interesting questions in regard to the survival and distribution of species. The soil of the uplands in this part of the State is entirely residual, resulting directly from the disintegration of the underlying rocks. Under such conditions a closer corelation between geological formations and plant distribution could naturally be expected, although of course, as elsewhere, moisture, drainage, shade and other factors are most important. After the region was elevated above sea level, in the remote past, ages must have elapsed before any great amount of soil could have been formed over most of the area. The greater part of the surface must then have possessed the characters of a rocky barren, with plants gradually appearing that were adapted to such a region. As the process of soil making proceeded the flora would of course undergo a corresponding transition, through the extinction of the old forms, their modification and the introduction of other species adapted to the changed conditions. Possibly in the small isolated rocky barrens of the present time we find survivors of some of the later stages of these ancient floras.

In the appended list the species regarded as local or peculiar to the barrens are marked with an asterisk.

POLYPODIACEAE.

Cheilanthes lanosa (Michx.) Watt.* Common on cliffs, in fissures and along ledges in barrens.

Asplenium parvulum Mart. & Gal. Uncommon on faces of cliffs.

Asplenium platyneuron (L.) Oakes. Common along ledges in barrens.

Asplenium Trichomanes L.* Common in clefts and on somewhat protected cliff faces.

Camptosorus rhizophyllus (L.) Link. Uncommon on moist shaded cliffs.

Dryopteris marginalis (L.) A. Gray.* Rare at two or three places on shaded cliffs.

Woodsia obtusa (Spreng.) Torr. Very common along ledges and in clefts in barrens.

EQUISETACEAE.

Equisetum arvense L. Uncommon in moist places.

SELAGINELLACEAE.

Selaginella rupestris (L.) Spreng.* Very common in exposed parts.

GRAMINEAE.

Digitaria filiformis (L.) Koehler.* Frequent in thin dry soil.

Panicum tennesseense Ashe. Common in thin dry soil.

Alopecurus geniculatus L. Frequent in wet depressions.

Aristida basiramea Engelm.* Common in dry exposed situations.

Eragrostis capillaris (L.) Nees. Similar situations to last. Common.

Melica nitens Nutt.* Frequent on cliffs and ledges.

Festuca octoflora Walt. Common in thin soil.

Glyceria nervata (Willd.) Trin. Uncommon in moist places.

Cyperaceae.

Cyperus aristatus Rottb.* Common in wet depressions.

Cyperus ovularis (Michx.) Torr. Frequent in dry soil.

Cyperus filiculmis Vahl. Frequent with last.

Eleocharis ovata (Roth) R. & S. Common in pools and depressions.

Stenophyllus capillaris (L.) Britton. Frequent with last.

Carex laxiflora blanda (Dewey) Boott. Wet depressions. Uncommon.

Carex triceps hirsuta (Willd.) Bailey. Frequent in dry soil.

Commelinaceae.

Tradescantia reflexa Raf. Common in dry soil and along edges of cliffs.

Juncaceae.

Juncus marginatus Rostk. Very common in wet depressions.

Luzula campestris bulbosa A. Wood. Common in dry soil.

Liliaceae.

Allium canadense L. Common in dry soil.

*Allium mutabile Michx.** Very local but abundant in wet depressions.

Nothoscordum bivalve (L.) Britton. Common in dry soil.

Camassia esculenta (Ker.) Robinson. Frequent in rather dry situations.

Orchidaceae.

Spiranthes gracilis (Bigel.) Beck. Occasional in dry soil.

Fagaceae.

Quercus stellata Wang. Small stunted specimens frequent on knolls.

Quercus marylandica Muench. Small specimens frequent on knolls.

Quercus Muhlenbergii Engelm. Small specimens occasional on knolls.

Ulmaceae.

Celtis mississippiensis Bosc. Common on knolls and along terraces.

Polygonaceae.

Rumex hastatulus Baldw.* Very common in thin soil, early moist but soon dry.

Polygonum aviculare L. Frequent in dry soil.

Polygonum tenue Michx.* Common in dry soil.

Caryophyllaceae.

*Arenaria patula Michx.** Common in thin soil, early wet but soon dry.

Portulacaceae.

Claytonia virginica L. Common in dry soil.

Talinum parviflorum Nutt.* Very local, but not uncommon in thin soil, early wet but soon dry.

Talinum calycinum Engelm.* Common with last and somewhat more widely distributed.

Portulaca pilosa L.* Common in thin soil, early wet but soon dry.

Ranunculaceae.

Ranunculus micranthus Nutt. Common in dry soil.

Ranunculus fascicularis Muhl. Common throughout in dry soil.

Lauraceae.

Sassafras variifolium (Salisb.) Ktze. Occasional on knolls.

Cruciferae.

Draba brachycarpa Nutt. Common in dry soil.

Selenia aurea Nutt.* Common in thin dry soil throughout.

Arabis laevigata (Muhl.) Poir. Frequent on cliffs and ledges.

Arabis canadensis L. Occasional with last.

Crassulaceae.

Sedum Nuttallianum Raf.* Common in thin soil, early wet but soon dry.

Sedum pulchellum Michx. Not so common as last, in similar situations.

Saxifragaceae.

Saxifraga texana Buckley.* Frequent in dry soil. April.

Heuchera hirsuticaulis (Wheelock) Rydb. Uncommon on cliffs and ledges.

Ribes missouriensis Nutt. Frequent along shelves and ledges.

Rosaceae.

Amelanchier canadensis (L.) Medic. Frequent on knolls and along edges of cliffs.

Crataegus macropoda Sarg. Frequent on knolls and in dry soil.

Crataegus furcata Sarg. Common with last.

Crataegus magnifolia Sarg. Uncommon along ledges.

Rubus villosus Ait. Frequent in dry soil and on knolls.

Rubus nigrobaccus Bailey. Frequent on cliffs and ledges.

Rosa setigera Michx. Frequent on knolls.

Prunus serotina Ehrh. Occasional on knolls and ledges.

Prunus americana mollis T. & G. This or another species, perhaps more than one, occurs along ledges.

Leguminosae.

Cercis canadensis L. Frequent on knolls and ledges.

Baptisia bracteata (Muhl.) Ell. Frequent on knolls and in dry soil.

Trifolium carolinianum Michx.* Frequent in dry soil.

Tephrosia virginiana (L.) Pers. Frequent on knolls and in dry soil.

Lespedeza virginica (L.) Britton. Occasional on knolls and in dry soil along ledges.

Stylosanthes biflora (L.) BSP. With the last and about as frequent.

Lathyrus pusillus Ell.* Locally abundant along banks and in moist situations.

Linaceae.

Linum medium (Planch.) Britton. Occasional in dry soil.

Oxalidaceae.

Oxalis violacea L. Common in thin dry soil.

Rutaceae.

Ptelea trifoliata L. Occasional along ledges and near streams.

Polygalaceae.

Polygala incarnata L. Uncommon in dry soil.

Polygala sanguinea L. Common on knolls and in dry soil.

Euphorbiaceae.

Crotonopsis linearis Michx.* Very common in thin dry soil, sometimes almost to the exclusion of other species.

Acalypha gracilis Gray. Frequent in dry soil.

Euphorbia maculata L. Common in thin dry soil. Quite villous.

Euphorbia dentata Michx. Frequent in dry soil. Perhaps introduced.

Anacardiaceae.

Rhus trilobata Nutt. Frequent along ledges.

Hypericaceae.

Hypericum pseudomaculatum Bush. Infrequent in thin dry soil.

Hypericum Drummondii (G. & H.) T. & G. Frequent in dry soil.

Cistaceae.

Lechea tenuifolia Michx. Common in dry soil.

Cactaceae.

Opuntia macrorhiza Engelm.* This or perhaps a new species is common in dry soil and on knolls throughout the barrens.

Lythraceae.

Cuphea petiolata (L.) Koehne. Frequent in dry soil.

Onagraceae.

Oenothera linifolia Nutt. Common in thin soil, early wet but soon dry.

Umbelliferae.

Chaerophyllum texanum C. & R.* Common throughout in dry soil.

Spermolepis echinata (Nutt.) Heller. Locally abundant in a few places, in thin dry soil.

Ptilimnium Nuttallii (DC.) Britton. Common throughout in dry soil.

Cynosciadium pinnatum DC.* Very local but not rare in pools and wet depressions.

Daucus pusillus Michx. Common in dry soil.

Ericaceae.

Vaccinium arboreum Marsh. Occasional along ledges and edges of cliffs.

Vaccinium vacillans Kalm. This and perhaps one or two other low species are common on knolls and ledges of the barrens as well as in the surrounding rocky woods.

Primulaceae.

Dodecatheon Meadia L. Uncommon in more protected parts.

Oleaceae.

Fraxinus americana L. Small stunted specimens frequent on knolls.

Gentianaceae.

Sabbatia campestris Nutt. Frequent on knolls.

Hydrophyllaceae.

Phacelia dubia (L.) Small.* Very common throughout in dry soil and along ledges.

Labiatae.

Isanthus brachiatus (L.) BSP. Occasional in thin dry soil.

Scutellaria versicolor Nutt. Occasional in dry soil.

Scrophulariaceae.

Linaria canadensis (L.) Dumont.* Frequent in dry soil.

Solanaceae.

Physalis heterophylla Nees. Frequent in dry soil.
Physalis pumila Nutt. With the last, and about as common.

Acanthaceae.

Ruellia ciliosa Pursh. Common in dry soil.

Plantaginaceae.

Plantago virginica L. Common in dry soil.
Plantago aristata Michx. Common with last.

Rubiaceae.

Diodia teres Walt. Very common in dry soil.

Campanulaceae.

Specularia leptocarpa (Nutt.) Gray.* Locally frequent in dry soil.

Valerianaceae.

Valerianella radiata (L.) Dufr. Common in thin soil, early wet but soon dry.

Compositae.

Liatris squarrosa Willd. Infrequent in dry soil along bluffs.
Rudbeckia hirta L. Common throughout on knolls and in dry soil.
Rudbeckia amplexicaulis Vahl.* Local and uncommon along Silver Creek.
Coreopsis tinctoria Nutt.* Very common in thin soil, early wet but soon dry.
Coreopsis lanceolata L.* Common in dry soil and in situations similar to last species.
Coreopsis pubescens Ell. Uncommon in more sheltered situations.
Marshallia caespitosa Nutt. Local in dry gravelly soil, on bluffs near mouth of Silver Creek.

Issued December 15, 1910.

NEW ACARINA FROM INDIA.*

H. E. Ewing.

INTRODUCTION.

At present our knowledge of the Acarina is almost entirely confined to European and North American forms, with the possible exception of the family *Analgesidae,* or "Bird Mites." As the members of this family can be easily collected from the skins of birds in museums, its representatives have been obtained from all parts of the world.

A comparative study of those few forms which we do have from the tropics with the many now known from the North Temperate Zone appears to indicate, though we would hardly expect it, that, as a rule, it is the tropical forms that are the smaller and less remarkable in appearanace. In other words, for most free-living families at least, it appears that it is in temperate climates that they reach their greatest development. This point was strongly emphasized a few years ago by Mr. A. D. Michael of England, who then examined and described[1] some very fantastic and bizarre forms collected by Mr. Bostock in New Zealand. Every one of these species Mr. Michael referred to previously created genera, yet they showed a great exaggeration of the characters found in warmer climates.

A careful study of some fifteen species received from the southern part of India has been made by the writer. Judging from my knowledge of these forms as compared with our North American and the European Acarina, I have been convinced of the correctness of Mr. Michael's view. I find that, with one possible exception, all these

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*Presented by title to The Academy of Science of St. Louis, December 5, 1910.

[1]Unrecorded Acari from New Zealand. Journ. Linn. Soc. 30: 134-149.

species from a tropical climate are easily referable to well known genera, and in two cases the species are identical with temperate forms. Of the new species, which are described in this paper, all are of a modest appearance and of a relatively smaller size than our forms.

The new forms described in this paper were all, except one, obtained from some moss and dirt which was sent moist through the mails enclosed in tin cans. The material, as a whole, came though in fine condition and plenty of live individuals were found. For this collection, I am indebted to my brother, R. L. Ewing, who very carefully carried out the instruction given in regard to the collecting of the material and with such good results.

This moss and dirt was collected near Springfield Post Office, Nilgiri Hills, South India. The following is the exact data given by the collector: "The moss was gathered along a footpath running through a grove of young wattle, situated on a hill-side. The moss was plentiful, forming a thick carpet. The wattle formed a dense shade. The elevation is 6000 feet above sea level."

In the following pages nine new species are described. They are distributed into five families.

DESCRIPTION OF NEW SPECIES.

GAMASIDAE.

MACROCHELES Latreille.

With peritreme; first pair of legs without claws; dorsal shield entire; no post anal plate; hind femora unarmed; male genital aperture on the anterior margin of sternum; second pair of legs of the male slightly enlarged and usually provided with teeth.

One species.

Macrocheles hastatus n. sp.

Dark reddish brown, some specimens paler.

Mouth-parts well developed. Mandibles of the male with very long, curved, lateral, spear-like, chitinous projections, hence the name *hastatus*. Hypostoma of male extending forward in the form of two very long cusps which are about equal in length to the lateral spear-like projections of the mandibles.

Body almost twice as long as broad, strongly constricted in front of the shoulders, sides almost straight, and on the dorsal side evenly rounded behind. Dorsally, abdomen sparsely clothed with minute hairs. On the ventral side, the ventral plate projects beyond the dorsal margin of the abdomen immediately behind the anus. Anus small, circular and situated about twice its diameter from the posterior margin of this ventral plate.

Second pair of legs of the male enlarged and with a prominent tooth-like projection on the femur. The coxae of the posterior pair of legs are nearer together than the coxae of the other two legs.

Length, 0.78 mm.; breadth, 0.42 mm.

In moss. I was unable to find any living specimens of this species, for all of the specimens evidently had been dead before the moss was collected, as they were mostly in bad shape and were only empty shells. By putting together some seven or eight of these dead, shell-like specimens all the important characters could be obtained. Nilgiri Hills, South India.

GAMASUS Latreille.

Peritreme more than twice as long as broad; legs of the first pair provided with claws; dorsal shield entire; genital opening of the male at the anterior margin of the sternal plate; legs of the second pair in the case of the male frequently enlarged and armed with chitinous tubercles; epigynium of female triangular.

One species.

Gamasus dentatilinea n. sp.

Pl. XXXV. f. 5.

Female. In general appearance a very light yellowish brown.

Mouth-parts prominent; epistoma large, rectangular; from each lateral anterior corner there projects a prominent, sharp cusp; palpi about one-half as long as the first pair of legs, last segment equal in length, but much narrower than the penultimate; from the inner, distal edge of the penultimate segment there arises a sharp spine almost as long as the segment itself; antepenultimate segment slightly longer and wider than the penultimate; mandibles long and stout, and when extended they may reach beyond the tips of the palpi, constricted at their middle where there is a very long bristle at each side equal to one-half the total length of the mandible; chelae of the mandibles stout, almost straight, and each with a row of subequal, sharp teeth which extends the entire length of the same on its inner margin, hence the name, *dentatilinea.*

Abdomen almost twice as long as broad; margin slightly concave in front of the shoulders and broadly and evenly rounded behind. Abdomen dorsally clothed with rather short bristles, some of the larger of which are slightly clubbed and pectinate; shoulder bristles moderate and of the same kind as the larger abdominal bristles. Sternum subrectangular, extending from the front margins of coxae II to between coxae III, posterior margin concave. Female genital plate triangular, apex reaching beyond the posterior margins of coxae III and base situated far behind the posterior coxae.

Anterior and posterior legs much longer than the other two pairs. Tarsus of leg I, one and a half times as long as tibia and well clothed with simple setae; tibia twice as long as broad and longer than the patella, which is slightly curved. Posterior legs extending for more than half their length beyond the posterior margin of the abdomen, tarsus very long and tapering with an indicated segmentation near its base, tibia slightly over one-half as long as the tarsus.

Length, 0.54 mm.; breadth, 0.24 mm.

In trash. Described from a single female which came through from India alive and in good condition. She was very active.

Uropodidae.

uropoda Latreille.

Sculptures present on the ventral surface for the reception of the legs; legs of the first pair with claws; dorsal surface of the body sometimes with pits, but never sculptured, its margin unbroken.

Two species.

Uropoda discus n. sp.

Reddish brown; integument more strongly chitinized around the margins of the body, and in the region of the sternum and the coxae of the legs.

Body longer than broad with the front margin somewhat flattened and the hind margin rather narrowly rounded; with a few minute hairs on the dorsal surface. Upper plate of the exoskeleton extending down somewhat on the ventral surface at the sides in order to join the ventral plate.

Posterior part of the sternum of the male thickened and containing the circular genital opening which is situated immediately between the posterior coxae. In front of this posterior thickened area the sternum is roughly rectangular but between the second and third coxae a lateral angle is produced. Epigynium of female almost two-thirds as broad as long, extending from between the second coxae to behind the posterior margin of the fourth coxae. It is evenly rounded in front and slightly truncate behind. Anus very small and situated at the posterior margin of the abdomen.

Tarsus of leg I twice as long as tibia, clothed with many straight bristles, and ending in a rather long pedicel with minute claws; tibia broader than the tarsus and two-thirds as broad as long. Posterior pair of legs slightly longer than the second and third pairs. The femora of the last two pairs of legs are each provided with a triangular tooth on their posterior margins near the base. The tarsi of the three posterior pairs of legs are all very long and tapering.

Length, 0.40 mm.; breadth, 0.38 mm.

In moss. From Nilgiri Hills, South India. Described from one male and two females.

Uropoda postgenitalis n. sp.

Pl. XXXV. f. 3.

Color reddish brown; margins of the body darker than the rest of the body. Integument thick and with shallow pits; pits, though rather evenly distributed, are somewhat irregular in shape and size.

Mouth-parts rather small and hidden by a slightly projecting anterior, roundly curved, margin of body.

Body almost as broad as long, subcircular in outline with margins slightly roughened. Body clothed above with hairs that are unique in their structure. They each possess a single stalk-like base, but this basal stalk is soon resolved into three or even four elements. Of these different elements one is always much larger than the rest, and may be considered as composing the main body of the bristle. The other smaller elements which arise not far from the base of the bristle, extend along the larger one like whip-lashes. These bristles are arranged as follows: there are two rows of seven bristles each which run longitudinally, one on each side of the median line; a row of marginal bristles which completely encircles the body, of these there are about thirty; about an equal number scattered over the upper surface of the abdomen in no special order or arrangement.

Genital opening of the male large, circular and situated behind the last pair of coxae! Epigynium of female very long, fully twice as long as broad, extending from the front margin of the second coxae to the hind margins of the fourth coxae. It is widest near its middle and is narrowly rounded in front and truncate behind.

Excavations for the legs moderate, but snugly containing them when folded. Last three pairs of legs subequal. The femora are the stoutest segments while the tarsi are long and tapering.

Length, 0.52 mm.; breadth, 0.42 mm.

In dirt. From Nilgiri Hills, South India.

Oribatidae.

oribata Latreille.

Abdomen with chitinous wing-like expansions called pteromorphae; no spatulate hairs present; lamellae attached to the cephalothorax by their inner margins; tarsi with tridactyle claws; first tarsus never broadened at its end.

Three species.

Oribata tessellatala n. sp.

Very dark chestnut brown.

Cephalothorax as broad as long. No true lamellae present but lateral thickened areas which extend almost to the tip of the rostrum. Both the superior and the antero-lateral bristles apparently absent.

Abdomen as broad as long, hairless, with a semicircular free margin. Pteromorphae large, antero-ventral free margin deeply emarginated. The pteromorphae are peculiar in that they show the epidermal cells forming a tessellated appearance when viewed from above. Genital covers small, rectangular, each twice as long as broad. They are situated between the posterior coxae. Anal covers twice as long as the genital, situated their length from the latter and one-third their length from the posterior margin of the ventral plate, broader toward their posterior ends.

Legs of moderate size. Claws tridactyle, dactyles unequal.

Length, 0.80 mm.; breadth, 0.45 mm.

In moss. From Nilgiri Hills. Three specimens.

Oribata nilgiria n. sp.

Body dark chestnut brown, pteromorphae and legs much paler.

Cephalothorax almost as broad as long; no true lamellae present but lateral thickened areas which extend forward beyond the middle of the cephalothorax. Superior bristles very minute; antero-lateral bristles apparently absent. Pseudostigmatic organs with long straight pedicels and clavate, pectinate head.

Abdomen as broad as long, uniformly rounded behind. Pteromorphae large, extending forward almost to the tip of the rostrum, showing vertical chitinous thickenings. Genital covers short and broad, subrectangular, two-thirds as broad as long and each with a longitudinal row of fine minute hairs, row of hairs down the middle of each cover. Anal covers almost twice as long as the genital, situated about their length behind the latter and a third their length from the posterior margin of the ventral plate. They are broadest at their posterior ends, and each has two minute hairs, one at each end.

Tarsus of leg I longer than the tibia, well clothed with simple bristles and each possessing three plumose hairs on their inner margins; tibia much broader distally than proximally, with an inner plumose bristle and an outer very long tactile bristle; genual over twice as long as broad and three-fourths as long as tibia, with an inner plumose bristle.

Length, 0.32 mm.; breadth, 0.24 mm.

In moss. Described from an abundance of live material which came from the Nilgiri Hills.

Oribata appressala n. sp.

Pl. XXXV. f. 1.

Light reddish brown.

Cephalothorax pyramidal; lamellae long and narrow, extending two-thirds of the distance to the tip of the rostrum, broadest at their posterior ends; lamellar hairs straight, about as long as the lamellae themselves and extending for one-third their length beyond the tip of the rostrum; interlamellar hairs present, straight, erect and equal to the lamellar hairs; antero-lateral hairs almost straight and about one-half as long as the lamellar hairs. Pseudostigmata hidden by the pteromorphae, with slender pedicels and swollen, clavate heads.

Abdomen two-thirds as broad as long, evenly and broadly rounded behind. Pteromorphae truncate, appressed and not extending beyond the anterior margin of the abdomen. Genital covers small, situated at the anterior margin of ventral plate, each about two-thirds as broad as long. Anal covers much larger than the genital covers, situated about their length from the latter and about one-third their length from the posterior margin of the ventral plate, each with a straight inner margin and with an oval outer margin.

Anterior pair of legs extending beyond the tip of the rostrum by one-third their length; tarsus as long as the tibia; tibia twice as long as the genual, distal end almost twice as broad as the proximal end; genual three-fifths as broad as long. All the tarsal claws tridactyle with dactyles unequal.

Length, 0.32 mm.; breadth, 0.22 mm.

In moss. Collected by R. L. Ewing in the Nilgiri Hills, South India.

NOTHRIDAE.

NOTASPIS Herm.

Lamellae present; cephalothorax plainly demarcated from the abdomen; body with smooth integument; last three pairs of legs inserted at the edges of the body.

One species.

Notaspis brevirostris n. sp.

Pl. XXXV. f. 2.

In general appearance a uniform, light brown.

Cephalothorax very short, broader than long. Lamellae very close together, short with long, free, cusp-like ends which extend almost to the tip of the rostrum and each bearing a simple, slightly curved lamellar hair about twice as long as the lamella itself and extending over one-half its length beyond the tip of the rostrum. Pseudostigmatic organs each with a long slender pedicel and an enlarged, flattened, sharp-pointed head; both the head and pedicel simple.

Abdomen two-thirds as broad as long; dorsum hairless. Genital covers large, rectangular extending almost to the front margin of the ventral plate, each about twice as long as broad. Anal covers about the same size as the genital covers, and situated about one-fifth their length behind the genital covers and an equal distance from the posterior margin of the abdomen. They are much broader at their posterior end than at their anterior end.

Anterior pair of legs extending about one-half their length beyond the tip of the rostrum; tarsus slightly longer than the tibia and with a single, moderate, curved claw; tibia twice as long as genual and about twice as broad at its distal end as at its proximal end. It has on its lateral margin near the distal end a bristle slightly longer than the segment itself; genual almost two-thirds as broad as long and with a prominent inner and outer bristle. Posterior pair of legs extending slightly beyond the posterior margin of the abdomen; tarsus shorter than the tibia; tibia club-shaped and with a prominent bristle on its outer margin near its distal end.

Length, 0.30 mm.; breadth, 0.20 mm.

In moss. A single live individual came through from India in the moss. Nilgiri Hills.

Listrophoridae.

labidocarpus Trt.

Body strongly compressed; skin transversely striated. Legs of the third and fourth pairs of the usual form but deprived of suckers and armed with stout spines; legs of the first and second pairs composed of a single piece in the form of a chitinous clasper.

One species.

Labidocarpus compressus n. sp.

Pl. XXXV. f. 4.

In general appearance hyaline except for the anterior and basilar portions of the cephalothorax which being strongly chitinized are brown.

Cephalothorax V-shaped from a side view, and, like the whole body, is greatly compressed. Beak stout, almost structureless, but with a small pair of dorsal hairs. Toward the middle of the dorsal surface of the cephalothorax there are two pairs of long bristles, the inner pair of which is the largest. Posterior part of cephalothorax transversely striated.

Abdomen half as long again as the cephalothorax, striated dorsally, with a prominent pair of lateral bristles near its anterior end and a very long pair of terminal bristles which equal the abdomen itself in length.

Anterior group of legs formed into large, stout, chitinized clasping organs. Each is almost as broad as long. Posterior group of legs small and of the usual form. Tarsus of leg III with a long distal claw-like spine longer than the segment itself; inside of this spine are situated two short tooth-like spines. Tarsus of leg IV also with a similar claw-like spine but apparently with only one inner tooth-like spine.

Length, 0.44 mm.; height, 0.22 mm.

From the Indian Fruit Bat, *Pteropus edwardsii.* Several specimens found on one of these bats from Ceylon.

EXPLANATION OF ILLUSTRATIONS.

Photomicrographs made by the writer.

Plate XXXV. Fig. 1. *Oribata appressala*, dorsal view, × 75.—Fig. 2. *Notaspis brevirostris*, dorsal view, × 75.—Fig. 3. *Uropoda postgenitalis*, ventral view of the male showing the extreme posterior situation of the genital opening, × 75.—Fig. 4. *Labidocarpus compressus*, side view, × 75.—Fig. 5. *Gamasus dentatilinea*, dorsal view of the female showing the mandibles extended, × 50.

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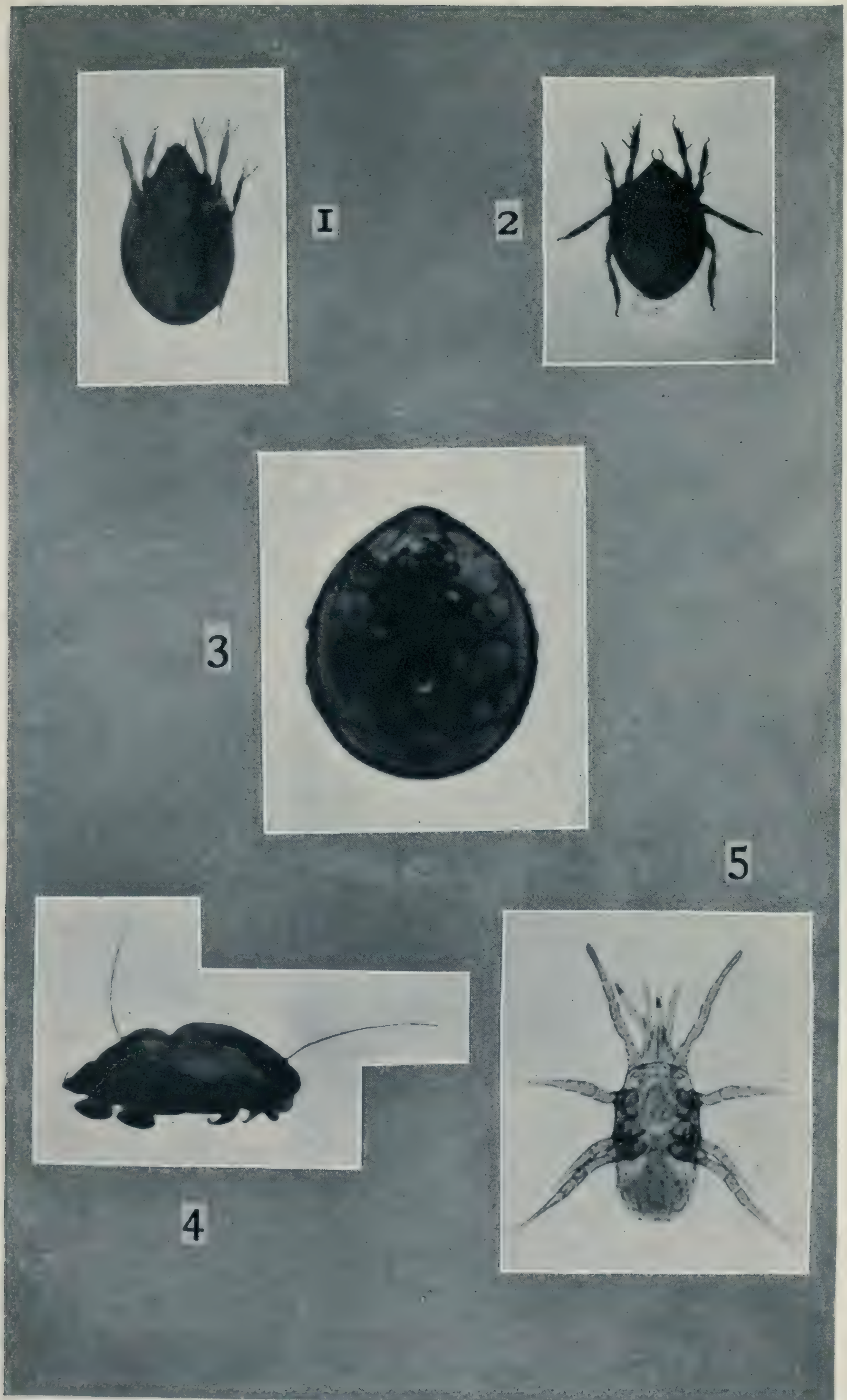

NEW ACARINA FROM INDIA.

THE GUADALUPAN SERIES; AND THE RELATIONS OF ITS DISCOVERY TO THE EXISTENCE OF A PERMIAN SECTION IN MISSOURI.*

Charles R. Keyes.

A most spirited controversy was the Permian Question in American geology during the middle of the last century. For more than 50 years was it warmly debated without tangible results. While some of the attendant problems still remain not fully solved it is with great interest that it may now be announced that recently data of a critical character have been secured for the definite settlement of the main question.

Singularly, during all of this period of nearly two generations of discussion the only real evidences favoring the occurrence of strata of true Permian equivalent in this country are contained in papers first read before our Academy and published in the initial volume of its Transactions. To this record I desire to call especial attention at this time, and also to refer to the significance of certain discoveries which bear directly upon the general question that the Far Southwest and Mexican tableland have recently afforded.

Among the earliest communications made to our St. Louis Academy of Science were several presented by one of its most active and distinguished members, Dr. B. F. Shumard. One of these papers in particular, read at the regular meeting of March 8, 1858, was an announcement of the discovery of true Permian fossils in the white limestones of the Guadalupe mountains on the southern boundary of New Mexico, not far from El Paso.[1] Soon

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*Presented by title to The Academy of Science of St. Louis, November 21, 1910.

[1] Trans. Acad. Sci. St. Louis, 1:113; 387-403. 1860.

afterwards this important discovery was also announced in France.[2]

The far-reaching significance of Shumard's results and their bearing upon the proper interpretation of the so-called Permian section of Kansas, of the uppermost coal measures of Missouri, and of the general, or schematic, section of American Carbonic rocks, appear, until lately, to have been entirely overlooked. Only when the Carbonic section of the Rio Grande region is critically examined and paralleled with that of the Mississippi Valley province do the real positions of the several parts of the latter present themselves.

The main discussion of a Permian equivalent in America has always centered around the age of the rock-sequence in Kansas. My own survey of the facts chances to be singularly critical. After a rather wide acquaintance with the Carbonic rocks of Missouri and eastern Kansas, I had the good fortune, in company with Messrs. Karpinsky, Pavlow, Tschernychew, Amalitzky, Nikitin, Stuckenberg, and other Russian geologists, who had given the subject most attention, to examine carefully many of the sections of the original Permian rocks of eastern Russia. While the Russian and American sequences of the Carbonic rocks were recognized as remarkably alike lithologically I attempted to show[3] that if any parallelism was possible only the uppermost terrane, that next to the Cimarronian Red-beds of the Kansas section, had any likelihood of proving to be eventually of Permian age. Faunally the greater part, at least, of the disputed Kansas section must be compared with the Russian Artinsk formation, which is, as is well known, very much older than any of the original Permian beds. This is the section which I had distinguished as the Oklahoman series;[4] it includes the Chase and Marion formations in

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[2] Bull. Geol. Soc. France, II. 15:531-533. 1858.
[3] Jour. Geol. 7:332. 1899.
[4] Am. Geologist, 18:27. 1896.

that part of the general section lying above the horizon of the Cottonwood limestone.

Later, after a long sojourn in southwestern United States, I made the observation[5] that "after seeing at close range the Red-beds of New Mexico I was convinced that the Permian question in America was not to be settled on the basis of Kansas stratigraphy."

In tracing the Kansas Red-beds, or Cimarronian series, southwestward around the southern end of the Rocky mountains into central New Mexico the courses of the Canadian river and the Rio Pecos were followed, the valleys of these streams cutting off to the north and west the extension of the great plains of the Llano Estacado. Upon stratigraphic grounds mainly I thought that I had found the Cimarronian part of the Carbonic sequence uninterrupted until a point was reached to the southwestward where it rested directly upon the limestones forming the backslope of the Guadalupe mountains, the locality from which Shumard had received from his brother the fossils which he described as true Permian in age.

On comparing the general terranal sequences of the two provinces mentioned we find that there are, in the Mississippi section of the Carbonic strata, great thicknesses of rocks which are not represented. Paralleling the serial divisions of the two sections:

Geologic Age.		*Mississippi Province.*		*Rio Grande Province.*	
CARBONIC	*Late*	Cimarronian	1,200	Cimarronian	1,000
		Wanting		Guadalupan	3,500
	Mid	Oklahoman	1,500	Maderan	1,000
		Missourian	2,000	Manzanan	1,000
		Des Moines	500	Wanting?	
		Arkansan	10,000	Ladronesian	200
	Early	Mississippian	1,200	Socorran	500

In Kansas the so-called Permian beds are included in the Oklahoman and Cimarronian series, the latter being the Red-Beds section. The relationships of the several

[5] *Ibid.* **32**:218. 1903.

series of the Carbonic section in the Rio Grande region I have lately discussed at length.[6] The Red-beds of Kansas and the southern Rocky Mountains I have also considered in some detail.[7] It suffices here merely to note, by way of explanation, that in New Mexico there are present three great groups of red-beds: One, the Bernalillo Red-beds, in the Maderan series, the true Cimarronian Red-beds, and the Triassic Red-beds. Each of these red-beds sections has a thickness of about 1000 feet; and in some localities in New Mexico all three of them appear superposed upon one another, forming a continuous "Red-beds" sequence.

The exact stratigraphic level of the Guadalupan series is a subject that is now demanding critical attention. My own observations, which are mainly stratigraphical in character, point to a superior position of the Cimarronian Red-beds, with reference to the Guadalupan division. Girty,[8] depending largely upon paleontologic deduction, is inclined to give the Cimarronian an inferior situation, notwithstanding the fact that the red-beds are almost devoid of organic remains. Thus this author is forced to make the Cimarronian red shales an exact equivalent of the Hueco limestones (Maderan-Manzanan series) of the west Texas section. Insofar as there is any stratigraphic evidence adduced for this conclusion the author seems to be influenced by certain brief notes published by Graton and Gordon.[9] From impressions gained by the latter on the east side of the Rio Grande area these authors seem to regard all of the red-beds of this valley as belonging to the Bernalillo shales division (Maderan) and report that above these red shales occurs a thick black limestone lithologically similar to the Hueco limestone which, in the Guadalupe mountains, immediately underlies the Guadalupan series. This may be the cor-

[6] Jour. Geol. 14:147-154. 1906.
[7] Proc. Iowa Acad. Sci. 15:143-144. 1909.
[8] U. S. Geol. Surv. Prof. Pap. 58:48. 1908.
[9] Jour. Geol. 15:805. 1906.

rect stratigraphic interpretation of the southern New Mexican red beds, but it is wholly at variance with my own observations in the region. I am quite familiar with all of the localities visited by Messrs. Graton and Gordon. In the Sierra Oscuro, the Sierra San Andreas, the Sierra de los Caballos, the Sierra Manzano, and the Sierra Sandia, and in every case where the black limestone appears to hold a position higher than the red beds there are indisputable evidences of profound differential movements of the strata along fault-lines. Singularly enough, the only place where the direct evidence of faulting is not yet fully determined is the identical locality where the authors mentioned say that the black superior limestone is missing from its normal position, above the red-beds. This is on the east side of the Sandia mountains, and the dark limestone in inclined beds rises to a height of several hundreds of feet abruptly out of the red-beds. It may be that the Red-beds of Kansas are older than the Guadalupan series but much stronger evidences shall have to be forthcoming before I shall be willing to admit that the Cimarronian Red-beds are the stratigraphic representatives of the Hueco limestones, or of the Bernalillo red shales.

Whether or not the great Guadalupan series, 3500 feet in thickness, is above or beneath the Cimarronian Red-beds is immaterial in the present connection; the important consideration is that there is small doubt but that it is much younger than any of the so-called Permian beds of Kansas (Oklahoman). The stratigraphic position and faunal horizon of the Guadalupan series have close relationships with those of the original Permian of Russia. This is the only section yet discovered in America which satisfies the conditions of such a correlation. The recent investigations amply attest the correctness of Shumard's early work and the astuteness with which his main conclusions were drawn. It has taken half a century to put the proper estimate upon his efforts.

The final elimination of the so-called Kansas Permian section below the Red-Beds, from the Late Carbonic period, and the finding of the Great Guadalupan series younger than any other Paleozoic rocks, excepting the Red-Beds perhaps, on the continent, calls especial attention to Girty's pregnant suggestion that it does not seem necessary to regard Russian Permian deposition as the last chapter in the Paleozoic history. It is a fact long known to paleontologists that from a strictly faunal viewpoint the original Permian fossils are still distinctly Paleozoic in all of their facies. There is little to herald the immediate appearance of a new Mesozoic era. Should the Guadalupan series prove to be younger than any yet discovered Paleozoic strata Shumard's discovery will have an added interest.

Shumard numbered 54 species of fossils, 26 of which were previously undescribed, among his collections from the Guadalupe mountains. The prolificy of marine life in this region is clearly indicated by the fact that Girty recently enumerated more than six times as many species as did his predecessor in the field.

The recognition of the great Guadalupan section has an important bearing upon the proper interpretation of our own local geology of Missouri. Than the instance of Shumard's discovery in a distant land I know of no better example of the intimate and dependent relationship of all phases of scientific knowledge. In Missouri we have probably not sufficient data ever to be able to determine definitely whether or not there exist rocks equivalent to the Permian section of the general geologic column, as has sometimes been claimed. The Guadalupan fauna now sets all doubts aside and proves beyond peradventure that there is no part of the Missouri rock-section that we can even hope to find to be of Permian age.

When, after sifting all the available evidence, both published notes and in the field, after visiting most of the leading localities, and after critically inspecting the original Permian rocks of the Urals, I ventured, more than a decade ago, the opinion that faunally at least the so-called Permian strata of Kansas and of northwest Missouri must be regarded as much older than the true Permian section of Russia and that in the Mississippi valley Permian deposition, with the possible exception of the red-beds, was entirely wanting, my statements were severely criticised. I think, however, that the results of the recent investigations in the Guadalupe mountains more than substantiate the conclusions which I long ago reached.

Summing up, it may be concluded:—

(1) That the real discovery of true Permian equivalents in America must be ascribed to Dr. B. F. Shumard, who, by the way, took no part in the Kansas controversy.

(2) That Late Carbonic time in America is a vastly more important period than has been generally heretofore supposed.

(3) That the so-called Permian section below the Red-Beds of central Kansas belongs in reality to a Mid Carbonic series and is not the homotaxial equivalent of the original Permian division.

(4) That no part of our Missouri strata can be regarded as belonging to the Late Carbonic or Permian period.

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ABUNDANCE OF METEORITES ON THE PAINTED DESERT, AND ITS BEARING UPON THE PLANETESIMAL HYPOTHESIS OF THE ORIGIN OF THE EARTH.*

CHARLES R. KEYES.

Prefatory.

On the borders of the great Painted Desert, in northeastern Arizona, is a remarkable truncated cone known as Coon Butte. This low hill rises scarcely 200 feet above the level of the vast unbroken plain which stretches away illimitably in all directions and which forms part of the general surface of the High Plateau. Even from short distances it ordinarily would be barely noticeable were it not for the fact that it is located on the crest of a slight swell in the great plains-surface. This fact, coupled with the circumstance that the hill is near a good desert waterhole, makes Coon Butte an important feature of the local landscape.[1]

The recent notoriety into which this unimportant eminence of Coon Butte has come on account of the abundance of meteoric material found in its vicinity is out of all proportion to its merits. The novelty of these meteoric finds now appears to lie not so much along the traceries of cosmic speculation, as it does along the more sub-

*Presented by title to The Academy of Science of St. Louis, November 21, 1910.

[1] Coon Butte, or Coon Mound, is a very appropriate title in the minds of the denizens of the Canyon Diablo desert. The landmark, inconspicuous as it is, is especially distinguished by a term indicating that the Coon tanks, or Coon springs, are near by, where ample supplies of wholesome water is obtainable. Probably at one time, not so very long ago, two large rock monuments stood on the rim of the crater nearest the water-holes. This is a happy and quite generally used emblem directing the desert traveler to potable water.

stantial lines of geologic discovery as yet not fully interpreted. Owing to peculiarities of climate the unheard of abundance of meteoritic material is brought into special prominence. It indicates as very probable that from the desert regions of the globe shall come chief knowledge regarding cosmic substances.

Volcanic Phenomena About Coon Butte.

Meteoric Hypothesis of Origin. Local tradition of the Canyon Diablo country has long ascribed the depression in the top of Coon hill to the impact of a falling star. Some of the oldest inhabitants may be found who may even claim that their fathers were witnesses of the great event. At any rate, the idea presents many attractive aspects; and there are today $100,000 being expended in drilling and sinking shafts to uncover and mine out the huge mass of pure iron and nickel supposed to be lying deeply buried in the bowels of the earth at this place.

Without attempting to enter, in the present connection, into a prolix discussion of the possible meteoritic origin of Coon Butte it may be said that the evidence adduced in support of such a genesis seems incomplete, indecisive, and unsatisfactory. On the other hand consideration of the volcanic phenomena of the region about appears to be strangely neglected. Critical testimony concerning the great activity of local vulcanism abounds.

The important fact connected with the Coon Butte meteorites appears to be not so much whether or not there exists the hypothetical large one, as it is the real significance of the presence of the countless small ones which have been obtained in the neighborhood on the surface of the desert.

Extent of Local Vulcanism. Coon Butte lies in the midst of widespread and prodigious volcanic effects. Less than a score of miles to the west rises one of the most majestic volcanic piles of the Southwest country. The San Francisco mountains are the remnants; and the main crater walls are still 15,000 feet above sea-level. Around their base, and for distances of miles from the central mass, are numberless craterlets and ash-cones. To the north and east of Coon Butte, for many miles extends a broad, diversified stretch of country known as the Painted Desert, the surface of which is abundantly studded with lofty denuded necks of old volcanoes. A few miles to the southward stretches away interminably one of the great lava fields of the globe. Round about Coon Butte, then, within a radius of a score of miles, are hundreds of minor ash-cones and other manifestations of explosive vulcanism. Many of these rise 400 to 500 feet above the level of the vast plain and often have craters at their summits as perfectly preserved as on the day when they were formed. Some of these ash-cones display at their bases the ragged, basset edges of the layered rocks through which the volcanic powers found exit. Other ash-cones, 200 to 300 feet in height, with perfect craters in their tops, rise out of the floors of deep circular depressions entirely surrounded by steep rocky cliffs the crest of which is the general plains-surface, and the base of which is the level of the flat-bottomed rifts. Crater Salt-Lake to the eastward of Canyon Diablo is identical in every respect with Coon Butte, except that from its floor project two small and perfect ash-cones.[2] All things considered it would be difficult to fancy an origin for the Coon Butte depression very different from the hundreds of volcanic disturbances of the explosive type that are found everywhere throughout the vicinity. Coon Butte cannot be considered by itself. It is not an isolated, anomalous, incomparable feature of the landscape. It must be viewed in connection with its similar geologic surroundings.

Geologic Descriptions. The ash-cones about the San Francisco mountains were early described by Newberry;[3]

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[2] For a good photographic view, see Bull. Geol. Soc. Amer. 17:720, *pl. 80.* 1907.

[3] Colorado River of the West, Ives' Rept. 3:72. 1861.

and were later especially noted by Dutton.[4] Gilbert[5] gave the first succinct account of the Black Mesa country on the south. The details of the geological phenomena presented at Coon Butte and the vicinity are fully explained by Foote,[6] Gilbert,[7] Fairchild,[8] Merrill,[9] and Telghman and Barringer,[10] and the accounts of these authors reference may be made.

Significance of Certain Geologic Features.

Geologic Section. The drill records of borings made in the bottom of the Coon Butte crater are of exceptional interest. As given by Messrs. Barringer and Telghman the following section appears to be characteristic.

Geologic Section of the Coon Crater.

	FEET.
1. Soil, sand, surface material and wash from cliffs	27
2. Lake-bed formations, lying horizontally and containing diatoms, shells of mollusks and abundant gypsum crystals	61
3. Sand, which gives reaction for nickel and iron, and contains fragments of metamorphosed sandstone, sandstone, pumice, etc.	135
4. Sand and rock, sand-grains crushed slightly, if any, and not metamorphosed, barren of meteoric material	300
5. Sand and "silica" (rock-flour), with abundant slag-like material containing iron and nickel and metamorphosed sandstone	80
6. Silica powder, fine (rock-flour), and sand, no meteoric material	20
7. Bed-rock, a grayish sandstone	..

Character of the So-called Lake-Beds. Of the several distinctive strata passed through in drilling numbers 2 and 5 are of noteworthy significance; the last mentioned, near bed-rock, on account of being the only zone in which undoubted meteoric material occurs; and the first because of constituting the so-called lake-beds.

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[4] Ann. Rept. U. S. Geol. Surv. **6**:113. 1885.

[5] U. S. Geog. and Geol. Surv. W. 100 Merid. **3**:128. 1875.

[6] Am. Jour. Sci. III. **42**:413. 1891.

[7] Science, N. S. **3**:1. 1896.

[8] Bull. Geol. Soc. America, **18**:493. 1907.

[9] Smith. Misc. Coll. **50**:461. 1908.

[10] Proc. Acad. Nat. Sci. Phil. **57**:861. 1906.

The so-called lake-beds are mainly composed of coarse silts. Their great thickness and uniform lithologic character might be difficult to explain were it not for the fact that other depressions exist in the vicinity that still retain their waters. A single local "cloud-burst" may fill with water such an enclosed basin to a depth of a dozen or a score of feet, as shown in the sudden rise in the level of the Laguna del Perro in eastern New Mexico,[11] the overflow of the Rio Carmen in the San José bolson in Chihuahua, Mexico,[12] and the appearance of the ephemeral lakes in the Rio San Juan valley in Tamalipas state. Zuni Salt-Lake, a few miles east of the Coon Butte, occupies a similar crateriform depression in the plain and out of its waters rise two small ash-cones.

The filling of such ephemeral pools and other bodies of water in the desert must be exceedingly rapid. The well-known playa formations are one phase. Certain of the so-called Tertiary lake deposits of western United States are another. Desert soil accumulations sometimes are a third sort. In physical characteristics the resemblance of all of these deposits to the loess is as remarkable as it is genetically suggestive.

Wind-blown dusts of the desert are caught and retained by bodies of water, and under favorable conditions enormous deposits are rapidly built up. The vast boraciferous clays, 5000 to 8000 feet in thickness, of southern California are thus explained.[13] The great inland sea, or arm of the Pacific ocean, once covering the deep Death valley, the Mojave basin and the Santa Clara valley is regarded as long in drying up. The disappearance of the water may have been more rapid than the great thickness of the terranes at first thought suggests, for the reason that as an accompaniment of the evaporation of the waters in an excessively dry climate there must have been a filling-up of the basin by the prodigious quantities

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[11] Journ. Geol. 16:434. 1908.

[12] Am. Jour. Sci. IV. 16:378. 1903.

[13] Trans. Amer. Ins. Mining Eng. 40:674. 1909.

of wind-borne dust derived from the adjoining deserts. In the case of the larger example noted it is not to be inferred that since the clays and sands have such an enormous thickness, the waters were in the beginning at least of the same depth, but rather that the arm of the ocean and afterwards the inland sea was always very shallow, and that as the area was filling up with the sediments the waters continued to rest on the surface of the basin rising with the rise of the bottom.

In the phenomena connected with the filling of the Coon Butte lakelet by "lake deposits" is probably to be found the key to the entire mystery of the formation of the vast Western American "Fresh-water Tertiaries."

Lower Meteoric Zone in Coon Crater. The bed of coarse materials lying immediately above the basal member of the section in Coon Crater is especially noteworthy on account of the meteoric fragments which occur so abundantly. This is at a depth below the floor of the crater of about 600 feet. Its formation appears to represent an episode when eolic agencies had full sweep as at the present time, when concentration, as it were, of the large and heavy rock-fragments was going on through the exportation of the finer soil materials. So soon as a sporadic "cloud-burst" chanced partially to fill the crater, lake conditions prevailed and the process of residual concentration through deflative influences ceased.

As will be more specially noted hereafter meteoric falls were probaly not more frequent during the time represented by this zone, than during any other period of equal length. In the one case the finer soil particles were constantly removed, while in the other they were rapidly deposited.

Mineralogic Composition of Canyon Diablo Meteorites.

The Canyon Diablo meteorites have been described by many writers. Since the first announcement of their discovery by Foote[14] unusual interest on account of the discovery of diamonds in some of the masses has been taken in these falls.

Details of the petrologic and mineralogic characters need not be here described; they are fully set forth in the papers of Mallard,[15] Brezina,[16] Daubreè,[17] Friedel,[18] Moissan,[19] Huntington,[20] Derby,[21] Mallet,[22] Farrington,[23] Merrill and Tassin,[24] and Merrill.[25]

The complete list of minerals found in the meteorites of the district as given by the last mentioned author[26] is of great interest. Further reference to it will be made in another connection.

Kamacite (nickel-iron).
Plessite (nickel-iron).
Taenite (nickel-iron).
Schreibersite (iron phosphide).
Rhabdite (iron phosphide).
(Unidentified black iron phosphide).
Cohenite (iron carbide).
Graphitic iron (?).
Troilite (iron sulphide).
Lawrencite (iron chloride).
Moissanite (carbon silicide).
Diamond (colorless, yellow and black), carbon.
Cliftonite (carbon).
Graphite.
Amorphous carbon.
Silicon.
Platinum.
Copper.
Olivine.
Chromite.
Fayalite (?).
Daubreèlite.

Abundance of Meteoric Material About Canyon Diablo.

The Canyon Diablo country, in which Coon Butte is located, has become so famous for the unique character of some of its meteoric minerals that several equally re-

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[14] Amer. Jour. Sci. III. 42:413. 1891.
[15] Comptes Rendus, 114:812. 1892.
[16] Ueber Neue Meteoreisen 1893; also Wien. Sammlung 1895:288.
[17] Comptes Rendus, 114:412. 1892; 116:345. 1893.
[18] Comptes Rendus, 115:1037. 1892; 116:290. 1893.
[19] Comptes Rendus, 116:288. 1892; 139:773. 1904.
[20] Proc. Amer. Acad. Sci. 29:209. 1894.
[21] Amer. Jour. Sci. III. 49:101. 1895.
[22] *Ibid.* IV. 21:347. 1906.
[23] *Ibid.* 22:303. 1906.
[24] Smith. Misc. Coll. 50:203. 1907.
[25] *Ibid.* 50:481. 1908.
[26] Smith. Misc. Coll. 50:483. 1908.

markable features have been lost sight of. Concerning these meteoric materials not the least instructive consideration is their seemingly wonderful abundance. During the past decade or two literally thousands of meteoric masses have been gathered from the district. In Arizona the search for "meteoric stones" and "nickel-irons" constitutes an important branch of the local "curiosity business." For many years one Indian trader of the region has employed numbers of men and boys to look for "heavy stones" and "green stones"; and he has disposed of large numbers of the small specimens besides numbers of large masses. It was through this and other indefatigable collectors of the neighborhood that the meteoric finds were first brought to the notice of the scientific world.

According to the written accounts of the Canyon Diablo falls few of the meteoric masses were found within the crateriform depression of the Coon Butte. From the country about, within a radius of a score of miles, the large majority of the masses found are reported. The Indian trader's collecting grounds are much more extensive. In its general bearing this wide distribution is of far-reaching importance.

That Canyon Diablo, or Coon Butte, should appear to be the center of a meteoric shower is partly illusory, partly due to accidental circumstances, and partly a result of incomplete observation. The phenomenon is neither isolated nor strictly local, but, as will be shown later, one of wide prevalency. In the Coon Butte area the meteoric masses have been collected more industriously than elsewhere. The hard limestone floor of the plain, constantly swept bare of its soils, permits meteoric stones to remain indefinitely exposed on the surface of the ground. The small amount of chemical decay going on is merely sufficient to impart to the nickeliferous irons or stones a slight greenish tinge which enables them to be easily recognized among the myriads of pebbles strewing the surface of the ground. With proper investigation and similar favorable climatic and geologic conditions other desert tracts would doubtless yield meteoric materials in equal abundance.

Occurrence of Meteorites in Desert Regions.

Although the abundance of meteoric materials at Canyon Diablo excites wide attention and is even regarded as something unparalleled, it does not appear to be quite so unusual as has been generally inferred. The marked success of the Indian trader Voltz in collecting meteoric stones for the purpose of sale as curiosities is merely the result of exceptional diligence along lines which are the experience of many a ranchero of the Mexican tableland. Few of the stock ranches of the grazing country do not have lying about the premises some larger or smaller fragments of the "heavy stones."

As already noted meteoric falls are probably not more frequent in desert regions than elsewhere on the earth's surface; but the anomalous climatic conditions tend to give them great prominence. The thin air, the cloudless skies, and high altitudes contrast sharply with the thick atmosphere, the prevailingly cloud-covered firmament of the sea-coast of humid countries. In the high dry regions the frequency of meteoric manifestations immediately arouses the wonderment of the sojourner from cloudy-land. The constant stream of light-paths across the heavens reminds one every night in the year of the November meteoric showers of other parts of the world.

As especially emphasized later on arid climate strongly militates against the rapid decay of rocks. There is practically no such phenomenon in dry regions as chemical decomposition of rock-masses as it is known in the moister regions of the globe. For years, without notable oxidation, meteoric stones and irons remain on the surface of the desert. When they fall in humid lands meteoric masses are immediately lost to view in dense vegetation, are covered by soft earth, and are subject to rapid disintegration; but in desert regions the very reverse is true. The dry climate, and the constant removal of the lighter soils by the winds,[27] tend to keep all pebbles and larger rock-fragments continually exposed on the surface of the ground. The pebble-mosaics, such as are described by Blake,[28] Tolman,[29] and others,[30] covering large tracts of arid plain amply attest the extent of this remarkable phenomenon.

These are some of the reasons for observing that the great abundance of meteoric falls in the Canyon Diablo district does not appear to be unique but is really a general desert phenomenon.

Bearing of the Planetesimal Hypothesis.

It follows from a consideration of the plantesimal theory of the earth's origin, as recently and specifically set forth by Professor Chamberlain,[31] that there should be falling upon the surface of our planet a constant rain of rock-forming materials derived directly from extra-terrestrial sources. That such a shower actually takes place seems now fully demonstrated by a number of facts. That it is an important general source of ore materials appears also sufficiently substantiated.

The meteoritic theory is not a new one. So long ago as 1848, Meyer[32] presented a well supported hypothesis of an origin of the planetary and stellar bodies, through meteoric agglomeration. Since the first appearance of the astute German author's work the theory has had the hearty support of many able thinkers.

That portion of the stellar dust which falls into the sea goes to form the characteristic bottom-muds of the ocean. Another part which falls upon the moister land areas mingles immediately and almost unnoticed with

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[27] Bull. Geol. Soc. Amer. 19:73. 1908.

[28] Trans. Amer. Inst. Mining Eng. 34:161. 1904.

[29] Journ. Geol. 17:149. 1909.

[30] Bull. Geol. Soc. Amer. 19:74. 1908.

[31] Carnegie Inst. Yearbook, 3:208. 1905.

[32] Beiträge zur Mechanik des Himmels, 157. 1848.

the soil. A third portion falling upon desert tracts remains exposed and is preserved unchanged for a much longer time. But whether falling upon land or water the stellar particles, on account of their high specific gravity and their prevailingly metallic character, tend sooner or later to sink beneath the lighter floating crust of the lithosphere.

In its ultimate analysis the meteoritic hypothesis is not so radically distinct from Laplace's nebular hypothesis as some of its advocates would have us believe. It is not so entirely novel as it might at first glance appear. As shown by G. H. Darwin[33] the meteoric swarm is dynamically analogous to a gas; and in reality the laws of gases strictly apply.

Peculiarities of Desert Rock Weathering.

Insolation. The peculiarities of rock disintegration in dry climates has an especial bearing upon meteoritical augmentation in general, and in particular upon meteoric phenomena displayed about Coon Butte. Without entering upon details emphasis may be laid upon the strictly mechanical character of desert rock weathering. In arid lands chemical rock decay is almost unknown. Destruction of rock-masses is accomplished mainly by spauling due to great changes in diurnal temperatures at the surface. To this distinctive geologic process the term insolation is appropriately applied.

As Russell[34] has pointed out, rock-decay appears to be the direct result of normal climatic conditions; in cold or arid regions the rocks are scarcely at all decayed. The surprisingly small extent of chemical decomposition which rock-masses of the desert undergo is well shown by the great talus slopes and other accumulations of colluvial deposits which form veritable rubble-heaps of pro-

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[33] Phil. Trans. Royal Soc. London, 180:1-69. 1889.

[34] Bull. Geol. Soc. Amer. 1:134. 1890.

digious size, with fragments so fresh to all appearances that they seem to come direct from some titanic rock-crusher. Even the adobe soils of arid regions, when examined under the microscope, attest the strictly mechanical origin of their finest materials.

Under such climatic conditions basic or metallic masses of meteoric origin must, without appreciable change in chemical composition, remain indefinitely upon the surface of the ground. Meteoric minerals that are highly unstable under conditions of a moist climate do not in a dry climate readily assume more stable forms.

Pebble Mosaics of the Desert. Eolation in the desert gives rise to certain characteristics of the soil not met with in moist lands. These features serve at once to obscure meteoric masses as effectually as does thick vegetation. Singularly enough one of the most notable effects of the winds upon the dry soils is, by the removal of the finer materials, to impart a gravelly appearance to the ground. Most arid plains-mantles are mainly composed of fine loams. There are often sands; but as a whole there is really little gravel or coarse rock.

That the desert loams have the appearance of gravels is due to the fact that the winds constantly carry away the loose fine materials. When the pebbles in the soil are more abundant than usual it is not uncommon to find areas acres in extent covered by a single layer of small angular stones as closely and as evenly set as in mosaics. Upon careful search it is probable that such pebble pavements will yield meteoritic material even more abundantly than the bare rock-surface of the Canyon Diablo region. In the interests of astronomy and cosmic geology they are well worth systematic investigation. Application of the Indian trader's methods and confinement of effort to a search for the "heavy stones" and "green stones" might soon disclose means more certain than at present for distinguishing meteoric pebbles from the myriads of the smaller rock fragments with which they are mingled.

Black Coloration of Desert Rock Surfaces. For other reasons also, meteoric masses might not be easy to recognize among the rock fragments of the pebble pavements, or on the gravel-strewn plains. The majority of the more basic rocks of the desert are susceptible to notable discoloration and wind-polishing. Until the pebbles are broken in two they give little suggestion of the real lithologic character. The only clew in such cases to meteoric material is sometimes the greenish tint of certain pebbles, that is caused by a slight hydration of the nickel content.

In arid regions the more basic iron-bearing rocks are almost invariably coated with a black iron and manganese film which, after being thoroughly polished by the wind-blown dusts and sands, imparts every appearance of the masses having been fused on the surface. In general aspect it is not very unlike the surfaces of recently fallen meteorites in moist lands. Among such dark laquered rock-fragments it would be with the greatest difficulty that true meteorites could be distinguished. That meteorites do actually occur abundantly under such conditions is now widely known among dwellers of the desert; and that they will be more generally detected when especially sought after is more than probable.

Exportation of Finer Rock-Waste. The general phases of erosion of desert regions by the winds are fully described in the recent writings of Walther,[35] Pasarge,[36] Spurr,[37] Cross[38] and others.[39] Its bearing upon the disclosure of meteoric falls should be here emphasized. The movement of desert soils and sands is to be regarded as much more than a mere idle shifting of dry particles as is commonly inferred. Besides the constant sweeping back and forth of the soils and sands over the surface of

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[35] Abhdl. K. Sächische Gesell. d. Wissenschaften, 16. 1901.

[36] Zeitschrift d. deut. geol. Gesell. 56:193. 1904.

[37] Prof. Pap. U. S. Geol. Surv. 42:110. 1907.

[38] Bull. Geol. Soc. Amer. 19:53-62. 1908.

[39] *Ibid.* 19:63. 1908.

the parched land there is in reality a steady and notable advancement of soil materials in the direction of the prevailing winds eventually transporting them far beyond the boundaries of the arid tract. This exportation of desert soil appears to be more rapid, more extensive, and more constant than the flow of sediments in rivers from an area of equal size.

Black Sands of Desert Soils and Arctic Snows.

Magnitude of Meteoric Augmentation. From the occasionally recorded falls of the larger meteoric irons and stones something of their nature has been made known. Our prevailing conceptions of extra-terrestrial materials are largely confined to such masses. In the broader problems it is, however, the constant and almost imperceptible shower of cosmic dust and smaller stellar particles upon the earth's surface that is of greatest consequence. By this, and not by the rarer larger masses, must the volume of cosmic augmentation to the earth's bulk be measured.

Not only the magnitude but the more common evidences of the cosmic dust shower ordinarily escape notice. This is especially true in countries with moist climates. In the last mentioned situations, about the only direct suggestion of such phenomenon is the fact that hailstones are frequently found containing small particles of what is presumably meteoric iron.

In desert and cold portions of the globe the chances of observation upon cosmic materials falling upon the surface of the earth are much more favorable than they possibly can be in moist countries. By the melting of snow in the arctic regions fine metallic particles composed mainly of iron, nickel, cobalt, etc., are obtained; and their source often occasions wonderment. The reality of the heavenly host and something of its importance may be gained when the frequency and numerical extent of meteoric falls are taken into consideration. In every 24 hours there are, according to Young,[40] no less than from 15,000,000 to 20,000,000 of meteorites entering the earth's atmosphere. The collection of some thousands of meteoritic stones and irons in the Canyon Diablo district no longer demands the intervention of special explanations to account for their reality.

It is however, to the desert regions of our earth that we must turn in order to gain our chief knowledge concerning the exact nature, great volume, and general prevalency of the meteoritic augmentation to the earth's mass.

Abysmal Sea Deposits. The great abundance of those peculiar masses brought up in deep-sea dredgings called chondres which occur throughout the abysmal deposits covering the floor of the ocean is especially noted by Murray and Renard[41] in the reports of the Challenger expedition. These masses are largely composed of basic minerals closely related to the earthy minerals known as bronzite and with small doubt are of cosmic origin. The materials from the bottom of the deep seas should be examined anew in the light of their possible celestial origin.

Dark Bands in Arctic Snow-fields. The banded appearance of arctic glaciers has seldom found adequate explanation. Its main cause appears to be due to layers of fine dust and minute rock-fragments. Nordenskiold[42] in particular calls attention to the distinct layered appearance of certain arctic snow-fields in which the dark zones were found to be imparted by minute black grains most of which were metallic in character. Chamberlain[43] in presenting some fine photographic views of the fronts of the Bryant, Krakokla and other Greenland glaciers specifically emphasizes the marked banded appearance. Although he incidentally states that the dark bands are

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[40] Astronomy, 472. 1898.

[41] Narrative of the Cruise of H. M. S. Challenger, 2:809. 1885.

[42] Comptes rendus de l'Acad. d. Sci., 77:463. 1873.

[43] Jour. Geol. 3:568. 1895.

composed of fine mineral particles and that the particles are "mainly terrestrial" he gives no data upon which he bases his latter conclusions, and he leaves it to be inferred that he regards at least part of the material as meteoritic in character. The myriads of dust-wells which the same observer describes[44] in the surface of the great Iglooda-homyn glacier in Greenland seem to have a like significance.

Metallic Sands of Arid Soils. Important as may be such phenomena as are afforded by the larger Canyon Diablo falls it is also to the desert regions that it seems we must turn for information concerning the rain of stellar dust. The prevalency of black sand-grains in the desert soils has generally escaped notice. On the vast high plains of the dry Mexican tableland fine metallic particles occur abundantly in the soils miles removed from the mountains, and from outcrops of igneous rocks. The plains are so level, the distances so great, and the rain-fall so scant, that it precludes the transportation of the heavy grains by means of water. The high specific gravity of the material must prevent their movement by means of the winds. Yet after severe rain showers which occur at rare intervals when little rills traverse the plains-surface with its relative high gradients quantities of the iron sands accumulate along their paths. A thorough chemical investigation of the composition of these sands would be highly instructive. The better known placer black sands which have recently attracted wide attention are totally distinct; and their origin may usually be directly traced to decomposing igneous masses. The metallic sand-particles of the desert rocks would long resist decay. Should these particles prove to be undoubtedly of meteoritic origin it would make such estimates of the average meteoritic augmentation as those of Chamberlain and Salisbury[45] very inadequate. As it is these figures must be vastly too low.

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[44] *Ibid.* 215.

[45] Geology, 1:381. 1905.

Bearing Upon Meteoritic Source of the Ores.

In the consideration of the petrologic aspects of the larger stony masses termed meteorites in the same manner as that by which the igneous rocks of the globe are examined, suggestive relationships are at once established. They appear to have a very important bearing upon the source of the ore materials. Of the four main groups usually recognized among the common terrestrial rocks of igneous origin the ultra-basic class is quite rare. Among the stony meteorites the rock-species distinguished are not only largely ultra-basic in character but the cosmical series begins with the most basic of the earthly classes and continues through yet unnamed series in which the metals form a large proportion of their make-up.

So long ago as 1871 Meunier[46] recognized nearly 50 lithologic types among the meteorites, of most of which he later[47] described the microscopical characters and among which he noted a wide range of metallic elements.

The metals occurring in meteorites include nearly all of those found in the common ores. Gold and silver are the only conspicuous metals which do not yet appear to exist abundantly in celestial minerals. There are, however, good grounds why these two metals have not been reported; and other equally good reasons why certain other metals seemingly occur only sparingly; so that the apparent absence of some of these elements in the composition of known meteorites in no way precludes their derivation from this source.

In explanation of the notable difference in the relative abundance of elements in terrestrial and sideral rocks it is suggested by Farrington[48] that there are good grounds for believing this unlikeness to be apparent

[46] Geol. des. Metèorites: Moniteur scientifique Quesneville, 1 et 15 février. 1871.

[47] Bull. Soc. d'Hist. nat. d'Autun. 16. 1893; and *Ibid.* 17. 1895.

[48] Journ. Geol. 9:394. 1901.

rather than real. Only the crust of the earth is commonly considered; and the analysis of most meteoritic materials do not often show the true proportions of stony matter.

On the theory of meteoritic agglomeration the original and often the immediate source of ore materials cannot be so largely magmatic as it is vadose in nature. Qualified in some ways and somewhat strengthened in others, the general arguments of Forschammer, Sandberger, Winslow, Van Hise and Bain assume a new interest and an added value. The main shortcoming, if such it be, is merely in ascribing a rôle or principal origin of the ore materials to rock-weathering, when a somewhat broader interpretation of the facts and conditions seems necessary.

The manner by which metallic substances of meteoritic origin may become incorporated with ore materials generally is not an intricate one. After reaching the surface of the earth all cosmic dust and fragments must mingle with the soil, more or less quickly oxidize, and enter through means of the circulating ground-waters or otherwise sooner or later reach the deep-seated zone, in the same way as any of the heavier mineral particles liberated from the surface rocks through decomposition are supposed to do. The processes involved are essentially the same as for the changes and movements of rock-forming materials generally. The distinction to be made is merely that instead of all of the ore materials being derived from the breaking down of rocks of the lithosphere a very large proportion is regarded as coming from extra-terrestrial sources.

In the course of the inward migration of ore materials temporary ore-bodies are often localized in the vadose zone, and even lower down. How much of these materials is of recent extra-terrestrial origin and what proportion is really a product of rock decay is at the present moment difficult to estimate. Even dominant notions concerning ore-bodies seemingly directly associated with igneous masses appear to be in need of careful revision. The meteoritic phase has received as yet insufficient application. That it is far more important than has been suspected is clearly shown by recent observations on desert ores. That this is the main source of vadose ore materials now seems not unlikely. It is probable that much of the so-called general metallic content of the sedimentary rocks is in reality derived immediately from meteoritic sources, for its derivation entirely from the country-rock of mining districts especially those far removed from volcanic activity, has never been a very satisfactory explanation.

The supplies of metaliferous materials derived from meteoritic sources, inferentially at least, equal if not actually greatly exceed in amount those derived from the secular decay of rock-masses. It is also a question whether of the worked ore-bodies of the world the majority of mines are not really operated in the so-called vadose ores. Casual perusal of the vast descriptive literature on the mines of the world appears to give ample support to this statement.

Resumé.

From the foregoing notes it may be inferred:

(1) That Coon Butte is most probably of volcanic origin; the direct evidences being the numerous similar phenomena in the vicinity showing undoubted connection with the explosive type of vulcanism.

(2) That the great abundance of meteoritic materials in the neighborhood of Coon Butte is due to favorable climatic conditions coupled with marked deflative activity on a hard rock stratum rather than to extensive comminution of a huge meteorite falling at this point.

(3) That as compared with the conditions afforded by moist lands desert regions generally are exceptionally favorable for the disclosure of abundant meteoritic material.

(4) That in the form of dust is probably the chief meteoritic augmentation to the earth's volume, with the abundance of metallic grains in the desert soils and arctic snows as evidence.

(5) That the principal ultimate source of ore materials is possibly meteoritic in character rather than magmatic.

Issued December 29, 1910.

ECOLOGICAL NOTES ON THE CLADOCERA AND COPEPODA OF AUGUSTA, GEORGIA, WITH DESCRIPTIONS OF NEW OR LITTLE KNOWN SPECIES.*

C. H. Turner.

This communication is but a fragment of what was planned to be an exhaustive ecological study of the Cladocera and Copepoda of Augusta, Georgia. The various ponds and other bodies of water were visited at regular intervals, a careful record made of the temperature of the water and the condition of the body of water, and a collection made with a Birge dredge. These collections were taken to my laboratory and worked over at once. The species were identified and measured and, usually, a record made of other small animals that were collected at the same time. When this work had been in progress for a little more than one year, it was suddenly terminated because I then left Augusta to reside, permanently, in another part of the country. Partly as the result of ravages of mice and partly because, as the work progressed, my ideas as to what measurements were essential underwent a change, the records are not so complete as I would like. However, since it will be impossible for me to complete the work; and since so little has been published on the ecology of the American entomostraca, I have thought it best to publish the data that I have.

Augusta, Georgia, is situated on the fall line separating the Piedmont Plateau from the Atlantic Coastal Plain. At this point, the level, sandy plain is dotted with numerous artificial ponds. These ponds, which have been excavated by the numerous brick-yards of the locality, vary in extent from a few square yards to several acres. There are also a few creeks, which empty into the Savannah

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River, and several lagoons and numerous ditches. The brick-yard ponds, the ages of which varied from less than a year to more than twenty years, lay in a flood plain; but, since there had not been a large flood for twenty years, they furnished an excellent opportunity for the study of the succession of entomostracan life in fresh water ponds. When the work had been in progress a few months, there occurred a large flood, which, temporarily, turned all of these ponds into one vast lake. This commingling of the waters of the several ponds defeated the most important aim of this series of studies. For this reason, no mention of the relative ages of the different ponds is made in this communication. Since no collections were made at the time of the flood nor for several weeks after it had completely subsided, it is thought that the data giving the entomostracan associates of each form are reliable.

The tables that are found in the body of this communication record things as they were in Augusta at the time of this investigation; but, they do not pretend to predicate what must be the conditions elsewhere. Indeed, since the period of study extended over only a little more than one year, it would be claiming too much to insist that the conditions here recorded must be invariably the case even in Augusta. However, such facts as are recorded are positive and it is thought that they will be of some value to future students of the ecology of the Entomostraca.

One fact that I noticed deserves more than passing attention. Not once in my Augustan experience did I find a cladoceran bearing "winter eggs." It is well known that, in warm climates, the Cladocera do not form "winter eggs"; but, since many of my collections were made in water with a temperature of a little above zero centigrade, the result just recorded was not expected. Indeed, I often broke a thin layer of ice in order to make my collections. In Ohio, where the winters are much more severe than they are in Augusta, I have often found cladocerans bearing "winter eggs" in water that was free from even a suggestion of ice. Although I did not take the temperature of the water in those Ohio ponds, yet, since no ice had formed on the surface, it was certainly higher than zero centigrade. It seems then that a temperature which would be low enough to induce cladocerans of a cold clime to produce "winter eggs" is not necessarily low enough to induce those of a milder climate to do so. My records do not show whether or no male cladocerans occur in Augusta; the Copepoda, both the Calanidae and the Cyclopidae, produce numerous males. It is not claimed that observations made throughout one winter are sufficient to warrant the assertion that the Cladocera of Augusta never form "winter eggs;" but this does not militate against the statement made above.

COPEPODA.

Calanidae.

diaptomus Westwood.

1. diaptomus sanguineus Forbes, var. minnetonka Herrick.

Diaptomus sanguineus, Forbes, '76, pp. 15, 16, 23; fig. 24, 28-30.
Diaptomus minnetonka, Herrick & Turner, '95, pp. 71-72; Pl. XIII., Fig. 8-10.
Diaptomus sanguineus, Schacht, '97, pp. 133-137, Pl. XXIII.-XXV.

Near Augusta, this form, which is abundant, seems to be confined to marshes and ditches having a temperature of from 10° to 16° C. Associated with it, in addition to the entomostracans mentioned in table I., were:—young crayfish, Brancippi, Assellidae, gammarids, water-boatmen, hydrachnids, and planarians.

2. diaptomus stagnalis Forbes.

Diaptomus stagnalis, Forbes, '82, p. 646; Pl. VIII., Fig. 8, 10-12, 14.
Diaptomus stagnalis, Herrick and Turner, '95, pp. 66, 67; Pl. III.; XIII., Fig. 11, 13.
Diaptomus stagnalis, Schacht, '97, pp. 138-141; Pl. XXVIII., Fig. 2.

Alike *D. sanguineus,* this species is an inhabitant of marshes and ditches; but is more abundant. I have never found *D. sanguineus* except in company with *D. stagnalis,* but I have frequently found the latter in places where the former was not in evidence.

The temperature of the water in which it was found varied from 4° to 12° C.

The females varied much in color. From some localities, the specimens were blood red all over, except dark streaks due to eggs in the brood-sac; from other localities, the thorax was bright blue tinged with yellow, through which shone the orange to brown digestive tract, the distal half of the abdomen was orange, the antennae were reddish brown, and the legs a deep blue; from another locality the body was straw color, with a dash of red on the antennae and a portion of the thorax, while the legs were almost black. With one exception, the males encountered were all bright red. The exception was a pale, pink male found among a large number of males of the typical color. This was probably a case of albinism.

The dimensions of the females are given in table IV. The following dimensions of the male are averages derived from measurements of twenty-five individuals. Length of the thorax 2.13 mm., length of the abdomen 1.04 mm., length of the abdominal furca 0.14 mm., length of the abdominal setae 0.70 mm., total length, excluding the abdominal setae, 3.17 mm., total length, including the abdominal setae, 3.87 mm.

Associated with it, in addition to the Entomostraca mentioned in table I., were: Brancippi, Assellidae, gammarids, water-boatmen, diving beetles, hydrachnids, planarians, *Limnaeus,* and *Hydra fusca.*

3. **Diaptomus augustaensis,** n. sp.

Pl. XXXVI. f. 1-4.

This is a small, slender species closely related to *D. ashmedi.*

Female.—Thorax long and slender, almost three times as long as wide: suture between the head and thorax distinct in fresh specimens; but indistinct on the dorsal aspect of specimens mounted in balsam. The last two thoracic segments distinct, the last strongly bifid; each arm of the bifurcation broad and slightly concave on the posterior margin, with the two posterior angles terminating in a sharp spine or tooth.

The abdomen is slender; including the furca, it is not half so long as the cephalothorax. The first abdominal somite, which is about as long as the remainder of the abdomen, including the furcal rami, is dilated laterally and armed on each side with a prominent spine; the second segment is slightly shorter than the third; the furcal rami are about twice as long as wide.

The 25-jointed antennae reach about to the base of the furcal rami. On the fifth foot, the basal joint bears, at its outer angle, a small spine;

the basal joint of the outer ramus is a trifle over twice as long as wide; the second segment is slightly shorter than the first, it tapers to a sharp point and curves inward (towards the inner ramus); about half way up the concave margin, there is a prominent tooth, between this tooth and the tip there are numerous fine serrations. [This tooth is a constant feature, but is not to be seen in mounts that show a cephalic rather than a lateral view.] There is the merest trace of a third joint, this bears two long setae, which are finely pectinated, and a shorter seta. The inner ramus, which is about as long as the first joint of the outer ramus, is of about uniform width throughout and terminates in two sub-equal setae, which are usually hairy.

Viewed from the side, the dorsal margin is feebly but uniformly convex.

Male.—The inner distal angle of the geniculate antenna is extended into a straight, pointed, process, which is longer than the penultimate joint.

On the inner border of the basal segment of the larger fifth leg there is a hyaline plate which is more than half as long as the segment, and bears on its inner distal angle a prominent tooth. The inner margin of the second basal segment is strongly convex and bears a narrow hyaline flange. The proximal fourth of the inner margin of the distal joint of the outer ramus of this leg is convex; the next two fourths concave; near the convexity, in the proximal portion of this concavity, there is a prominent spine. This distal segment is about twice as long as broad and its broadest part is its distal border; from its outer angle, springs a stout, pectinated, lateral spine, which is about half as long as the segment; from the inner angle of this border arises a sickle-like seta, which is longer than the outer ramus of the leg. The inner ramus of the leg is sub-clavate and extends to about the middle of the distal joint of the outer ramus; its free blunt end bears, at about its middle, a small tooth.

The smaller fifth leg reaches to a little beyond the base of the last segment of the larger leg.

This form was found in only one locality, which was a temporary pond in a marsh. The depth of the water was from two to six inches, the bottom was covered with plants (dead), the temperature of the water was 4° C.

4. DIAPTOMUS MISSISSIPPIENSIS Marsh.

Diaptomus mississippiensis, Marsh, '94, p. 15; pl. I., fig. 1-3.
Diaptomus mississippiensis, Herrick & Turner, '95, p. 78; pl. XLVII., fig. 1-3.
Diaptomus mississippiensis, Schacht, '97, pp. 173-176; pl. XXXIII., fig. 1-4.

This was found in only one pond; but it was abundant in both shallow and deep water. The temperature of the water varied from 16° C. to 21° C. The pond was about ten years old and, in the shallow places, many plants were found.

The length of the female varied from 1.32 mm. to 1.57 mm.

In addition to the Entomostraca mentioned in table I., associated with it were hydrachnids, may-fly larvae, rotifers, snails, water-boatmen.

Cyclopidae.

cyclops O. F. Mueller.

5. cyclops viridis Jurine, var. brevispinosus Herrick.

Cyclops brevispinosus, Herrick and Turner, '95, p. 95; pl. XXIII., fig. 1-4; pl. XXIV., fig. 7-12.

Cyclops viridis, var. *brevispinosus*, E. B. Forbes, '97, p. 41; pl. XI., fig. 1-2.

This form was found on only one occasion; then it was in a roadside ditch with a temperature of 15° C.

6. cyclops viridis Jurine, var. insectus Forbes.

Cyclops insectus, Forbes, '82, p. 649; pl. IX., fig. 6.

Cyclops viridis, var. *americanus*, Herrick & Turner, '95, pp. 91-92; pl. XIV., fig. 1-9.

Cyclops viridis, var. *insectus*, E. B. Forbes, '97, pp. 41-44; pl. XI., fig. 3-6.

In the neighborhood of Augusta, this form is widely distributed; it is found in ditches, marshes, no-outlet ponds and ponds with outlets. Where there is an abundance of algae and other vegetation, this species is almost certainly to be found. The temperature of the water varied from 4° C. to 19° C.

It is frequently covered with parasitic Protozoa, the color of which is often green.

7. cyclops viridis Jurine, var. ingens Herrick.

Cyclops ingens, Herrick & Turner, '95, p. 92; pl. XXV., fig. 1-8.

This variety was found in six localities; but always in either a flooded meadow, a marsh, or other temporary pond. The temperature of the water varied from 4° C. to 8° C. In those places and under those conditions, the species was abundant. This is a very large form.

On one occasion, in a pond formed by the overflow of Butler's Creek, I found a specimen which had the structural peculiarities of *C. ingens,* but a size but little larger than the large forms of *C. insectus*. The dimensions were as follows: length of the first thoracic somite 0.74 mm., length of the thorax 1.20 mm., length of the abdomen 0.60, length of the abdominal furca 0.18, length of the abdominal setae 1.18, total length, excluding the setae, 1.80, total length, including the setae, 2.98, length of the antennae 0.78. width of the first abdominal somite 0.22, width of the remainder of the abdomen 0.16, length of the abdominal furca 0.06.

Gammarus was associated with this variety.

8. CYCLOPS BICUSPIDATUS Claus.

Cyclops forbesi, Herrick & Turner, '95, p. 104.
Cyclops bicuspidatus, E. B. Forbes, '97, pp. 44-47; pl. XII., fig. 1-4.

This form was found in three localities: among plants, in a marsh; in the weedy, temporary, portion of a no-outlet pond; and in a shallow lagoon with a bare red-clay bottom. The temperature of the water varied from 12° C. to 15° C.

In addition to the Entomostraca mentioned in the table, associated with it were gammarids, hydrachnids, and may-fly larvae.

9. CYCLOPS SIGNATUS Koch, var. CORONATUS Claus.

Cyclops signatus, var. *coronatus*, Herrick & Turner, '95, p. 106; pl. XV., fig. 1-4.

This variety was found in two localities; in the shallow, grassy, edge of a large pond which was fed and drained by a large creek; and in a large hole filled by the overflow from Butler's Creek. The temperature of the water was 8° C. The specimens were conspicuously banded with blue.

10. CYCLOPS SIGNATUS Koch, var. TENUICORNIS Claus.

Cyclops signatus, var. *tenuicornis*, Herrick & Turner, '95, pp. 106, 107; pl. XV., fig. 5-7; pl. XX., fig. 1-7; pl. XXXIII., fig. 1, 2.
Cyclops albidus, E. B. Forbes, '97, pp. 47-49; pl. XIII.

This form is common about Augusta. I found it in marshes, in no-outlet ponds containing much vegetation, and in lagoons that were almost free from aquatic vegetation; when the temperature of the water ranged from 6° C. to 15° C. On no occasion did I find this variety associated with the variety *coronatus*.

11. CYCLOPS ATER Herrick.

Cyclops ater, Herrick & Turner, '95, pp. 89-90; pl. VI., fig. 11, 12; pl. XII., fig. 9-12; XXI., fig. 13-15, 17, 18.
Cyclops ater, E. B. Forbes, '97, pp. 49-51; pl. XIV., and pl. XV., fig. 1-3.

This form was found in the temporary portion of a no-outlet pond, in temporary ponds, and in a pond fed by the overflow from a large creek. The temperature of the water ranged from 4° C. to 17° C. The color of the thorax varied from dark blue to almost black.

12. CYCLOPS SERRULATUS Fischer.

Cyclops serrulatus, Herrick & Turner, '95, pp. 111-112; pl. XV.; fig. 8-11; pl. XIX., fig. 2-5; pl. XXVI., fig. 10; pl. XXIX., fig. 17-19.
Cyclops serrulatus, E. B. Forbes, '97, pp. 54-57; pl. XVII., pl. XVIII., fig. 1-3.

This is the commonest copepod about Augusta. It abounds in temporary ponds, ditches and permanent ponds of both types. It is found among vegetation and where the aquatic vegetation is practically absent. The temperature of the water in which it was found varied from 4° C. to 28.5° C.

In addition to the Entomostraca mentioned in the table, associated with it were gammarids, hydrachnids, may-fly larvae, diving beetles, larvae of Diptera, planarians, rotifers, snails, water-boatmen, Hydra.

13. CYCLOPS PHALERATUS Koch.

Cyclops phaleratus, Herrick & Turner, '95, pp. 120, 121; pl. XVII., fig. 1-7; pl. XVIII., fig. 2-2d; pl. XIX., fig. 1; pl. XXI., fig. 6-10.

Cyclops phaleratus, E. B. Forbes, '97, pp. 59-63; pl. XX., fig. 3.

This form was found in only one locality and on only one occasion. Then it was collected, among vegetation, in the temporary portion of a large no-outlet pond, the temperature of the water of which was 21° C.

14. CYCLOPS FIMBRIATUS Fischer.

Cyclops fimbriatus, Herrick & Turner, '95, pp. 121-122; pl. XVII., fig. 8, 9; pl. XXI., fig. 11; pl. XXV., fig. 9-14.

This form is rare about Augusta. It was found on only one occasion; then it was found, among cat-tail rushes and weeds, in a large no-outlet pond, the surface of which was covered with duck weeds.

HARPACTICIDAE.

CANTHOCAMPTUS.

15. CANTHOCAMPTUS MINUTUS, Herrick & Turner, '95, pp. 131, 132; pl. XLVII., fig. 7-21; pl. L., fig. 7, 8.

This form was found in two localities, among filamentous algae, in a shallow, sandy, marsh, and in a hole fed by a creek. The temperature of the water varied from 4° C. to 12° C.

CLADOCERA.

SIDIDAE.

PSEUDOSIDA Herrick.

16. PSEUDOSIDA TRIDENTATA Herrick.

Pseudosida tridentata, Herrick & Turner, '95, pp. 147-148; pl. XXXVI., figs. 2-6; pl. L., fig. 9.

Near Augusta, this form is rare. It was found on only one occasion; then it was encountered, among submerged plants, in the temporary portion of a permanent, no-outlet, pond.

In addition to the Entomostraca mentioned in the table, associated with it were dipterous larvae, gammarids, and may-fly larvae.

DAPHNELLA Baird.

17. DAPHNELLA BRANDTIANA Fischer.

Daphnella brandtiana, Birge, '91, p. 382.
Daphnella brandtiana, Herrick & Turner, '95, p. 149; pl. XXXVII., fig. 3-6.

This species was found on only one occasion; then it was collected, in large numbers, in a large no-outlet pond, in which there was no vegetation. The temperature of the water was 19° C.

18. MOINA BRACHIATA Jurine.

Moina brachiata, Herrick & Turner, '95, pp. 162-163; pl. XXXIX., fig. 5-8; pl. XLIII., fig. 1, 2.

This form is abundant about Augusta, among plants, in one of the large no-outlet ponds.

CERIODAPHNIA Dana.

19. CERIODAPHNIA MEGOPS Sars.

Ceriodaphnia cristata, Birge, '78, p. 6; pl. II., fig. 8, 9.
Ceriodaphnia megops, Herrick & Turner, '95, pp; 168-169; pl. XLI., fig. 20.

About Augusta, this form is abundant in ditches and marshes with a water temperature of 4° to 12° C.

SCAPHOLEBERIS Schoedler.

20. SCAPHOLEBERIS MUCRONATA Mueller.

Scapholeberis mucronata, Birge '78, pp. 8-9; pl. I., fig. 7.
Scapholeberis mucronata, Herrick & Turner, '95, pp. 174-175; pl. XLIII., fig. 4-7; pl. XLV., fig. 5.

This species was found, in abundance, in several of the temporary ponds having a temperature of from 4° C. to 10° C.

21. SIMOCEPHALUS VETULUS Mueller.

Simocephalus vetulus, Birge, '78, p. 8.
Simocephalus vetulus, Herrick & Turner, '95, p. 178; pl. XLIV., fig. 7; LII., fig. 6-9.

This form was found, in large numbers, in three temporary ponds, the water temperature of which was 4° C. to 8° C.

22. SIMOCEPHALUS SERRULATUS Koch.

Simocephalus americanus, Birge, '78, pp. 6-8; pl. I., fig. 6.
Simocephalus cerrulatus, Herrick & Turner, '95, p. 179.
Simocephalus americanus, Herrick & Turner, '95, p. 179; pl. XLV., fig. 9.

About Augusta, this form is abundant in ditches, marshes, no-outlet ponds, and holes fed by creeks. The temperature of the water in which it was found varies from 4° C. to 29° C.

In addition to the Entomostraca mentioned in the table, associated with it were hydrachnids, gammarids, may-fly larvae, diving beetles, water-boatmen, *Brancippus*, dragon-fly larvae, and *Limnaeus*.

DAPHNIA Schoedler.

23. DAPHNIA SCHOEDLERI Sars.

Daphnia schoedleri, Herrick & Turner, '95, p. 193.

This species was found in temporary ponds with a water temperature of from 8° C. to 15° C. The number of teeth upon the postabdomen varied from six to ten, otherwise it corresponds with the species found by Brady in England.

24. DAPHNIA HYALINA Leydig.

Pl. XXXVII. f. 1-8.

Daphnia laevis, Birge, '78, pp. 12-13; pl. II., fig. 5-7.
Daphnia hyalina, Birge, '91, pp. 388-389.
Daphnia hyalina, Herrick & Turner, '95, pp. 195-196; pl. XXII., fig. 7, 8; pl. XXVII., fig. 6; pl. XXXV., fig. 16; pl. XLIX., fig. 3-5; pl. LIII., fig. 1-4.

This form was very abundant in two of the large no-outlet ponds. It was found in water with a temperature of from 19° C. to 20° C.

All who have had a first-hand acquaintance with *Daphnia hyalina* have noticed the marked morphological difference of individuals captured from the same pond. In some the head bears a spine, in others it does not; in some the dorsal spine is short, in others it is long; in some cases the spine is at the dorso-caudal angle of the shell, in others it is lower down. Heretofore, so far as my knowledge goes, these forms have been considered individual peculiarities, distinct varieties, or even distinct species. The relative length of the spine is apparently an individual matter, at least its relative size is not determined by the age of the animal. In the forms that are found around Augusta, the other differences are differentiations due to age. In the young embryo in the brood pouch, the caudal spine is so bent down and appressed against the body that the posterior border of the body appears to be rounded (Pl. XXXVII. f. 1) or slightly pointed (Pl. XXXVII. f. 2) and the head is spineless. The free swimming but immature form has a long caudo-dorsal spine and a short, but prominent, head spine (Pl. XXXVII. f. 3); in this stage the body is relatively quite long. Between now and the breeding stage, the body becomes relatively much higher; otherwise there is no marked change, except, perhaps, a slight shortening of the spine on the head (Pl. XXXVII. f. 4-5). When the animal begins to breed, the long spine on the posterior border progressively retreats ventrad; this is due to the enormous development of the brood sac (the old female bearing fully three times as many eggs as the youngest breeders—Pl. XXXVII. f. 6-8). In old forms the spine on the head disappears entirely (Pl. XXXVII. f. 8).

BOSMINA Baird.

25. BOSMINA LONGIROSTRIS O. F. M.

Bosmina longirostris, Birge, '78, p. 15.
Bosmina longirostris, Herrick & Turner, '95, p. 207; pl. XLV., fig. 2; pl. LXV., fig. 2.

This form was abundant in the temporary portions of a large no-outlet pond, at a water temperature of 21° C.;

in that same pond, at another season *Bosmina atlantaensis* was found.

26. BOSMINA ATLANTAENSIS Turner.

Bosmina atlantaensis, Turner, '94, p. 23; pl. VII., fig. 12, 13.
Bosmina atlantaensis, Herrick & Turner, '95, p. 209; p. 273.

In the light of our present knowledge of the genus, the original description of this species was too condensed; hence I am giving a more complete description.

The shell is smooth; length greater than the height; the body uniformly arched from the caudo-dorsal margin to the beak, vental margin straight; caudal margin less than half the greatest height, which is slightly caudad of the middle. The flagellum is about midway between the eye and the beak, or slightly nearer the beak. In a few cases, there was a faint trace of a pigment fleck at the base of the flagellum. The spine is short and slightly curved caudad; antennules nearly twice as long as the greatest height of the animal. They are slender and slightly, but uniformly, curved from the beak to their tip. The sensory seta is much nearer to the beak than to the tip of the antennules.

This species is abundant in two permanent, no-outlet ponds, in which the water had a temperature of from 10° to 16° C.

Ever since reading Burckhardt's Faunistische und systematische Studien ueber das Zooplankton der grösseron Seen der Schweiz und ihrer Grenzgebiete, I have been inclined to regard this as a variety of *Bosmina longirostris;* but, since there is still some uncertainty in my mind, I have not felt it wise to change the name.

27. **Bosmina reversaspina** n. sp.

Pl. XXXVIII. f. 1.

The body is longer than wide and the greatest height is in front of the middle; indistinctly marked with irregular striae, which run, approximately, parallel to the dorsal surface; on the head these lines converge towards the front. In specimens mounted in canada balsam, no markings are visible on the lower part of the body, nor on the head. The dorsal margin is uniformly convex, protruding a little in front of the eye; ventral margin is nearly straight. The flagellum is near the eye; the beak is short; antennules long and slightly curved. The spines are long and stout and curved towards the front (cephalad), toothed on the posterior borders. (In no other *Bosmina* do we find a spine of this type). The postabdomen is truncated, convex at its caudo-ventral angle; on the caudal margin, near the caudo-ventral angle, are several small bristles; the claws are slightly flexible and bear neither spines nor teeth; but, on their caudal margins, there are several bristles.

Habitat: Augusta, Ga.; shallow marsh with a grassy bottom and a water temperature of 12° C.; collected January 23, 1908. Besides the Entomostraca mentioned in the table, associated with it were gammarids, Asselidae, hydrachnids, etc., but no filamentous algae. The grass was dead.

ACANTHOLEBERIS Lilljeborg.

28. ACANTHOLEBERIS CURVIROSTRIS O. F. M.

Acantholeberis curvirostris, Herrick & Turner, '95, p. 218; pl. XLVI., fig. 1-4.

This rare form was found, on only one occasion, in a hole fed by the overflow from Butler's Creek. The temperature of the water was 8° C. To the best of my knowledge, this is the first time that this form has been found in America.

ILYOCRYPTUS.

29. ILYOCRYPTUS SPINIFER Herrick.

Ilyocryptus longiremus, Birge, '91, pp. 392-393; pl. XIII., fig. 18.
Ilyocryptus spinifer, Herrick & Turner, '95, pp. 221-223; pl. LV., fig. 1-4; pl. LVI., fig. 18, 19, 21.

Near Augusta, this species is rare. The water in which it was found had a temperature of 6° C.

EURYCERUS *Baird.*

30. EURYCERUS LAMELLATUS O. F. M.

Pl. XXXVIII. f. 2.

Eurycercus lamellatus, Herrick & Turner, '95, p. 226; pl. XLVI., fig. 7, 8; pl. LI., fig. 6; pl. LX., fig. 5, 6; pl. LXII., fig. 19.

In Butler's Creek and in the ponds fed and drained by it, this species is abundant, when the water temperature ranges from 4° C. to 8° C.

In addition to the Entomostraca mentioned in the table, associated with it were gammarids, may-fly larvae, diving beetles, and hydrachnids.

CAMPTOCERCUS. Baird.

31. CAMPTOCERCUS MACRURUS O. F. M.

Camptocercus macrurus, Birge, '91, p. 395.
Camptocercus macrurus, Herrick & Turner, '95, pp. 229-230; pl. LXI., fig. 10, 10a.

This is one of the most widely distributed of the Cladocera of Augusta; it being found in temporary ponds, in no-outlet permanent ponds, and in permanent ponds with an outlet; and at water temperatures of from 4° C. to 21° C. In addition to the Entomostraca mentioned in the table, associated with it were dragon-fly larvae, hydrachnids, *Limnaeus,* and may-fly larvae.

ALONOPSIS Sars.

32. ALONOPSIS LATISSIMA Kurz.

Alonopsis latissima, Herrick & Turner, '95, p. 232; pl. LXI., fig. 8; pl. LXIII., fig. 1 & 9.

This form was found on only one occasion; then it was collected, on December 12, 1907, among submerged plants, in a no-outlet, permanent, pond.

LEYDIGIA Kurz.

33. LEYDIGIA QUADRANGULARIS Leydig.

Leydigia quadrangularis, Herrick & Turner, '95, p. 234; pl. LIX., fig. 6; pl. LX., fig. 4.

This form was found in a no-outlet, permanent, pond and in a marsh, when the water temperature was 16° C. and 17° C. respectively.

ALONA Sars.

34. ALONA QUADRANGULARIS Mueller.

Alona oblonga, Birge, '78, p. 31.
Alona quadrangularis, Herrick & Turner, '95, pp. 240-241; pl. LXI., fig. 1, 2.

Although not abundant, this species was found in four localities; a temporary pond, two no-outlet ponds, and a creek. The temperature of the water was 8° C.

35. ALONA INTERMEDIA Sars.

Alona intermedia, Herrick & Turner, '95, pp. 244-245; pl. LXII., fig. 15.

This species was found on only one occasion; then it was in a marsh having a water temperature of 12° C. The bottom was grassy, the grass was dead.

36. ALONA CORONATA Kurs.

Alona coronata, Herrick & Turner, '95, p. 247.

This form was found on only one occasion; then it was collected, in abundance, from a ditch in a marsh, in January, 1908.

PLEUROXUS P. E. Mueller.

37. PLEUROXUS DENTICULATUS Birge.

Pleuroxus denticulatus, Birge, '78, pp. 20-21; pl. I., fig. 21.
Pleuroxus denticulatus, Herrick & Turner, '95, p. 256; pl. XLV., fig. 8; pl. LXIII., fig. 10a, 12, 13.

Near Augusta, this species was common, among vegetation, in certain marshes and no-outlet, permanent, ponds, having a water temperature from 8° C. to 17° C.

38. PLEUROXUS HAMATUS Birge.

Pleuroxus hamatus, Birge, '78, pp. 22-23; pl. II., fig. 13, 14.
Pleuroxus hamatus, Herrick & Turner, '95, p. 257; pl. LX., fig. 1.

This species was abundant, among vegetation, in two of the large, no-outlet, permanent ponds; at a water temperature of from 16° C. to 21° C.

CHYDORUS Leach.

39. CHYDORUS SPHAERICUS O. F. M.

Chydorus sphaericus, Birge, '78, pp. 23, 24.
Chydorus sphaericus, Herrick & Turner, '95, p. 261; pl. LXIV., fig. 4, 7, 8, 10.

This species was abundant in several of the no-outlet, permanent, ponds. It was found among vegetation and also where there was practically no vegetation. The temperature of the water in which it was found varied from 10° C. to 29° C.

List of Articles Referred to in this Communication.

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'76. List of Illinois Crustacea, with Descriptions of New Species. (Bull. Ill. State Lab. Nat. Hist. **1**: 3-25.)

'82. On some Entomostraca of Lake Michigan and Adjacent Waters. (Am. Nat. **16**: 537-543, 640-650, *pls. 8-9.*)

FORBES, E. B.

'97. A Contribution to a Knowledge of the North American Fresh-Water Cyclopidae. (Bull. Ill. State Lab. Nat. Hist. **5**: 27-82, *pls. 8-20.*)

HERRICK, C. L., and TURNER, C. H.

'95. Synopsis of the Entomostraca of Minnesota. (Geol. Nat. Hist. Surv. Minnesota, Zool. Series **2**: 1-524, *pls. 1-81.*)

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'94. On two New Species of Diaptomus. (Trans. Wisconsin Acad. Sci., Arts, Letters **10**: 15-17, *pl. 1.*)

SCHACHT, F. W.

'97. The North American Species of Diaptomus. (Bull. Ill. State Lab. Nat, Hist. **5**: 97-207, *pls. 21-35.*)

TURNER, C. H.

'94. Notes on the Cladocera of Georgia. (Bull. Sci. Lab. Denison Univ. **8**: 22-25, *pl. 7.*)

TABLE I.

ENTOMOSTRACAN ASSOCIATES.

	1. Canthocamptus minutus.	2. Cyclops ater.	3. Cyclops bicuspidatus.	4. Cyclops fimbriatus.	5. Cyclops phaleratus.	6. Cyclops serrulatus.	7. Cyclops signatus coronatus.	8. Cyclops signatus tenuicornis.	9. Cyclops viridis brevispinosus.	10. Cyclops viridis ingens.	11. Cyclops viridis insectus.	12. Diaptomus augustaensis.	13. Diaptomus mississippiensis.	14. Diaptomus sanguineus.
COPEPODA.														
1. Canthocamptus minutus	...	1	...	...	...	1	1	...	...	...	1	...	...	...
2. Cyclops ater	1	...	...	...	...	3	1	...	...	...	1	...	...	...
3. Cyclops bicuspidatus	...	...	...	...	...	2	...	1	...	...	2	...	...	...
4. Cyclops fimbriatus	...	...	...	...	...	1	...	1	...	...	...	...	...	...
5. Cyclops phaleratus	...	...	...	...	...	1	...	...	...	...	...	...	...	...
6. Cyclops serrulatus	1	3	2	1	1	...	2	c	...	...	c	...	c	...
7. Cyclops signatus coronatus	1	1	...	...	...	2	...	...	...	...	1	...	...	...
8. Cyclops signatus tenuicornis	...	...	1	1	...	c	...	...	...	...	...	...	2	...
9. Cyclops viridis brevicornatus	...	...	...	...	...	...	...	...	...	...	...	...	...	...
10. Cyclops viridis ingens	...	...	...	...	...	...	...	...	...	...	...	...	...	...
11. Cyclops viridis insectus	1	1	2	...	...	c	1	...	...	...	...	1	1	...
12. Diaptomus augustaensis	...	...	...	...	...	...	...	...	...	...	1	...	...	...
13. Diaptomus mississippiensis	...	...	...	...	...	c	...	2	...	...	1	...	...	...
14. Diaptomus sanguineus	...	...	...	...	...	...	...	...	...	...	...	...	...	...
15. Diaptomus stagnalis	...	1	...	...	...	2	...	1	...	...	2	...	...	c
CLADOCERA.														
16. Acantholeberis curvirostris	1	1	...	...	...	1	1	...	...	...	...	...	...	...
17. Alona coronata	...	...	...	...	...	1	...	1	...	...	...	...	...	...
18. Alona intermedia	...	...	...	...	...	...	...	...	...	...	...	...	...	...
19. Alona quadrangularis	1	1	...	...	...	3	1	1	...	...	...	...	1	...
20. Alonopsis latissima	...	...	...	...	...	...	...	...	...	...	...	...	...	...
21. Bosmina atlantaensis	...	1	...	1	...	3	...	2	...	...	1	...	2	...
22. Bosmina longirostris	...	...	...	...	1	3	...	...	...	...	...	...	...	...
23. Bosmina reversaspina	...	...	...	...	...	...	...	...	...	...	...	...	...	...
24. Camptocercus macrurus	...	1	...	...	...	c	1	2	...	1	1	...	3	...
25. Ceriodaphnia megops	...	...	...	...	...	...	...	...	...	1	1	...	...	2
26. Chydorus sphaericus	...	1	1	1	...	c	...	3	...	...	1	...	1	...
27. Daphnella brandtiana	...	...	...	...	...	...	...	...	...	...	...	...	1	...
28. Daphnia hyalina	...	...	...	...	1	3	...	...	...	...	...	...	1	...
29. Daphnia schoedleri	...	...	1	...	...	1	...	1	...	...	...	...	...	...
30. Eurycercus lamellatus	1	1	...	...	...	3	2	...	...	...	1	...	...	...
31. Ilyocryptus spinifer	...	...	...	...	...	...	...	...	...	...	1	...	...	...
32. Leydigia quadrangularis	...	1	1	...	...	2	...	1	...	...	1	...	...	...
33. Moina brachiata	...	...	...	...	1	2	...	...	...	...	...	...	...	...
34. Pleuroxus denticulatus	...	1	...	1	...	c	...	2	...	1	c	...	...	...
35. Pleuroxus hamatus	...	...	...	...	...	3	...	...	...	...	2	...	...	...
36. Pseudosida tridentata	...	...	...	...	...	1	...	...	...	...	...	...	...	...
37. Scapholeberis mucronata	...	...	...	...	...	...	...	...	...	2	...	...	...	1
38. Simocephalus serrulatus	1	3	1	...	...	c	1	2	1	2	c	1	1	1
39. Simocephalus vetulus	...	...	...	...	...	2	...	...	...	1	2	...	...	...

The numerals in the columns indicate the number of times the form opposite which head of the column in which the figure is found; the letter "c" indicates more than

15. Diaptomus stagnalis.	16. Acantholeberis curvirostris.	17. Alona coronata.	18. Alona intermedia.	19. Alona quadrangularis.	20. Alonopsis latissima.	21. Bosmina atlantaensis.	22. Bosmina longirostris.	23. Bosmina reversaspina.	24. Camptocercus macrurus.	25. Ceriodaphnia megops.	26. Chydorus sphaericus.	27. Daphnella brandtiana.	28. Daphnia hyalina.	29. Daphnia schoedleri.	30. Eurycercus lamellatus.	31. Ilyocryptus spinifer.	32. Leydigia quadrangularis.	33. Moina brachiata.	34. Pleuroxus denticulatus.	35. Pleuroxus hamatus.	36. Pseudosida tridentata.	37. Scapholeberis mucronata.	38. Simocephalus serrulatus.	39. Simocephalus vetulus.
...	1	...	...	1	...	...	...	...	...	...	...	...	...	...	1	...	...	...	...	...	...	...	1	...
1	1	...	...	1	...	1	...	...	1	...	1	...	...	...	1	...	1	...	1	...	...	...	3	...
...	...	...	...	...	...	...	...	...	...	...	1	...	...	1	...	...	1	...	...	...	...	...	1	...
...	...	...	...	...	...	1	...	...	...	...	1	...	...	...	...	...	...	...	1	...	...	...	...	...
...	...	...	...	...	...	...	1	...	...	...	...	...	1	...	...	...	...	1	...	...	...	...	...	...
2	1	1	...	3	...	3	3	...	c	...	c	...	3	1	3	...	2	2	c	3	1	...	c	2
...	1	...	...	1	...	...	...	...	1	...	...	...	...	...	2	...	...	...	...	...	...	...	1	...
1	...	1	...	1	...	2	...	...	2	...	3	...	...	1	...	...	1	...	2	...	...	...	2	...
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	...
...	...	...	...	...	...	...	...	...	1	1	...	...	...	...	...	...	...	...	1	...	...	2	2	1
2	...	...	...	...	...	1	...	...	1	1	1	...	...	...	1	1	1	...	c	2	...	...	c	2
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	...
...	...	...	...	1	...	2	...	...	3	...	1	1	1	...	...	...	...	...	...	...	...	...	1	...
c	...	...	...	...	...	...	...	...	...	2	...	...	...	...	...	...	...	...	...	...	...	1	1	...
...	...	...	...	...	...	...	...	...	...	2	...	...	...	...	...	1	...	...	1	...	...	1	3	1
...	...	...	...	1	...	...	...	...	...	...	...	...	...	...	1	...	...	...	...	...	...	...	1	...
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	...	1	...	...	...	...	...
...	...	...	...	...	...	...	...	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
...	1	...	...	...	...	1	...	...	2	...	...	...	...	...	1	...	...	...	...	...	1	...	1	...
...	...	...	...	...	...	...	...	...	1	...	...	...	...	...	...	...	1	...	...	1	...	...	...	...
...	...	...	...	1	...	...	...	...	2	...	c	...	...	...	...	...	2	...	2	1	1	...	2	...
...	...	...	...	...	...	...	...	...	1	...	...	...	1	...	...	...	...	2	...	...	...	...	...	...
...	...	...	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
...	...	...	...	2	1	2	1	...	...	1	c	...	...	...	1	...	c	1	c	c	1	1	3	...
2	...	...	...	...	...	...	...	...	1	...	...	...	...	...	...	1	...	...	...	...	...	1	1	...
...	...	...	...	...	...	c	...	...	c	...	...	...	...	1	...	...	c	...	3	c	...	...	c	...
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
...	...	...	...	...	...	...	1	...	...	...	...	...	...	...	...	...	...	1	...	...	...	...	2	...
...	...	...	...	...	...	...	...	...	...	...	1	...	...	...	...	...	...	...	...	...	...	...	2	...
...	1	...	...	1	...	...	...	...	1	...	...	...	...	...	...	...	...	...	...	...	...	...	2	...
1	...	...	...	...	...	...	...	...	...	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...
...	...	1	...	...	1	2	...	...	c	...	c	...	...	...	...	...	...	...	3	c	...	...	c	...
...	...	...	...	...	...	...	2	...	1	...	...	...	1	...	...	...	...	...	...	...	...	...	...	...
1	...	1	...	...	...	2	...	...	c	...	3	...	...	...	...	...	3	...	...	1	...	...	c	3
...	...	...	...	...	1	1	...	...	c	...	c	...	...	...	...	...	c	...	1	...	...	...	3	...
...	...	...	...	1	...	1	...	...	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
1	...	...	...	...	...	...	...	...	1	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...
3	1	...	...	1	...	2	...	...	3	1	c	...	2	2	2	...	c	...	c	3	...	...	...	2
1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	3	...	...	...	2	...

each is placed was found associated with th e animal the name of which stands at the
three times.

TABLE II.

DISTRIBUTION OF AUGUSTAN CLADOCERA AND COPEPODA ACCORDING TO TEMPERATURE.

	0°-4° C.	5°-9° C.	10°-14° C.	15°-19° C.	20°-24° C.	25°-30° C.
COPEPODA.						
1. Canthocamptus minutus......	p	p	p	......	......	......
2. Cyclops ater................	p	p	p	p	......	......
3. Cyclops bicuspidatus.........	......	......	p	p	......	......
4. Cyclops fimbriatus...........	......	......	......	......	......	......
5. Cyclops phaleratus...........	......	......	......	......	p	......
6. Cyclops serrulatus...........	p	p	p	p	p	p
7. Cyclops signatus coronatus...	......	p	......	......	......	......
8. Cyclops signatus tenuicornis.	......	p	p	p	......	......
9. Cyclops viridis brevispinosus.	......	......	......	p	......	......
10. Cyclops viridis ingens........	......	p	......	......	......	......
11. Cyclops viridis insectus......	p	p	p	p	......	......
12. Diaptomus augustaensis......	p	......	......	......	......	......
13. Diaptomus mississippiensis...	......	......	......	p	p	......
14. Diaptomus sanguineus.......	......	......	p	p	......	......
15. Diaptomus stagnalis.........	p	p	p	......	......	......
CLADOCERA.						
16. Acantholeberis curvirostris..	......	p	......	......	......	......
17. Alona coronata*.............	......	......	......	......	......	......
18. Alona intermedia.............	......	......	p	......	......	......
19. Alona quadrangularis........	......	p	......	......	......	......
20. Alonopsis latissima*..........	......	......	......	......	......	......
21. Bosmina atlantaensis.........	......	......	p	p	......	......
22. Bosmina longirostris.........	......	......	......	......	p	......
23. Bosmina reversaspina........	......	......	p	......	......	......
24. Camptocercus macrurus......	p	p	p	p	p	......
25. Ceriodaphnia megops........	p	p	p	......	......	......
26. Chydorus sphaericus.........	......	......	p	p	p	p
27. Daphnella brandtiana........	......	......	......	p	......	......
28. Daphnia hyalina.............	......	......	......	p	p	......
29. Daphnia schoedleri...........	......	p	p	p	......	......
30. Eurycercus lamellatus.......	p	p	......	......	......	......
31. Ilyocryptus spinifer..........	......	p	......	......	......	......
32. Leydigia quadrangularis.....	......	......	......	p	......	......
33. Moina brachiata.............	......	......	......	......	p	......
34. Pleuroxus denticulatus.......	......	p	p	p	......	......
35. Pleuroxus hamatus...........	......	......	......	p	p	......
36. Pseudosia tridentata*........	......	......	......	......	......	......
37. Scapholeberis mucronata.....	p	p	p	......	......	......
38. Simocephalus serrulatus......	p	p	p	p	p	p
39. Simocephalus vetulus........	p	p	......	......	......	......

A "p" indicates that the animal mentioned in the left-hand column was present.

An "*" indicates that the record was lost.

TABLE III.

DISTRIBUTION OF AUGUSTAN CLADOCERA AND COPEPODA ACCORDING TO THE CHARACTER OF THE HABITAT.

	Ditch.	Marsh.	No-outlet Pond.	Pond with Outlet.	Creek.
COPEPODA.					
1. Canthocamptus minutus	......	......	......	p	p
2. Cyclops ater	......	p	p	p	p
3. Cyclops bicuspidatus	......	p	p	p	......
4. Cyclops fimbriatus	......	......	p	......	......
5. Cyclops phaleratus	......	......	p	......	......
6. Cyclops serrulatus	p	p	p	p	p
7. Cyclops signatus coronatus	......	......	......	p	p
8. Cyclops signatus tenuicornis	......	p	p	p	......
9. Cyclops viridis brevispinosus	p	......	......	......	......
10. Cyclops viridis ingens	......	......	......	p	p
11. Cyclops viridis insectus	p	p	p	p	......
12. Diaptomus augustaensis	......	p	......	......	......
13. Diaptomus mississippiensis	......	......	p	......	......
14. Diaptomus sanguineus	p	p	......	......	......
15. Diaptomus stagnalis	p	p	......	......	......
CLADOCERA.					
16. Acantholeberis curvirostris	......	......	......	......	p
17. Alona coronata	p	p	......	......	......
18. Alona intermedia	......	p	......	......	......
19. Alona quadrangularis	......	p	p	......	p
20. Alonopsis latissima	......	......	p	......	......
21. Bosmina atlantaensis	......	......	p	......	......
22. Bosmina longirostris	......	......	p	......	......
23. Bosmina reversaspina	......	p	......	......	......
24. Camptocercus macrurus	......	p	p	p	......
25. Ceriodaphnia megops	p	p	......	......	......
26. Chydorus sphaericus	......	......	p	......	......
27. Daphnella brandtiana	......	......	p	......	......
28. Daphnia hyalina	......	......	p	......	......
29. Daphnia schoedleri	......	p	......	......	......
30. Eurycercus lamellatus	......	......	......	p	p
31. Ilyocryptus spinifer	p	......	......	......	......
32. Leydigia quadrangularis	p	p	p	......	......
33. Moina brachiata	......	......	p	......	......
34. Pleuroxus denticulatus	p	p	p	......	......
35. Pleuroxus hamatus	......	......	p	......	......
36. Pseudosia tridentata	......	......	p	......	......
37. Scapholeberis mucronata	......	p	......	......	......
38. Simocephalus serrulatus	p	p	p	p	p
39. Simocephalus vetulus	......	p	......	......	......

A "p" indicates that the animal opposite the name of which the letter stands was present in the body of water mentioned at the head of the column.

TABLE IV. DIMENSIONS OF AUGUSTA COPEPODA. (Females only)	Length of the first thoracic segment.	Length of the thorax.	Length of the abdomen.	Length of the abd. furca.
1. Canthocamptus minutus............	......	......	......	......
	*	......	......	......
2. Cyclops ater†......................	......	0.98	0.54	0.10
	......	......	......	......
3. Cyclops bicuspidatus†..............	0.48	0.96	0.52	0.14
	......	......	......	......
4. Cyclops fimbriatus.................	......	......	......	......
	*	......	......	......
5. Cyclops phaleratus†................	0.32	0.56	0.38	0.08
	......	......	......	......
6. Cyclops serrulatus.................	0.30	0.52	0.32	0.09
	0.42	0.72	0.48	0.12
7. Cyclops signatus coronatus†........	0.84	1.34	0.66	0.12
	......	......	......	......
8. Cyclops signatus tenuicornis†......	......	0.98	0.54	0.10
	......	......	......	......
9. Cyclops viridis brevicornatus.......	......	......	......	......
	*	......	......	......
10. Cyclops viridis ingens..............	......	1.80	0.98	0.22
	......	2.02	1.40	0.26
11. Cyclops viridis insectus............	0.42	0.88	0.53	0.13
	0.66	1.27	0.80	0.22
12. Diaptomus augustaensis............	......	......	......	......
	*	......	......	......
13. Diaptomus mississippiensis.........	......	......	......	......
	......	......	......	......
14. Diaptomus sanguineus.............	......	......	......	......
	*	......	......	......
15. Diaptomus stagnalis...............	1.00	2.20	1.00	0.13
	......	2.33	1.07	......

The top figure in each square gives the measurement of one
of the largest measured. Where only one figure is given that is
great that average does not mean much. This lack of uniform-
been made and the original measurements destroyed before I de-
Where an "*" occurs in the first block it indicates that the
The figures represent millimeters.

Length of the abd. setae.	Total length, excluding the abd. setae.	Total length, including the abd. setae.	Greatest width of the thorax.	Greatest width of the basal segment of the abdomen.	Width of the remaining abdominal segments.	Width of the abdominal furca.	Length of the antennae.	Length of egg sac.	Width of egg sac.
......	......	......	......	......	......	......	......	......	......
......	......	......	......	......	......	......	......	......	......
0.76	1.52	2.28	0.60	0.18	0.12	......	......	......	......
......	......	......	......	......	......	......	......	......	......
0.50	1.48	1.98	0.54	0.18	0.10	0.02	0.74	......	......
......	......	......	......	......	......	......	......	......	......
......	......	......	......	......	......	......	......	......	......
......	......	......	......	......	......	......	......	......	......
0.60	0.94	1.54	0.38	0.14	0.12	0.03	0.20	0.32	0.14
......	......	......	......	......	......	......	......	......	......
0.38	0.84	1.22	0.30	0.12	0.06	0.02	0.34	0.25	0.14
0.76	1.20	1.96	0.42	0.14	0.08	0.03	0.54	0.40	0.20
0.76	2.00	2.76	0.96	0.18	0.14	0.05	1.28	0.44	0.30
......	......	......	......	......	......	......	......	......	......
0.76	1.52	2.28	0.60	0.18	0.12	......	......	......	......
......	......	......	......	......	......	......	......	......	......
......	......	......	......	......	......	......	......	......	......
......	......	......	......	......	......	......	......	......	......
1.28	2.79	4.07	1.00	0.30	0.18	0.06	1.00	......	......
1.42	3.42	4.82	1.16	0.32	0.20	0.07	1.14	......	......
0.52	1.41	1.93	0.50	0.18	0.10	0.02	0.44	......	......
0.87	2.07	2.94	0.76	0.26	0.14	0.04	0.64	......	......
......	......	......	......	......	......	......	......	......	......
......	......	......	......	......	......	......	......	......	......
......	......	1.32	......	......	......	......	......	......	......
......	......	1.57	......	......	......	......	......	......	......
......	......	......	......	......	......	......	......	......	......
......	......	......	......	......	......	......	......	......	......
0.53	3.27	3.80	1.00	0.45	0.40	......	......	......	......
0.60	3.33	3.93	......	......	......	......	......	......	......

of the smallest individuals measured, the lower right figure that
the average of those measured. In many cases the variation is so
ity is due to the fact that the averages of some of the forms had
cided that it was best to give the two extremes.
records of the measurements of that species were lost in moving.

TABLE V.

DIMENSIONS OF AUGUSTAN CLADOCERA.

(Females only)

	Length of the head.	Length of the shell, exclusive of the head and the spine	Total length, including the spine.	Total length, excluding the spine.
16. Acantholeberis curvirostris........	....	1.06	....	1.56 ......
17. Alona coronata..................	....	0.42	....	0.48 ......
18. Alona intermedia.................	....	0.36	....	0.46 ......
19. Alona quadrangularis.............. *	....	....	....	....
20. Alonopsis latissima................ *	....	....	....	....
21. Bosmina atlantaensis..............	....	0.32	0.50	0.46 ......
22. Bosmina longirostris.............. *	....	....	....	....
23. Bosmina reversaspina..............	....	0.32	0.46	....
24. Camptocercus macrurus............ *	....	....	....	....
25. Ceriodaphnia megops..............	0.40 0.44	1.16 1.52	1.46 2.00	....
26. Chydorus sphaericus...............	....	0.33	....	0.38 ......
27. Daphnella brandtiana..............	0.36	....	....	0.86 ......
28. Daphnia hyalina.................. *	....	....	....	....
29. Daphnia schoedleri................ *	....	....	....	....
30. Eurycercus lamellatus.............	....	1.80 1.99	....	2.20 2.30
31. Ilyocryptus spinifer................ *	....	....	....	....
32. Leydigia quadrangularis........... *	....	....	....	....
33. Moina brachiata..................	0.28	0.64	....	0.96 ......
34. Pleuroxus denticulatus.............	....	0.54 0.55	....	0.60 0.64
35. Pleuroxus hamatus................	....	0.52	....	0.60 ......
36. Pseudosida tridentata.............. *	....	....	....	....
37. Scapholeberis mucronata...........	....	0.58	0.78	0.73 ......
38. Simocephalus serrulatus...........	....	...... 1.86	1.77 2.33	1.58 2.07
39. Simocephalus vetulus..............	....	2.36	3.01 3.46	2.90 3.33

Where there is only one number in a square, it is the average
upper is the dimension of the smallest individual measured and
An "*" indicates that the record of the measurements was
The figures represent millimeters.

Length of the spine.	Greatest height of the shell.	Height of the posterior margin of the shell.	Distance of the spine from the dorsal surface.	Distance from the eye to the beak.	Distance from the eye to the pigment fleck.	Distance from the eye to the flagellum.	Dimensions of the eye.	Dimensions of the pigment fleck.	Length of the antennules.
......	0.93	0.78	......	......	0.11	......	0.10	0.03	0.34
......	......	......	......	......	......	......	......	......	......
......	0.30	......	......	......	......	......	......	......	......
......	......	......	......	......	......	......	......	......	......
......	0.34	0.22	......	......	......	......	......	......	......
......	......	......	......	......	......	......	......	......	......
......	......	......	......	......	......	......	......	......	......
......	......	......	......	......	......	......	......	......	......
......	......	......	......	......	......	......	......	......	......
......	......	......	......	......	......	......	......	......	......
0.04	0.40	0.16	......	0.08	......	0.06	0.05	......	......
......	......	......	......	......	......	......	......	......	......
......	......	......	......	......	......	......	......	......	......
......	......	......	......	......	......	......	......	......	......
0.12	0.33	0.14	......	......	......	......	0.05	......	......
......	......	......	......	......	......	......	......	......	......
......	......	......	......	......	......	......	......	......	......
......	......	......	......	......	......	......	......	......	......
0.04	1.00	......	0.40	......	......	......	0.14	......	......
0.08	1.33	......	0.50	......	......	......	0.16	......	......
......	0.32	......	......	......	0.06	......	0.03	0.02	......
......	......	......	......	......	......	......	......	......	......
......	0.38	......	......	......	......	......	0.08	......	0.08
......	......	......	......	......	......	......	......	......	......
......	......	......	......	......	......	......	......	......	......
......	......	......	......	......	......	......	......	......	......
......	......	......	......	......	......	......	......	......	......
......	......	......	......	......	......	......	......	......	......
......	1.40	0.88	......	0.29	0.14	......	0.12	0.02	......
......	1.67	1.00	......	0.30	0.15	......	0.12	0.04	......
......	......	......	......	......	......	......	......	......	......
......	......	......	......	......	......	......	......	......	......
......	......	......	......	......	......	......	......	......	......
......	......	......	......	......	......	......	......	......	......
......	0.40	......	......	......	......	......	......	......	0.10
......	......	......	......	......	......	......	......	......	......
......	0.44	0.12	......	0.22	0.06	......	0.03	0.02	......
......	0.46	0.14	......	0.26	0.07	......	0.03	0.02	......
......	0.34	0.16	......	......	0.06	......	0.03	0.04	......
......	......	......	......	......	......	......	......	......	......
......	......	......	......	......	......	......	......	......	......
......	......	......	......	......	......	......	......	......	......
0.05	0.52	0.30	......	0.15	......	......	0.07	......	......
......	......	......	......	......	......	......	......	......	......
0.19	1.04	......	0.50	0.16	0.16	......	0.04	......	......
0.26	1.66	......	0.80	0.18	......	......	0.12	......	......
0.11	2.00	......	0.79	0.27	......	......	0.10	......	......
0.13	2.27	......	1.20	......	......	......	0.14	......	......

of all the specimens measured; where there are two numbers, the
the lower number that of the largest individual.
lost in moving.

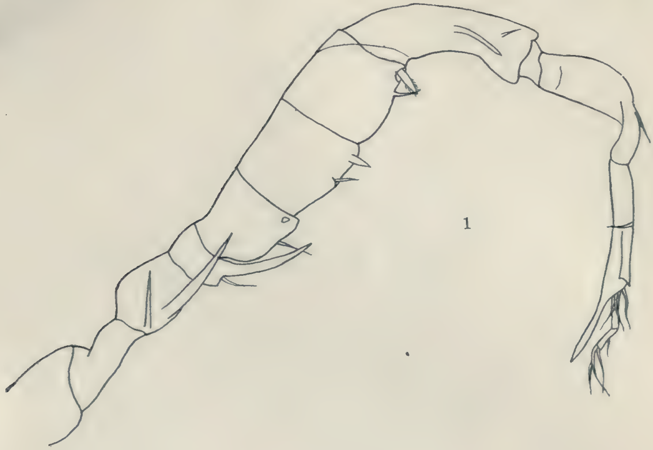
EXPLANATIONS OF ILLUSTRATIONS.

....Plate XXXVI.—Fig. 1. *Diaptomus augustaensis*, male, distal portion of the geniculated antenna.—Fig. 2. *Diaptomus augustaensis*, male, fifth foot.—Fig. 3. *Diaptomus augustaensis*, female, fifth foot.—Fig. 4. *Diaptomus augustaensis*, female, posterior end of the abdomen.

Plate XXXVII.—*Daphnia hyalina*, female, Stages in its life history.—Fig. 1. First stage (from the brood-pouch),—Fig. 2. Second stage (from the brood-pouch).—Fig. 3. Third stage (Free swimming).—Fig. 4. Fourth stage.—Fig. 5. Fifth stage (just before it begins to bear eggs).—Fig. 6. Sixth stage (four egg stage).—Fig. 7. Seventh stage (eight egg stage, two eggs are out of focus).—Fig. 8. Eighth stage (twelve egg stage, four eggs are out of focus).

Plate XXXVIII.—Fig. 1. *Bosmina reversaspina*, n. sp., female.—Fig. 2. *Eurycercus lamellatus*, female.

Issued December 31, 1910.



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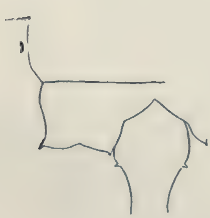

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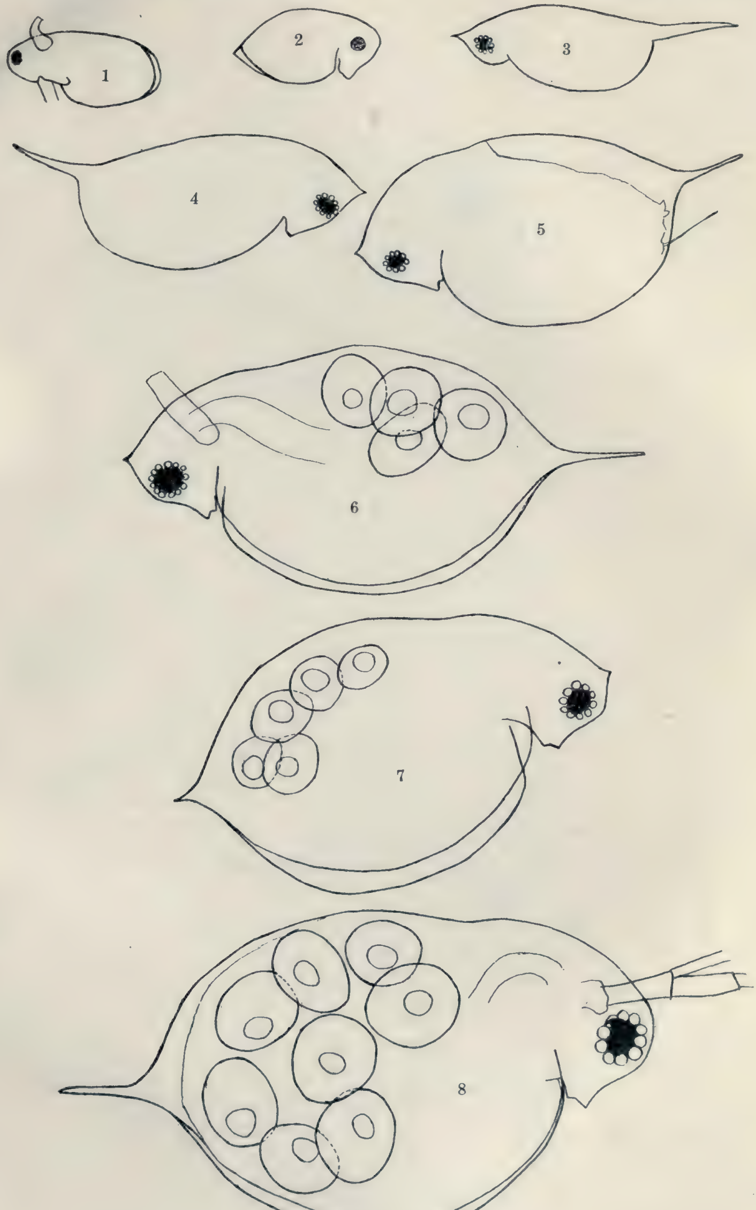
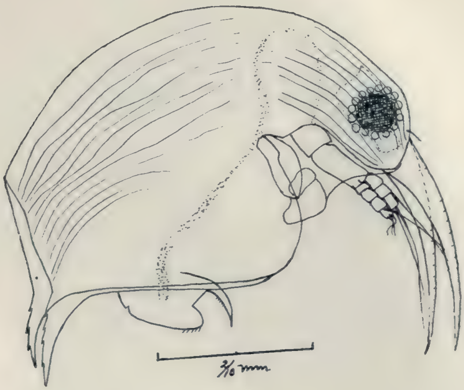


DAPHNIA HYALINA.



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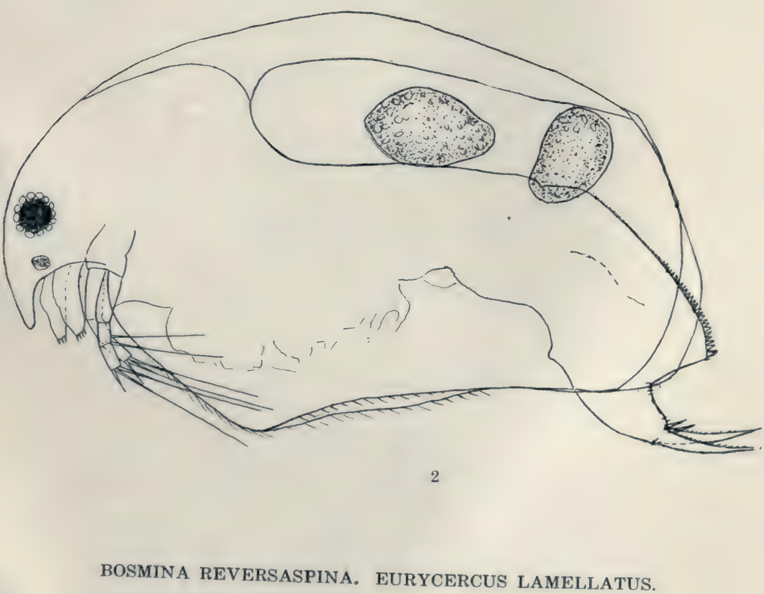

2

BOSMINA REVERSASPINA. EURYCERCUS LAMELLATUS.

LIST OF AUTHORS.

GENERAL INDEX.

INDEX TO GENERA.